Washington Connected Landscapes Project:

British Columbia – Washington Transboundary Habitat Connectivity Scoping Report

WASHINGTON WILDLIFE HABITAT CONNECTIVITY

WORKING GROUP

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Mission Statement of the

Washington Wildlife Habitat Connectivity Working Group

Promoting the long-term viability of wildlife populations in Washington State through a science-based, collaborative approach that identifies opportunities and priorities to conserve and restore habitat connectivity.

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Introduction

The transboundary region of Washington and British Columbia (Fig. 1) is important for the conservation of many wildlife species. Some species of conservation concern, such as wolverine (*Gulo gulo*) and Canada lynx (*Lynx canadensis*), have home ranges that span the international border. Other species depend on the region for seasonal habitat. All regional wildlife species will require a connected network of habitats spanning the border as they adjust their ranges to meet life history requirements under future changes to climate and land-use. Previous analyses have identified numerous areas within the region where habitat connectivity has been disrupted by human activities (Gaines et al. 2001; Singleton et al. 2002, 2004; WHCWG 2010) or by natural barriers to species movements. Particularly affected areas include the Fraser River-Coquihalla Valley, Okanagan Valley, Upper Columbia and Pend Oreille River valleys, and the various highway corridors that bisect the transboundary area. Fine-scale, operational analyses are urgently needed to guide on-the-ground conservation and management actions aimed at maintaining and restoring transboundary connectivity for wildlife.

While ongoing human development creates the impetus for connectivity science, climate change provides an additional sense of urgency. Maintaining and restoring ecological connectivity is the most oft-cited climate adaptation strategy for biodiversity conservation (Heller & Zavaleta 2009). This is because range shifts have been the primary biological response to past episodes of climatic change, yet species will now face widespread anthropogenic barriers to movement. The border between Washington and British Columbia runs perpendicular to the latitudinal gradient species ranges are likely to follow as climate changes, and bisects large tracts of natural lands that would otherwise offer opportunities for range migration and persistence. A clear example can be found where the northern-most extent of the arid Columbia Plateau Ecoregion extends from Washington into British Columbia; extensive development on the Canadian side of the border may prevent species south of the border from moving northward with warming temperatures.

The need for connectivity conservation planning has been identified in several conservation planning efforts for the transboundary region. For instance, the region bisects the heart of the Great Northern and North Pacific Conservation Cooperatives, which list landscape connectivity as a priority theme. The Western Governors' Association's (WGA) Wildlife Council has been working with states to develop a West-wide Crucial Habitat Assessment Tool (CHAT) aimed at mapping crucial wildlife habitats and connectivity areas (WGWC 2011). In addition, several conservation and recovery plans recognize the need for habitat connectivity. For example, the Grizzly Bear Recovery Plan identified the area between the North Cascades and Selkirk Recovery Areas as important for linkage analysis (USFWS 1997). The British Columbia Ministry of Environment's *Jeffersonii* Badger Recovery Team identified the need for transboundary analysis examining potential linkages of populations in British Columbia to those south of the border (*Jeffersoni* Badger Recovery Team 2008). The Canada lynx conservation assessment and strategy identified the importance of evaluating connectivity to the North Cascades from areas to the north and east (Ruediger et al. 2000; Koehler et al. 2008). As well, the multi-jurisdictional Okanagan-Similkameen biodiversity assessment identified the need for transboundary connectivity analysis to inform conservation and planning for both the Okanagan-Similkameen and Kettle corridors (SOSBP 2012).

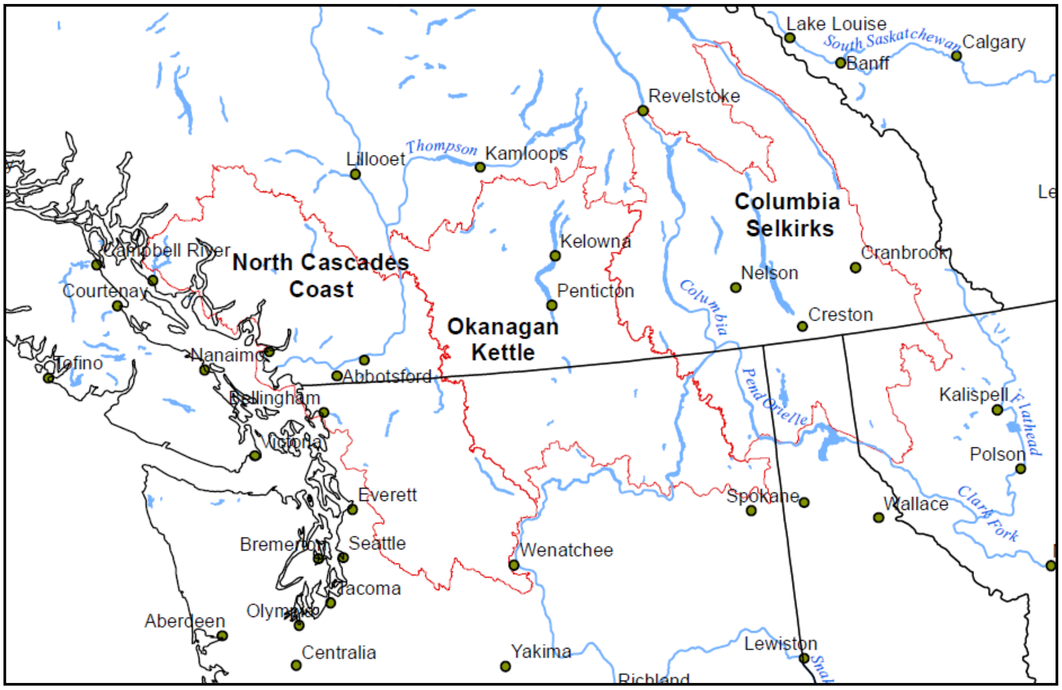

Figure 1. The British Columbia–Washington Transboundary Region, including the North Cascades-Coast, Okanagan-Kettle, and Columbia-Selkirks Subregions.

Objectives of the Scoping Report

The specific objectives of this report are to (1) describe our process to gather stakeholder input on connectivity needs in the transboundary region, and summarize the results of this effort; (2) review and summarize existing and ongoing analyses that address connectivity and/or climate-connectivity; and (3) propose future analyses aimed at providing stakeholders with the information they have identified as necessary to guide their decision-making around connectivity conservation, now and into the future.

Scoping Process

During the production of its statewide connectivity analysis (WHCWG 2010), the Washington Wildlife Habitat Connectivity Working Group (WHCWG) formed a Transboundary Subgroup to ensure cross-border coordination with states and provinces neighboring Washington State, and conducted outreach with British Columbia partners on methods and products as they were developed. Following completion of the statewide analysis, there was recognition that any future analysis of the transboundary region would require additional collaboration with on-the-ground practitioners from both sides of the border. In fall 2011, the Transboundary Subgroup hosted a half-day workshop at the WildLinks conference in Vancouver, British Columbia, titled *Transboundary Cascades to Rockies Landscape Coordination Dialogue*. The workshop's purpose was to facilitate a dialogue with regional experts from the transboundary landscape that connects the Cascades to the Purcells/Selkirks. Presentations on completed or ongoing field studies, conservation efforts, connectivity analyses, and an ecoregional overview were followed by discussion of potential coordination of products and talent on this landscape and next steps. The workshop established a clear interest in further connectivity analyses on this landscape, as well as the importance of placing any additional work in a broader transboundary context.

Following up on this workshop, the Transboundary Subgroup revisited its membership and structure to begin providing this context through a scoping report. A "living" communications database of contacts was developed, and a review was initiated to identify existing analyses completed or underway to address connectivity in the lands along the border of Washington and British Columbia based on current condition and in light of climate change.

Building from the 2011 workshop dialogue and subsequent outreach efforts, a second workshop was held at the North Cascades Institute during WildLinks 2012. The primary purpose of this second workshop was to determine the needs of on-the-ground practitioners regarding additional science and interpretation, and to identify challenges to implementing existing science around connectivity conservation planning. To accomplish this, we designed the workshop to gather stakeholder input on four specific topics: (1) a survey of existing products and methods used to evaluate habitat connectivity, (2) information about how existing products are being applied and how their use could be more effectively communicated, (3) the use and application of climate change science in connectivity conservation planning, and (4) an inventory of existing spatial data that had been used or may be useful in connectivity analyses. Members of the Transboundary Subgroup presented a map of generalized subregional areas in the transboundary region (Fig. 1), and input was received on refining the subregional boundaries and which subregion to focus on for initial analyses. Presentations by the Transboundary Subgroup provided updated reviews of completed or ongoing transboundary connectivity science and conservation efforts, including:

- *Introduction and Summary of the Transboundary Connectivity Subgroup* by Tory Stevens (BC Parks, Transboundary Subgroup co-chair).
- *Review of Connectivity Analyses within the Transboundary Region between Washington and British Columbia Including Patterns that have Emerged* by Bill Gaines (Washington Conservation Science Institute, Transboundary Subgroup co-chair).
- *Approaches to Analyzing Climate Change and Impacts to Connectivity* by Meade Krosby (University of Washington).

To elicit input from workshop attendees, participants were divided into nearly equal groups and facilitated discussions were held on each of the four topic areas. Meeting notes were recorded and later summarized by topic area (See Appendices A and B). Additional efforts were made to include input from stakeholders unable to attend the workshop. A final scoping effort occurred on January 30, 2013, at the full group meeting of the Washington Wildlife Habitat Connectivity Working Group. This group includes a diverse membership representing most regional federal, state, and provincial land and wildlife management agencies, tribes, universities, and non-governmental organizations. The meeting was held as an all-day WebEx during which a summary of the transboundary scoping effort (to date) was presented along with an explanation of how the input was used to develop proposed next steps. The Transboundary Subgroup then gathered additional input from the working group. The summary presented below and the detailed notes in Appendix A reflect the collective input we received concerning the application of connectivity science to land-use planning. Some of the key messages we heard included:

- While many habitat connectivity assessments have been completed, most are at scales coarser than is appropriate for guiding operational implementation of their results. In addition, a variety of methods have been used, which at times show vastly different results, leading to confusion about how the information should be applied in conservation planning.

- While fine-scale operational analyses are needed to support the application of habitat connectivity science to conservation planning, practitioners cannot wait for their completion before making decisions. They must make decisions now with existing information and adapt as new data becomes available. Therefore, interpretation of existing connectivity analyses would help in decision-making.
- Connectivity analyses need to account for future changes, both in climate and human land-use patterns.
- While a range of climate change projections and climate-connectivity products are available, practitioners do not yet have the capacity to interpret and apply them to their decision-making around connectivity conservation; the need for interpretation of climate-related connectivity analyses is more urgent than the need for new science.
- The development of a broader group (e.g., Cascadia Partner Forum) could facilitate communication and coordination among federal, state, and provincial decision makers, and nongovernmental organizations across Landscape Conservation Cooperative boundaries.
- Outreach to stakeholders, the general public, and decision makers needs to occur early and often. This communication needs to be made using plain language that all can understand.

Review of Existing Assessments

Current Condition Habitat Connectivity Assessments

We reviewed several existing connectivity assessments, or biodiversity assessments that included assessments of habitat connectivity, completed in or near the transboundary area of Washington and British Columbia. These assessments included the work of Singleton et al. (2002, 2004) on wide-ranging carnivore species, the statewide assessment of habitat connectivity completed by the Washington Wildlife Habitat Connectivity Working Group (WHCWG 2010), the *South Okanagan-Similkameen Biodiversity Assessment* (SOSBP 2012; Table 1), the *Terrestrial Viability Assessments for the National Forests in Northeastern Washington* (Gaines et al. in press), *Regional Conservation Planning in the Face of Climate Change: an Example from Southeast BC* (Utzig & Bergenske 2011), and the WHCWG ecoregional analysis of the Columbia Plateau (WHCWG 2012, 2013*a*). We provide a comparison of the methods used in these six studies in Table 2. The major objectives of this review were to (1) compare and contrast methods, (2) identify general connectivity patterns, and (3) identify lessons that could be used to guide future assessments.

<u>Landscape Permeability for Large Carnivores</u> (Singleton et al. 2002, 2004)

The assessment of landscape permeability presented by Singleton et al. (2002) provided an important first step in our understanding of the importance of the transboundary region for the recovery and viability of wide-ranging carnivore species (Fig. 2). This evaluation included most of the transboundary region and focused on four wide-ranging carnivores: wolverine, Canada lynx, grizzly bear (*Ursus arctos*), and gray wolf (*Canis lupus*). Singleton et al. (2004) provided additional detailed analyses of habitat permeability for grizzly bears. An important aspect of these assessments was the broad geographic scope they encompassed. Challenges regarding the accessibility and compatibility of spatial data layers across the international border were difficult but ultimately overcome. As a result, conservation practitioners learned about key fracture zones disrupting connectivity in the transboundary region, particularly within areas important to the conservation of carnivores. These fracture zones included the Fraser-Coquihalla, Cascades-Kettle, and Cascades-Monashee, and influenced both east–west and north–south connectivity. The assessment showed how cumulative impacts of transportation corridors and associated human development, especially in large valleys along major rivers, have contributed to fragmentation of the landscape. Finally, several important linkages were identified that provide some of the last remaining options for maintaining or restoring connectivity.

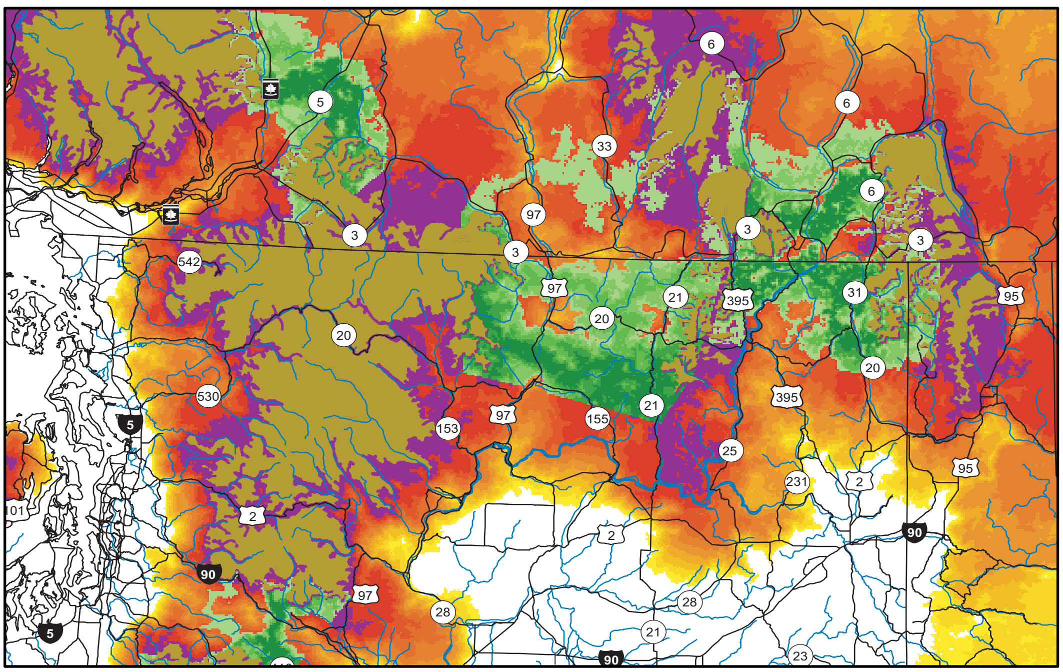

Figure 2. Map showing the Habitat Concentration Areas (brown) and potential linkages (green) for grizzly bears in the transboundary region (from Singleton et al. 2002).

<u>Washington Connected Landscapes Project: Statewide Analysis</u> (WHCWG 2010)

The statewide analysis completed by the Washington Wildlife Habitat Connectivity Working Group (WHCWG) extended beyond the state boundary to include the transboundary region (Fig. 3). The WHCWG approached their assessment of habitat connectivity from two different perspectives: focal species and landscape integrity. The focal species used in the analysis included 16 species representing a variety of habitats and risk factors and a range of moderate to high dispersal abilities (low mobility species were deemed more appropriately addressed at a finer scale). The focal species approach involved identifying Habitat Concentration Areas (HCAs) using a method similar to that of Singleton et al. (2002), and then using GIS-based tools to identify linkages (Shah & McRae 2008; WHCWG 2010) between HCAs. The identification of linkages between HCAs relied on the development of resistance maps for each focal species based on an interpretation of the dispersal ecology of the species and how natural features (e.g., vegetation type, slope, elevation) and human-created features (e.g., highways, development) influenced the movement of the focal species. Once the focal species connectivity networks (HCAs and linkages) were completed, an analysis was done to statistically derive guilds or groups of focal species with similar or complementary linkage networks. This resulted in three guilds: Generalist (e.g., mule deer—*Odocoileus hemionus*, western toad—*Anaxyrus boreas*), Montane (e.g., American black bear—*Ursus americanus*, wolverine), and Shrubsteppe (e.g., American badger—*Taxidea taxus*, white-tailed jackrabbit—*Lepus townsendii*).

The landscape integrity approach identified core areas (analytically equivalent to focal species HCAs) as large, contiguous areas of high "naturalness" (i.e., low "human footprint"). Resistance maps were developed based on the degree of naturalness (e.g., areas with low naturalness, such as urban areas, were given high resistance) and used to identify linkages between core areas (WHCWG 2010). The resistance values used in the model were assigned in different ways via a sensitivity analysis that resulted in four different core area and linkage networks. The final landscape integrity network was created by a composite of the four individual models (Fig.3).

When comparing the results of the focal species approach to the landscape integrity results, the landscape integrity approach identified a wider network of potential linkages, most similar to those identified for focal species that were habitat generalists (WHCWG 2010). The landscape integrity approach provides a means of quickly identifying a large set of potential linkages while the focal species approach provides information to address the needs of specific species that may be of conservation concern (e.g., federally listed species) . Additionally, the focal species approach can be used to identify linkages that address multiple species and provide a way of prioritizing among potential linkages.

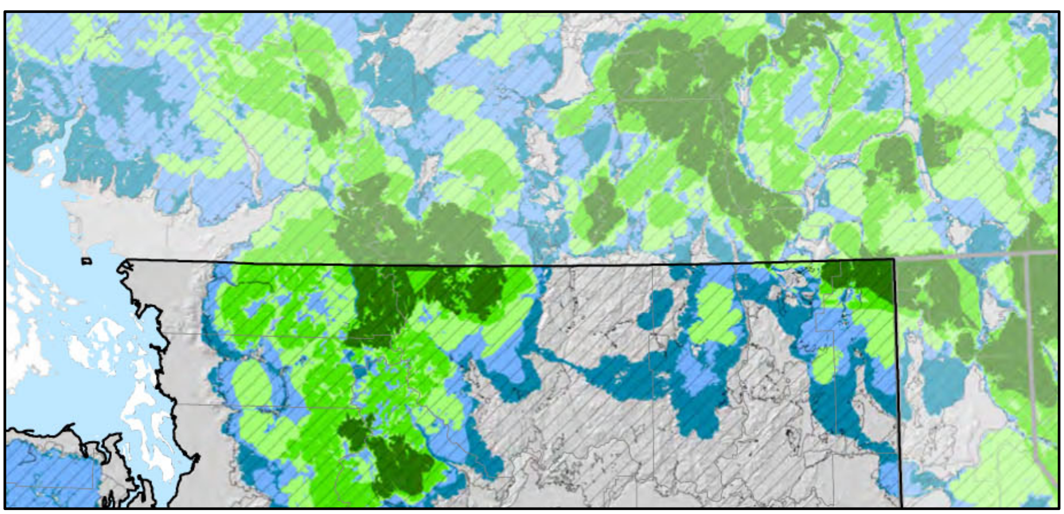

Figure 3. Map showing the composite of focal species connectivity networks (polygons colored blue and green) and landscape integrity (gray hatching) for the Montane Connectivity Guild identified by the WHCWG statewide analysis (WHCWG 2010). Colored polygons indicate number of overlapping focal species; dark green = 5, mid-green = 4, light green = 3, light blue = 2, dark blue = 1.

<u>South Okanagan-Similkameen Biodiversity Assessment</u> (SOSBP 2012)

The South Okanagan-Similkameen Biodiversity Assessment considered much of the Okanagan-

Kettle subregion that lies in British Columbia. An objective of the assessment included quantifying and mapping wildlife habitat connectivity (SOSBP 2012). To accomplish this, they conducted a course-filter evaluation of habitat connectivity independent of any species, and identified key habitat linkages for bighorn sheep (*Ovis canadensis*). The course-filter evaluation was based on the development of a resistance surface that included the landscape features elevation, slope, terrain ruggedness, accessibility to water, and urban areas (Table 1). The assessment area was then categorized into the following connectivity classes; low, moderate, high, and barrier to connectivity (Fig. 4). Habitat corridors for bighorn sheep were based on local data and expertise.

Table 1. Modeling inputs used in the South Okanagan-Similkameen Biodiversity Assessment.

Habitat variable	*Description of modeling assumptions*
Elevation	Lower elevation (valleys) received higher connectivity scores.
Slope	Steep slopes receive lower connectivity scores.
Terrain ruggedness	Terrain with less variability received higher connectivity scores.
Accessibility to water	Areas that are more readily accessible to water receive higher scores.
Urban Areas	Urban areas and roads were not considered to provide connectivity. Agricultural areas received lower connectivity scores

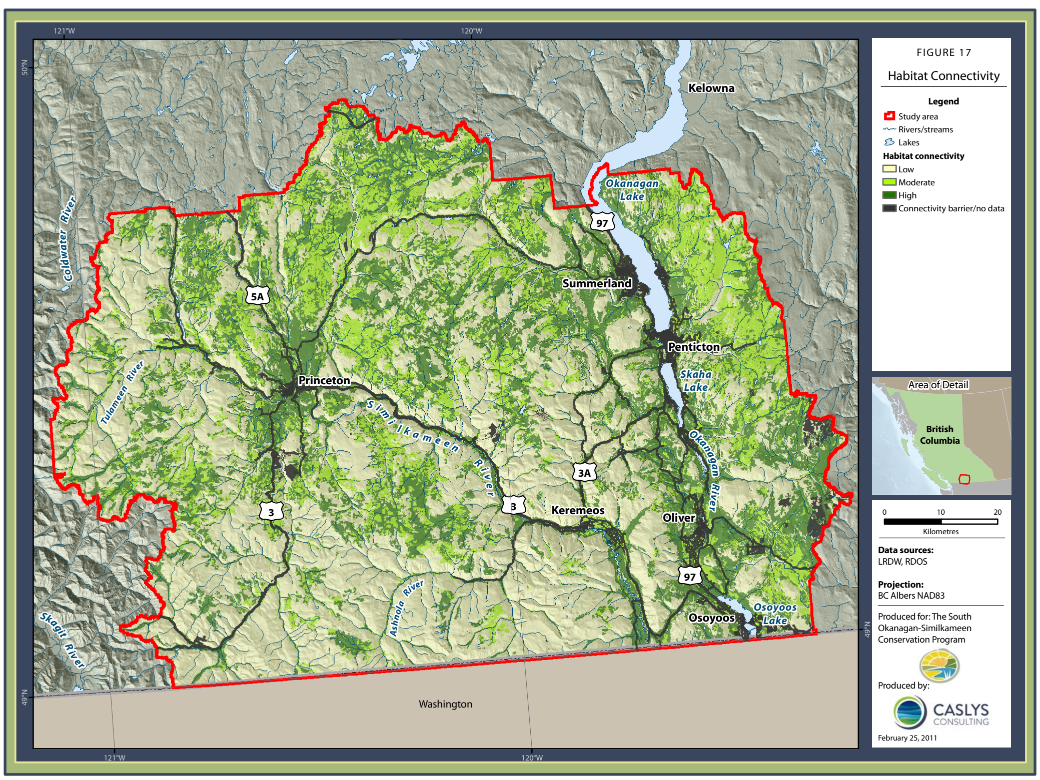

Figure 4. Coarse-filter connectivity assessment from the South Okanagan-Similkameen Biodiversity Assessment (SOSBP 2012).

Northeast Washington Focal Species Assessments (Gaines et al. in press)

Habitat connectivity was also evaluated as part of terrestrial species viability assessments completed to inform revisions to forest plans on the Okanogan [Okanagan]-Wenatchee and Colville National Forests in northeastern Washington (Gaines et al. in press). This effort focused on the Washington portion of the Okanagan-Kettle and Columbia-Selkirks subregions. Four focal species (from 35 that were evaluated) were selected to address issues associated with habitat connectivity. These species included the wolverine, Canada lynx, American marten (*Martes americana*), and bighorn sheep. For each species, resistance surfaces were developed using the following GIS datalayers; potential and current vegetation, forested canopy closure and tree size, roads, trails (motorized and non-motorized), housing density, elevation, and slope. Resistance surfaces were then summarized by watershed and will be used to evaluate the influence of various land management alternatives on habitat connectivity for each of the four focal species.

Similar to other broad-scale assessments (Singleton et al. 2002; WHCWG 2010), the northeast Washington focal species connectivity assessments showed that low-elevation valleys and associated human developments interrupted habitat connectivity for the focal species (Fig. 5). In addition, the finer-scale analyses showed how forest roads, especially areas with high road densities, impact habitat connectivity.

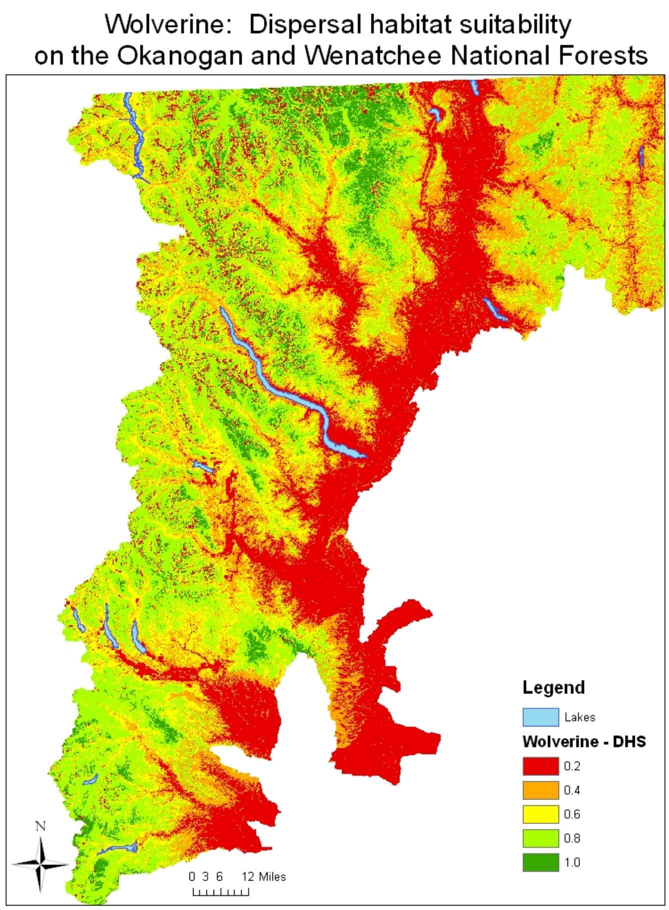

Figure 5. Dispersal habitat suitability for the wolverine used to assess habitat connectivity in the northeast Washington focal species assessments (Gaines et al. in press).

Regional Conservation Planning in the Face of Climate Change (Utzig & Bergenske 2011)

This broad-scale assessment addresses habitat connectivity and climate change (see climate change discussion below; Utzig & Bergenske 2011). The approach emphasizes north–south connectivity and connectivity across elevational gradients. Two species are featured, grizzly bear and woodland caribou (*Rangifer tarandus caribou*). A combination of empirical information on grizzly bear movement (Proctor et al. 2012) and professional input from local land managers is being used to identify important habitat linkages, especially across physical barriers such as highways and human development (Fig. 6).

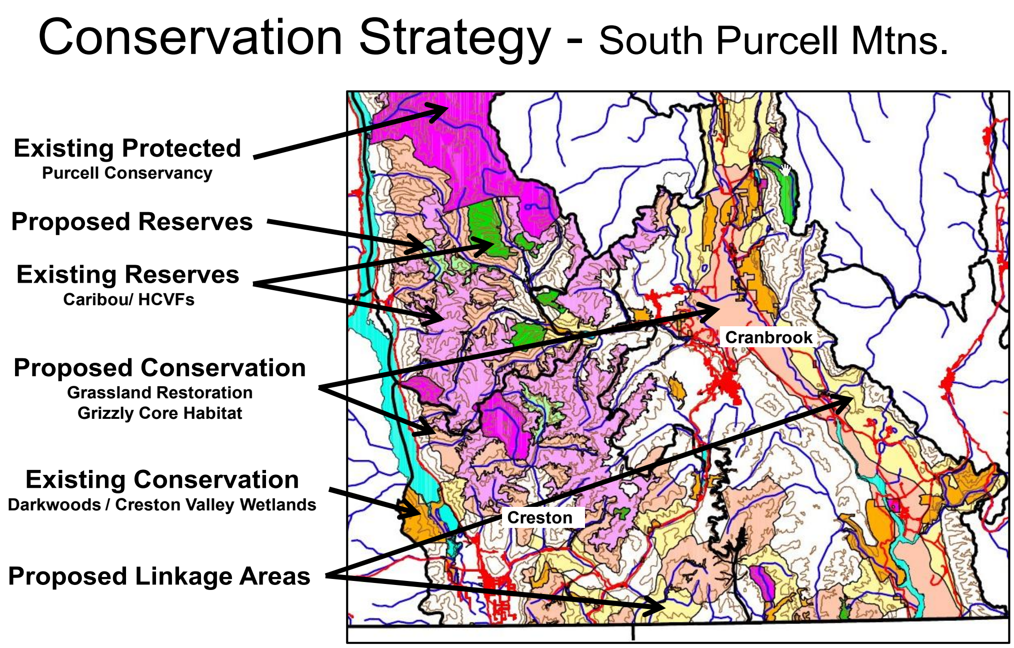

Figure 6. Proposed linkage areas identified for the Purcell Mountains in southeast British Columbia (Utzig & Bergenske 2011; map from Utzig 2013).

Washington Connected Landscape Project: Analysis of the Columbia Plateau Ecoregion (WHCWG 2012; 2013*a*)

The Columbia Plateau ecoregional connectivity analysis includes a portion of the transboundary region, in particular the US portion of the Okanogan Valley (WHCWG 2012). The primary goal of this project was "identifying the most important areas for maintaining and enhancing wildlife habitat connectivity across this ecoregion." The analysis provided a bridge between the broad patterns of connectivity observed in the statewide analysis and local-scale and project-level conservation efforts. The linkage network maps were derived from two modeling approaches: focal species and landscape integrity. They identified and modeled habitat connectivity for 11 focal species: sharp-tailed grouse (*Tympanuchus phasianellus*), greater sage-grouse (*Centrocercus urophasianus*), black-tailed jackrabbit (*Lepus californicus*), white-tailed jackrabbit, Townsend's ground squirrel (*Urocitellus* [*Spermophilus*] *townsendii*), Washington ground squirrel (*Urocitellus washingtoni*), least chipmunk (*Neotamias minimus*), mule deer, Western rattlesnake (*Crotalus oreganus*), beaver (*Castor canadensis*), and tiger salamander (*Ambystoma tigrinum*). The landscape integrity approach was similar to that used in the statewide analysis (WHCWG 2010) but based on finer-scale data and additional landscape features (e.g., powerlines). This analysis provided a vision for a connected landscape and actions that could be taken to achieve the vision. Relevant to the transboundary region, is the importance of a linkage for wildlife species associated with shrubsteppe habitats north–south along the Okanogan Valley, potentially linking wildlife populations across the transboundary area (Fig. 7).

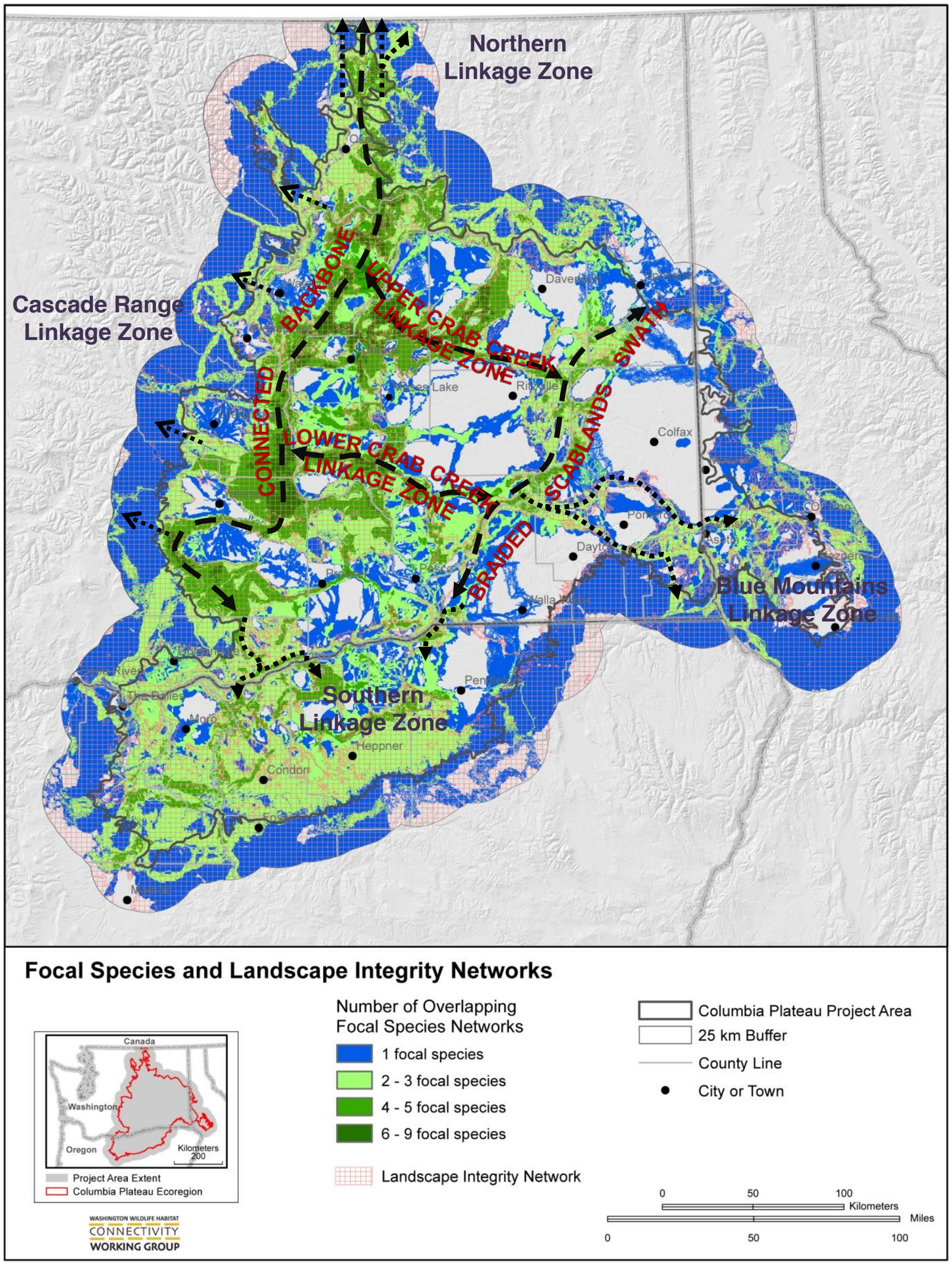

Figure 7. Vision for a connected Columbia Plateau Ecoregion in Washington from the connectivity analysis of the Columbia Plateau Ecoregion (WHCWG 2012).

The Columbia Plateau connectivity analysis (WHCWG 2012) is supplemented by an addendum (WHCWG 2013*a*) that provides additional detail useful for prioritizing and implementing connectivity conservation. The addendum provides maps, interpretive examples, and GIS files depicting linkage network centrality, linkage pinch-points, and barriers and restoration opportunities. These products are available for each of 11 focal species as well as composite products based on the suite of species.

Table 2. Comparison of the methods used to assess habitat connectivity in the six studies reviewed for the British Columbia–Washington transboundary region.

	Approach		*Core areas*			*Permeability*			
Study	*Focal species*	*Biodiversity*[a]	*Model*[b]	*Habitat*[c]	*Protected areas*[d]	*DHS*[e]	*Model*[f]	*Empirical*[g]	*Expert opinion*[h]
Singleton (2002, 2004)	X		X			X	X		
WHCWG statewide (2010)	X	X	X	X		X	X		
SOSBP (2012)		X				X			
NE WA (Gaines et al. in press)	X					X			
SE BC (Utzig & Bergenske 2011)	X				X			X	X
WHCWG Col. Plateau (2012)	X	X	X	X		X	X		

[a]*Assessment was not species-specific but intended to represent a broad array of biodiversity.*
[b]*Core Areas derived from modeled habitat.*
[c]*Core Areas derived from habitat inventory or recovery planning.*
[d]*Core Areas based on areas in protected status.*
[e]*DHS (Dispersal Habitat Suitability), also referred to as resistance surface.*
[f]*Habitat connectivity modeled, based on least-cost and/or circuit theory.*
[g]*Habitat connectivity areas based on telemetry studies of actual animal movements.*
[h]*Professional opinion used to identify areas important for connectivity.*

Climate-Connectivity Assessments

The assessment of existing climate-connectivity analyses was conducted by members of the WHCWG Transboundary Climate-Connectivity Subgroup, which consisted of Meade Krosby (University of Washington), Sean Finn (Great Northern Landscape Conservation Cooperative), Lynn Helbrecht (Washington Department of Fish and Wildlife), Rachel Holt (Veridian Ecological), Gregory Kehm (Independent Researcher), Guillaume Mauger (University of Washington), Tom Miewald (North Pacific Landscape Conservation Cooperative), Trevor Murdock (Pacific Climate Impacts Consortium), Dan Siemann (National Wildlife Federation), Amy Snover (University of Washington), Tory Stevens (BC Parks), Bryn White (South Okanagan-Similkameen Biodiversity Project), and Chad Wilsey (University of Washington).

The assessment was initiated at WildLinks 2012 and completed via WebEx meetings during the winter of 2012–2013. The ultimate objective was to determine whether one or a synthesis of many existing climate-connectivity assessments could be sufficient for identifying transboundary climate-connectivity priorities (e.g., resilient corridors or corridors likely to facilitate range shifts), and, if available information was found to be insufficient, to identify what additional processes or analyses would be required.

The workgroup first completed a literature review to identify existing climate-connectivity assessments within the transboundary region, and then summarized them in regards to (1) scale of analysis (spatial grain and extent); (2) the approach and underlying models used (e.g., current conditions, enduring features, future climate, and/or climate envelopes); and (3) the status of the analysis (completed or in progress). Results are described below and summarized in Table 3.

Washington Connected Landscapes Project: Statewide Climate-Gradient Corridors Analysis (WHCWG 2011)

This analysis spans Washington and neighboring areas of Oregon, Idaho, and British Columbia. It is a coarse-filter approach that identifies corridors that fall along the climatic gradients (specifically temperature) that species ranges are likely to follow as they track shifting climates. While a standard corridor might minimize the geographic distance and barriers to movement between two core areas, a climate-gradient corridor seeks to minimize changes in climate encountered between core areas (i.e., large, contiguous areas of high landscape integrity) of differing temperature. The corridors thus allow for movement from relatively warmer to cooler core areas, while following relatively gentle climatic gradients (e.g., avoiding crossing over cold peaks or dipping into hot valleys). They also avoid areas of high human footprint along the way, via the landscape integrity resistance layer developed in the WHCWG statewide analysis. The statewide climate-gradient corridor analysis spans the full spatial extent of the transboundary region (Fig. 8), but provides only a broad overview of climate-connectivity patterns that is not appropriate for interpretation and application at local scales. Thus, it might be most useful at identifying climate-connectivity priority areas at a relatively coarse scale (>5 km resolution), at which point additional, finer-scale information should be used to guide specific implementation actions.

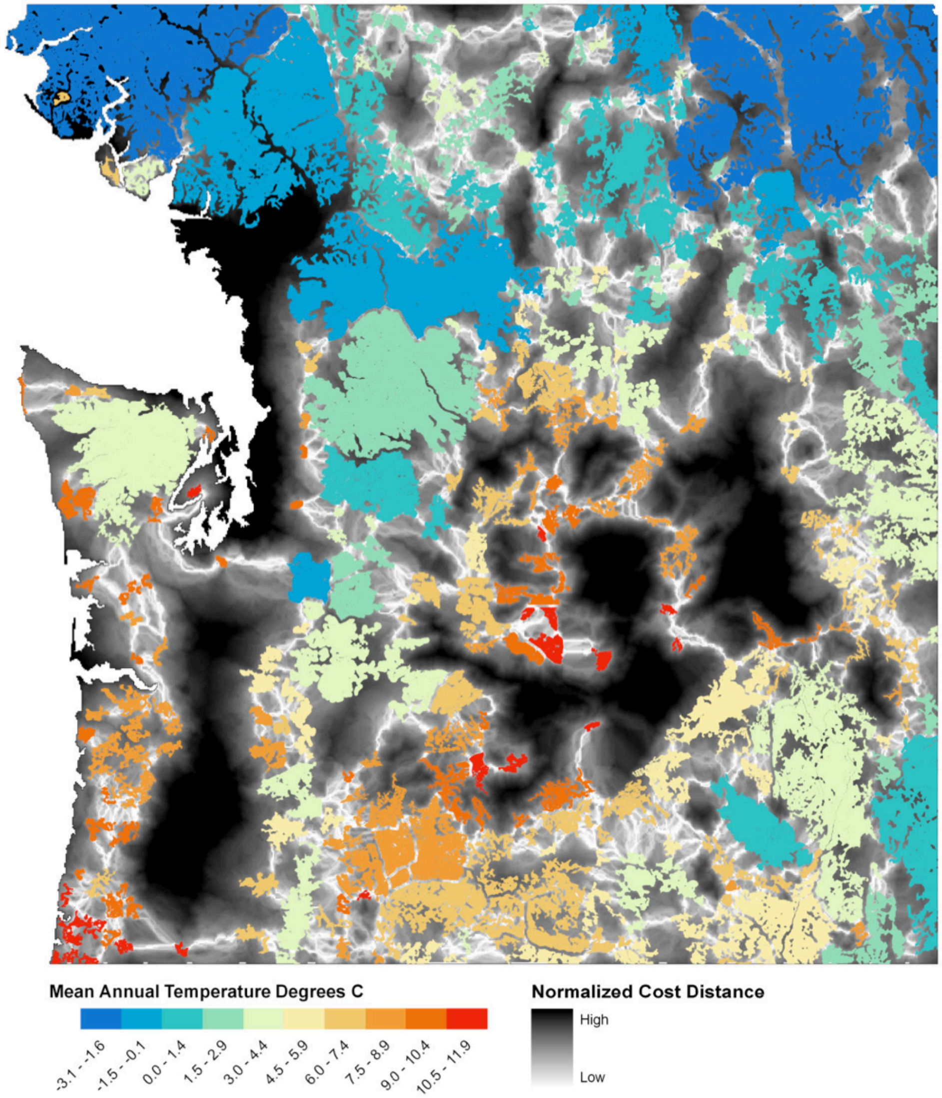

Figure 8. WHCWG statewide climate-gradient corridor network (WHCWG 2011). Corridors (glowing white areas above, with resistance to movement increasing as white fades to black) connect core areas of high landscape integrity (polygons above, shaded to reflect mean annual temperatures) that differ in temperature by >1 °C. The corridors thus allow for movement between relatively warmer and cooler core areas, while minimizing major changes in temperature along the way (e.g., crossing over cold peaks or dipping into warm valleys), and avoiding areas of low landscape integrity (e.g., roads, urban areas, agricultural areas).

Washington Connected Landscapes Project: Columbia Plateau Climate-Gradient Corridors Analysis (WHCWG 2013*b*)

This analysis uses the same methods as the WHCWG statewide climate-gradient analysis, but spans only the Columbia Plateau Ecoregion, and incorporates finer-scale land use and climate data layers than were used in the statewide analysis. For example, it uses a 90-meter resolution temperature layer, rather than the 1000-meter resolution layer used in the statewide analysis. It also uses the landscape integrity layer from the WHCWG Columbia Plateau analysis (WHCWG 2012), rather than the one used in the statewide analysis (WHCWG 2010). Together, these finer-resolution data layers improved the model's ability to track local temperature gradients and avoid local barriers to movement (e.g., powerlines, wind turbines, and railroads) that were not included in the statewide analysis (Fig. 9).

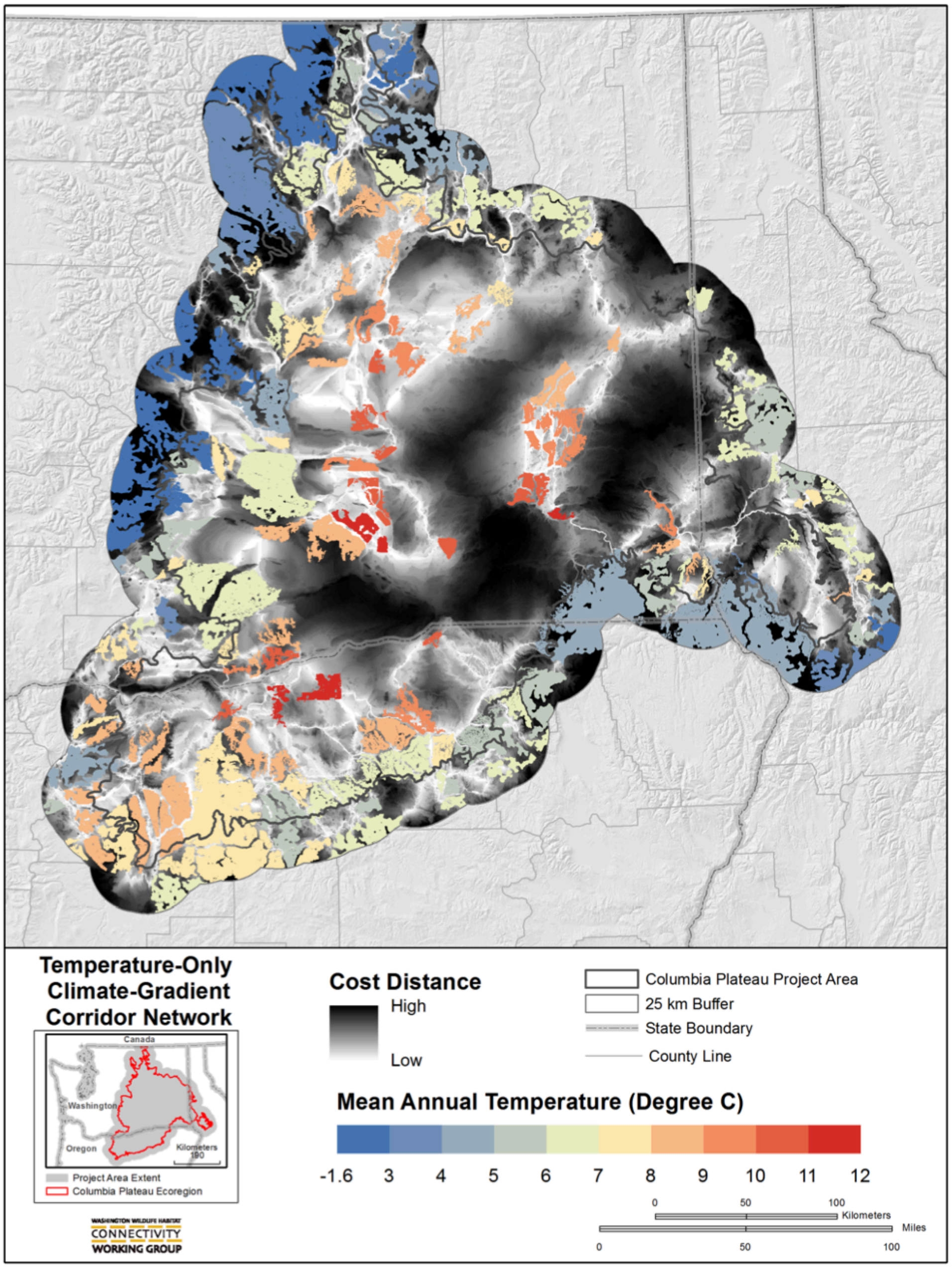

Figure 9. WHCWG Columbia Plateau climate-gradient corridor network (WHCWG 2013*b*). Corridors connect core areas of high landscape integrity that differ in temperature by >1 °C, minimizing changes in temperature along the way. Corridors are represented as glowing white areas, with resistance to movement increasing as white fades to black. Polygons represent the core areas, shaded to reflect their mean annual temperatures.

Effects of Climate Change on Wolverine Connectivity (McKelvey et al. 2011)

This analysis spans the Columbia River Basin (as well as areas outside the BC-WA transboundary region), including all of Washington and much of eastern British Columbia. It models the connectivity of projected areas of persistent wolverine habitat under climate change. Specifically, it models contiguous areas of projected future spring snow cover, which are important for wolverine reproduction and dispersal (Fig. 10). It does this by using downscaled models of current and future spring snowpack to model the number of potential pairwise paths among projected areas of persistent spring snow cover through the end of the century. In addition to identifying areas of potential future importance for maintaining wolverine habitat and dispersal under climate change, its results suggest that the contiguous areas of spring snow cover required by wolverines will become smaller and more isolated with time, reducing connectivity of wolverine populations across the transboundary region.

Figure 10. Wolverine climate-corridors (McKelvey et al. 2011). Study area is shown in gray, and contiguous areas of persistent spring snow cover >1000 km^2 (2070–2099) are shown in black.

Effects of Climate Change on Marten Connectivity (Wasserman et al. 2012)

This analysis spans northern Idaho and small portions of northeastern Washington and southern British Columbia. The analysis identifies future connected dispersal habitat for American marten based on projected upward movement of optimum dispersal elevations as the climate warms (Fig. 11). Specifically, it utilizes empirically-derived models of American marten connectivity and uses resistant kernel dispersal models to assess population connectivity under 5 potential scenarios of future warming. They found that even moderate future warming may result in severe reductions of population connectivity, leading to potentially large losses of genetic diversity.

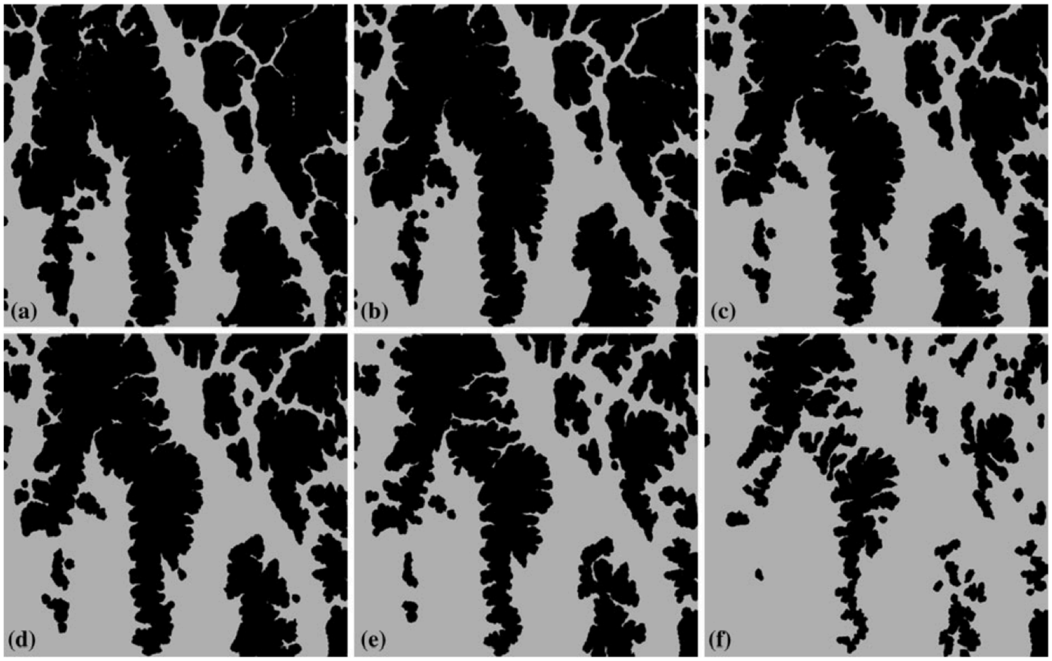

Figure 11. Effects of climate change on American marten connectivity (Wasserman et al. 2012). Panels (a) – (e) show resistant kernel maps of predicted connected dispersal habitat for American marten in the Northern Rockies under six scenarios of climate change: (a) current climate, with optimum dispersal at 1500 m; (b) upward movement of optimum resistance elevation by +100 m; (c) +200 m; (d) +300 m; (e) +400 m; and (f) +500 m. Black areas are predicted to be part of connected patches of dispersal habitat, while gray cells are not.

Temporal Corridors (Rose & Burton 2009)

This analysis spans all of British Columbia, but does not extend into Washington. It identifies "temporal corridors," areas where current and projected future climate envelopes for biogeoclimatic zones (e.g., Interior Douglas Fir) overlap. Specifically, it models the current climate envelope for each of 14 biogeoclimatic zones, and overlays it with 4 time-slices (current, 2020s, 2040s, 2080s) to identify areas where the climate is expected to remain within its bioclimatic envelope over time; the intersection of these areas (i.e., areas of persistent climate) is considered to represent the zone's temporal corridor. Such areas are expected to provide continuity in climatic space and over time. Temporal corridors appear to be relatively sparse in the central British Columbia portion of the transboundary region, compared to areas within the coastal and Rocky Mountain ranges (Fig. 12).

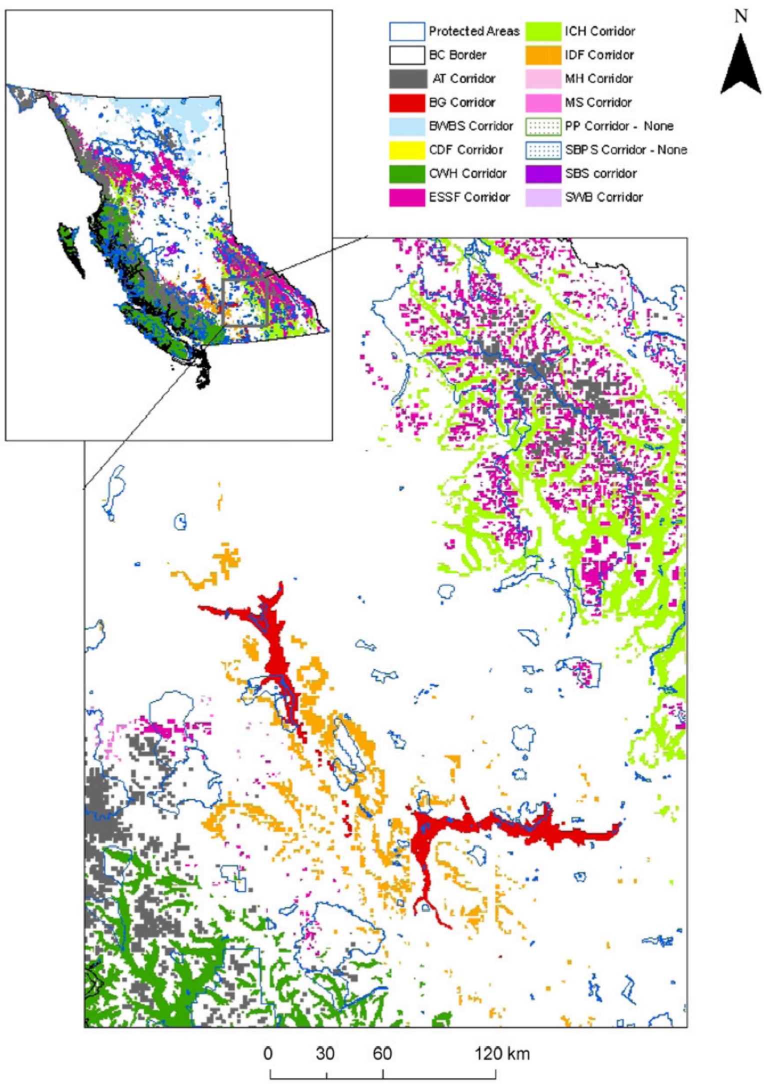

Figure 12. Close up of temporal corridors for British Columbia (Rose & Burton 2009). Colored areas represent temporal corridors, areas where the climate is expected to remain within the bioclimatic envelope of a biogeoclimatic zone (for 14 zones modeled) over time.

<u>Riparian Climate Corridors</u> (Krosby et al. in prep)

This analysis spans the Pacific Northwest, US (including Washington and most of Oregon and Idaho) but does not cross into British Columbia. It is a coarse-filter approach that identifies potential riparian areas and their condition, and then prioritizes those that span climatic gradients, have high connectivity (low human footprint), high canopy cover, and low exposure to solar radiation. Reports and map products are expected by fall 2013.

Table 3. Comparison of methods used to assess climate-connectivity in the five studies reviewed for the British Columbia–Washington transboundary region.

	Transboundary climate-connectivity priorities				
Study	*Spatial extent*	*Approach*	*Underlying models*	*Status*	*Developer/contact*
Climate-gradient corridors	WA/southern BC/ID	Models corridors along temperature gradients and areas of low human footprint	Current temperature and land use	Completed	WHCWG waconnected.org
Riparian climate corridors	WA/ID	Identifies potential riparian areas and prioritizes those with high connectivity along climatic gradients	Hydrology, current land-use, current temperature	Expected Summer 2013	Meade Krosby, David Theobald
Wolverine climate-connectivity	Southern BC/ID	Models contiguous areas of projected future spring snow cover (wolverine climate corridors)	Downscaled current and future climate; current and future snowpack	Completed	McKelvey et al. 2011
Marten climate-connectivity	Southern BC/ID	Identifies future connected dispersal habitat based on projected upward movement of optimum dispersal elevations for marten	Current and future temperature, resistant kernel connectivity model	Completed	Wasserman et al. 2012
Temporal corridors	BC	Identifies areas within both current and future climate envelopes, for biogeoclimatic zones and tree species	Current and future climate envelopes	Completed	Rose & Burton 2009

It is important to note that there are numerous other studies in the transboundary region that focus on climate impacts and/or adaptation strategies, more generally (e.g., West Kootenay Climate Vulnerability and Resilience Project [Holt et al. 2012]). However, we restricted our assessment to those that explicitly focus on identifying spatial *connectivity* priorities in light of climate change, as such models were most immediately relevant to our objectives.

Key Findings of Existing Assessments

Current Condition Habitat Connectivity Assessments

- There have been some significant disruptions in north–south habitat connectivity in the transboundary area as a result of transportation corridors and human development. Areas identified in previous assessments include; North Cascades to Coast Range, north and south through the Kettle and Granby mountains, and north and south in the Selkirk Mountains.
- There have been significant disruptions in east–west habitat connectivity as a result of transportation corridors and human developments, particularly the North Cascades-Kettle Range and North Cascades-Monashee/Rocky Mountains.

- The focal species and landscape integrity approaches can be used as complementary analyses. The landscape integrity approach casts a broad net that generally coincides most closely to habitat generalist species. The focal species approach can be used to identify linkages for specific species and used in multi-species linkage prioritization.
- Different methods have been used to conduct habitat connectivity analyses, resulting in vastly different results. There need for consistent application of methods to provide analyses that facilitate interpretation and reduce potential confusion.
- Cross border differences in data will challenge fine-scale assessments.
- As with all wildlife studies that rely on modeling, evaluation of model assumptions and results are critical.
- Communication among both the scientific and lay communities will be vital to successful analysis and implementation.
- Consideration of future human development patterns as well as future climate is important.

Climate-Connectivity Assessments

- Existing assessments vary broadly in terms of conservation targets, approaches, and scales of analysis; only the WHCWG statewide climate-gradient corridor analysis (WHCWG 2011) spans the full spatial extent of the transboundary region.
- Our effort to synthesize the range of existing assessments to identify transboundary climate-connectivity priorities revealed that no single analysis or combination of analyses would suffice; ultimately, priorities will be user-specific, and will vary with institutional goals and scales/methods of implementation.
- Practitioners need immediate assistance with interpreting existing climate impacts and climate-connectivity models and applying them to their connectivity conservation decision-making.
- While our assessment focused on existing connectivity analyses, we anticipate that interpreting a broader range of climate impacts and adaptation assessments in light of stakeholders' individual connectivity conservation objectives may be useful in informing transboundary climate-connectivity priorities.
- Ultimately, rather than new models, practitioners most need to have existing climate impacts and climate-connectivity assessments tailored to their individual connectivity conservation goals and objectives.

Proposal for Additional Transboundary Work

Based on our scoping process and review of existing analyses, we recommend a concerted effort in the transboundary region to (1) develop an approach for fine-scale transboundary habitat connectivity analysis, and implement it in a transboundary subregion that can be used to inform future work in other subregions; and (2) work with transboundary stakeholders to interpret existing climate connectivity products across multiple spatial and temporal scales.

Operational Scale Transboundary Habitat Connectivity Analyses

Based on our stakeholder scoping effort and reviews of existing connectivity analyses, we have developed a proposal for finer-scale habitat connectivity analyses aimed at informing conservation planning in the transboundary region. Specifically, information from these efforts helped us to determine; (1) our formal definition of the transboundary region, (2) the priority for where to begin our work within the transboundary region, (3) the most effective organizational structure for facilitating communication and developing stakeholder ownership in the analysis process and results, (4) key questions that would be informed by the analyses, and (5) the best methods for addressing these key questions and the needs of our stakeholders. In the following sections we address each of these five topics.

Transboundary Region and Subregions

We presented generalized maps of the area we referred to as the "transboundary region" for comment and input during our scoping meetings. The final map was adjusted based on ecological boundaries and conversations about subregional boundaries (see below), resulting in the map shown in Figure 1. The boundaries were based on the ecosection level of the hierarchical Ecoregion Classification System used by the BC Ministry of Environment. The Shining Mountains Project, an effort to expand this classification system beyond the borders of British Columbia, allowed the entire transboundary area to be defined by these ecological units (Demarchi et al. 2000).

Priority Subregion for Initial Analyses

Generalized subregions within the transboundary region (Fig. 1) were presented at the 2012 WildLinks scoping meeting, and input was solicited regarding how to define these areas and which subregion to focus on for the initial analyses. There was broad agreement that the Okanagan-Kettle subregion presents the highest priority. This reflected the numerous efforts already underway to identify linkages in this area, as well as an urgent need to integrate connectivity analyses with land use planning.

Organizational Structure

The Transboundary Subgroup (Fig. 13) will establish an Okanagan-Kettle subregional team with local knowledge and conduct an analysis of existing habitat connectivity. Projected future land-use patterns will be overlaid onto the analysis of existing connectivity patterns to identify and prioritize opportunities to maintain or restore important linkages. This information will be published in a report made available through web applications, synthesized GIS data layers, and the GNLCC data portal. These products will provide fine-scale information regarding priority areas for habitat connectivity within the Okanagan-Kettle subregion.

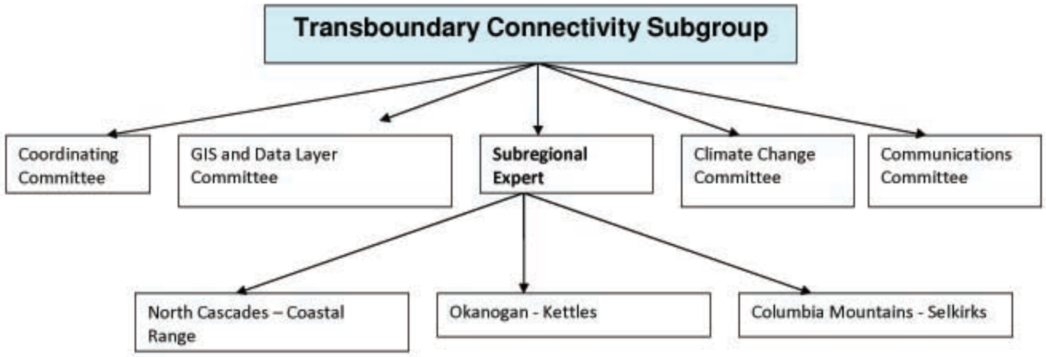

Figure 13. Proposed organizational structure for completing the Transboundary Habitat Connectivity Analysis.

Key Questions

Our scoping with stakeholders provided valuable input that we used to develop key questions to guide our proposed connectivity and climate analyses:

1. Where on the landscape are the linkages most likely to contribute to biodiversity or focal-species conservation?
2. Which of these linkages are most likely to be resilient to future human development patterns?
3. Which of these linkages are most likely to be resilient to climate change, and to promote climate-induced range shifts?
4. Based on the answers to the questions above, which linkages are priorities for maintaining or restoring connectivity?

Methods

Our proposed methods reflect stakeholder needs identified through our scoping effort, the tools and approaches developed and applied through previous assessments, and the emphasis on collaboration (with local managers, planners, and decision makers) identified as a key element to success in the transboundary region. Specifically, our approach consists of six broad steps discussed in detail below:

1. Conduct habitat connectivity analyses*.* We will convene our project team and establish the subregional team, gather spatial data layers (including future land-use patterns), identify appropriate focal species, develop resistance surfaces for focal species and landscape integrity, and conduct linkage analyses to map habitats and identify fine-scale linkages. The local knowledge of the subregional team will ensure that our modeling efforts use the best available existing data layers and reflect on-the-ground conditions.

We will take advantage of tools and approaches that were developed and/or applied in our statewide (WHCWG 2010) and Columbia Plateau ecoregional analyses (WHCWG 2012; 2013*a*). These tools include LinkageMapper (http://www.waconnected.org), HCA Toolkit (http://www.waconnected.org), Circuitscape (Shah & McRae 2008), and barrier identification (McRae et al. 2012).

2. Summarize results and develop products to best inform conservation planning. We will work closely with the subregional team and stakeholder groups to summarize analysis results, develop products, and provide decision support in ways that best inform on-the-ground conservation and meet the needs of local managers.

3. Develop and share documents and web-based products. High-quality maps and documents are essential to the usefulness of our work. We will present our results to a wide range of groups, including scientists, groups interested in applying these methods in other areas, and entities who will use these results to inform their resource conservation and management efforts. We will make resulting maps and guidance documents widely available via a report, peer-reviewed publications, conference and workshop presentations, and online tools.

4. Identify transboundary climate-connectivity priorities. The WHCWG Climate Change subgroup will work in collaboration with the Okanagan-Kettle subregional team and conservation stakeholders to identify linkages likely to be resilient to climate change and to promote climate-driven shifts in species ranges. Transboundary climate-connectivity results will be synthesized with spatial data layers generated in the current condition connectivity assessment (previous steps) to identify priority areas for connectivity conservation under current and future climates.

5. Develop and share documents and web-based products for transboundary climate-connectivity analysis. We will work with WHCWG transboundary partners to develop climate-connectivity adaptation plans tailored to the conservation goals of anticipated end-users. We will make resulting maps and guidance documents widely available via a report, peer-reviewed publications, conference and workshop presentations, and online mapping tools (e.g., Databasin, WHCWG website).

6. Identify model evaluation needs for future proposal development. The WHCWG is strongly committed to the evaluation of habitat connectivity models and included this important aspect in both its statewide and ecoregional analyses (WHCWG 2010, 2012). We anticipate the need to conduct model evaluation studies that test the assumptions and results of our analyses, in collaboration with stakeholders. The resources required to conduct these studies will be addressed in future proposals.

Summary and Conclusions

Understanding the network of current habitat linkages, potential barriers, and restoration opportunities in the transboundary region between British Columbia and Washington is a high priority for effectively managing and conserving wildlife today and into the future. Conducting transboundary habitat connectivity analyses that address climate change and future human development has been recognized as important in numerous scientific assessments and was reiterated during discussions with local and regional stakeholders over the past two years. However, the key questions, information needs, and technical and organizational approaches available for addressing these questions and needs were not clear until we conducted our comprehensive scoping effort. This allowed our Transboundary Subgroup to gain an understanding of completed or ongoing habitat connectivity and climate change assessments and to determine what information is still needed to better inform management. The numerous dedicated individuals who provided insights and information to our scoping effort thereby shaped the proposed transboundary work, by contributing to the following key findings:

- Fine-scale operational analyses are needed to support the application of connectivity science. However, practitioners must make decision now by using the best available scientific information and adapting as new information becomes available.
- Outreach and collaboration with stakeholders, the general public, and decision-makers needs to occur early and often. This communication needs to be made using plain language that all can understand.
- Connectivity analyses should address changes that result from climate and future human development.
- The need for interpretation of existing climate-related connectivity analyses is more urgent than the need for new science.

We have therefore proposed a body of work for the Washington Wildlife Habitat Connectivity Working Group that engages transboundary stakeholders to (1) develop and complete a new, operational scale suite of connectivity analyses in the transboundary Okanagan-Kettle subregion that will inform efforts underway on that landscape now and provide lessons to inform future, additional connectivity analyses in the remaining two transboundary subregions; while also (2) interpreting and integrating available climate and climate-connectivity models into these new analyses so that they account for the future movement needs of wildlife.

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Appendix A. Breakout Group Notes

Information presented below is taken from Lyons (2012).

CONNECTIVITY BREAKOUT GROUPS:
APPLICATION & COMMUNICATION, CLIMATE CHANGE, & GIS

With the presentations on Connectivity and Climate Change to stimulate discussion, facilitated discussions were hosted in three breakout groups to address the topics of **APPLICATION & COMMUNICATION, CLIMATE CHANGE and GIS.** The following is a collection of responses to questions posed by facilitators for each topic.

Application & Communication

QUESTIONS

How could you use scientific information about areas important to maintain and/or restore habitat connectivity for species in your work?

RESPONSES

- Scientific models lay the blueprint for action and provide quantitative science to support what needs to be done. They can provide a shared plan for action so that our work is coordinated. Need these course scale products brought down to a finer scale in key linkages so that on the ground actions and discussions can stem from them.
- Often it is not the lack of science but the political landscape that prevents success (i.e. lack of funding, fear of taking on a challenging issue, etc.). Socioeconomic analyses are needed for continued support of research. Facts and figures are needed to refute the idea that research funding is taking from economic growth. Data is also needed to support research and continued research. Keeping the focus centralized. Need political boundaries on maps for clarify how the information from analyses relates to place.
- Sometimes (my) agency has money to do projects, but doesn't have the synthesized scientific resources to point to where and how to spend it and how it adds up to a landscape context.
- Recurring theme: open space, public space generates more tax revenue and requires more tax dollars to run as opposed to profitability of commercialized space. Need to have economics in mind as well as our biological analyses.
- Need to get public more engaged.
- Need analyses and talking points on how impacts of land use effect biodiversity and economies (i.e. mining, logging for pine beetle, etc.). How do you tell public about issues when you don't have time to measure response to impacts?
- Putting in population growth into models to help forecast scenarios with and without action.
- Tell real stories in addition to the models. For example, animals are migrating to new areas because of climate change and development. Grizzlies are showing up in areas where people haven't seen them in 50+ years reported one BC biologist.
- Agencies need more accessible data to plug into land-management plans and these documents need editors.

CONNECTIVITY BREAKOUT GROUPS:
APPLICATION & COMMUNICATION CONTINUED

QUESTIONS	RESPONSES
Continued	- We need a map that shows not only habitat but indigenous resources that resonates with my audiences. It was suggested that something less scientifically rigorous and technical, and more human oriented with endearing features could be an important layer to bring into these mapping efforts. - Artistic influences to final products could make them more approachable. - A dynamic map: habitat, habitat quality, private land ownership, full corridors/connectivity. - A clearinghouse that provides access to available resources, data, potential planning documents, etc. could be extremely useful.
How could the information be made available to be most useful to you?	- Information gap – broad-scale information there but need more localized data and analyses. Need more transboundary species-specific information on fish management, migratory birds, etc. - Need a better translation method to get pertinent information across from 'information flood'. - Prioritize and identify which habitats are crucial – i.e. create a document similar to "Seafood Watch" to make habitat statuses known (Red, Yellow, Green delineation) that makes it easier from a managerial standpoint to interpret and work with. - More interpretation documents with each analysis that help the end user understand what the key findings and actions are from the work. - Make the data not only the report transparently and easily available to use - Ideally some human capacity could be made available to help in using and working with the science as it is generated. - Localize relevance and adaptability of models used – multiple models produced as they are regional/data specific. Not all models are transposed to all places for all problems. Each model has its own limitations and objectives set – but need models to communicate relevance.
What policies are you are of that recognize the need to address climate adaptation and/or connectivity that may be useful for us to be aware of?	- This question revealed differences in how land is managed (even public) on either side of the border, such as there is a permit system for the allocation of timber harvest and land use in Canada different from US. - WA has a climate adaptation action plan that stemmed from Government Executive Order, while lots of federal level progress on policies that recognize this issue in the past several years. - Columbia basin folks are trying to find more inclusive planning that allows transboundary areas to exist. - There was some concern centered on the feeling that conservation planning tends to be a by-product instead of priority. It was suggested that a government 'umbrella' between BC and US with open communication and similar land/habitat connectivity management plans could help align priorities. Another suggestion was made to create another forum wherein governments were invited as opposed to government run – this would be a more inclusive forum that includes First Nations, local governments, federal governments, public, conservation organizations, etc.

CONNECTIVITY BREAKOUT GROUPS:
APPLICATION & COMMUNICATION CONTINUED

QUESTIONS	RESPONSES
What key audiences do you think should be involved in creating this work? *What audiences need to be aware of the work as it is developed and once it is finalized?*	• Oftentimes, key stakeholders are missing. Green technology is often applied where there is money and valued resources, but many small fauna/flora are ignored (versus value to habitat). It's important that decision-makers are aware the value of habitat and connectivity prior to decisions made about land management of an area. • Land trusts should be involved. • Local governments – county level planning for zoning. Federal governments for larger parcels (i.e. USFS). • First Nations and tribes have their own land management use plans and a strong interest in plans outside of their land ownership areas where they have cultural and historical interest – many feel excluded from land management forums and have done their own land management apart from local government. Building a social awareness of connectivity and climate change – getting information out to non-profits and conservation-based organizations, hunting clubs, wildlife groups and then on to legislature, hitting committees that have the power to make these decisions. Additionally land-owners that manage large blocks of lands are another audience we need to target; getting information to them now will seep into their consciousness and could affect/integrate this information for future decisions. • Integrate social scientists or environmental education to help spread awareness. The target audience should be identified initially as opposed to the general 'public.' • We could share the message that "this work [data] has been done and there are ways to address climate change, as opposed to unmitigated disaster." • Get other agencies involved – give information on how to address climate change and what role their lands or agency may have in implementation. • Use species that have a universal value to people today and into the future such as elk to grow the participation in this work. • Engage all land owners private and public early on, especially as these models step down to a finer scale so that they contribute to the data, the interpretation of the findings, and have ownership in any discussion that emerges from the science. • Engage species experts. • Increase transboundary engagement – participation on both sides of the border from NGO's, scientists, universities, agencies, land owners, etc. • Universities are key for their resources and relationship to ongoing research, as well as the students that can provide needed capacity.

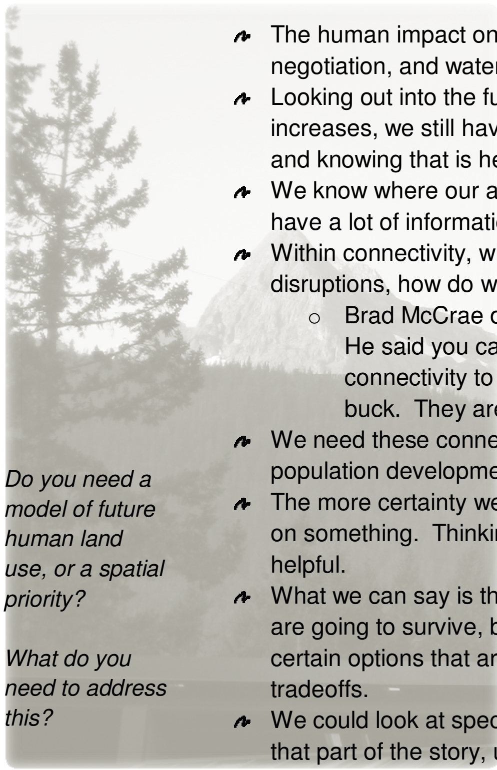
CONNECTIVITY BREAKOUT GROUPS:
CLIMATE CHANGE

QUESTIONS	RESPONSES
How would you expect to use models of connectivity priorities for climate change (if available) in your work)?	• Many models are more biologically based than climate based so knowing about specific climate models would be helpful. • When considering whether to list a species, or work towards recovery, agencies often look at climate as a threat separately. • More applicability would be helpful, interpretation is missing, and conclusions are being made that may or may not be applicable because those interpreting are regulation and not necessarily scientists. • Appeal to downscaling from a land management perspective, how can we make decisions that will promote resilience? • For specific species, it depends on the model whether it will be helpful or not. • Letting go of the idea that there is a future that already exists and getting comfortable with the idea that there is a range of future possibilities, and exploring ways to handle several different possible future outcomes. (Some geographic areas will have more certain outcomes than other.)

Where do we look for models? What models are you using that use climate models in connectivity?	• With modeling you pick a model or suite of models, and you also pick a scenario, so when reading a model, it is important to be really clear about what scenario is being used. The information available is overwhelming, so help is often needed to interpret it and help people understand the complexities. The Spittlehouse and Murdoch paper from BC suggests to always use 3 different models. There is also the issue of connectivity models that consider climate vs. climate models. These are two different things that require more clarification because they aren't necessarily intuitive.
	• Yale framework (Ecoadapt blueprints) has not been significantly used but they are out there. It provides a facet analysis to see how subjective facets were, but it doesn't cross the border.
	• Josh Lawler's Pacific Northwest Vulnerability Assessment.
	• BC shoreline sensitivity analysis, having to do with sea level rise, ends at the border.
	• Pacific Northwest Climate Variability– an ongoing project that includes most of BC down to northern CA and NV and is a downscaling of 10 models. The project looks at potential impacts and consists of:
	  o rainshift modeling for plants and animals
	  o future vegetation based on a dynamic vegetation model
	  o individual focal species monitoring (just getting started)
	  o transboundary region coverage,
	  o products available to address connectivity although it is not the focus
	  o outreach component with USGS, TNC, LCCs, etc.
	  o case study sites-application for areas on the ground, learning to do that most efficiently and effectively.
	  o communicates uncertainty
	• There are many projects in Washington that don't go across the border, so this is a gap (adapting these models to go into BC).
	• Forest Restoration Strategy on the OWNF, is a model that looks at ecological subregions and uses climate modeling. The model drives restoration decisions.

CONNECTIVITY BREAKOUT GROUPS:
CLIMATE CHANGE CONTINUED

QUESTIONS **RESPONSES**



Do you need a model of future human land use, or a spatial priority?

What do you need to address this?

- The human impact on connectivity is the biggest deal for land use planning, negotiation, and water use.
- Looking out into the future and development patterns, even though uncertainty increases, we still have some idea of what that will look like with development and knowing that is helpful.
- We know where our animals are and what they are doing now, but we don’t have a lot of information about where they will be going in the future.
- Within connectivity, where are vulnerable spots, and where there are already disruptions, how do we reconnect?
    - Brad McCrae described a model in Washington with barrier analysis. He said you can punch through a highway to see how that affects connectivity to see which activities would give the biggest bang for the buck. They are just now piloting that tool in the Columbia Plateau.
- We need these connectivity models to be connected with models of human population development to see how those conflict zones correlate with wildlife.
- The more certainty we have, the more likely the people will be inclined to act on something. Thinking in smaller time segments when forecasting can be helpful.
- What we can say is that climate change will be limiting human options. We are going to survive, but we will have fewer choices, so can we choose to save certain options that are important to us. People are recognizing that there are tradeoffs.
- We could look at species that might benefit from climate change and make that part of the story, using that to draw people into the conversation and not have everything we tell them be doom and gloom.
- In PNCVP case studies, there can be a bit of variability which creates an issue among the public, they want to “throw the baby out with the bathwater.”
- I need whatever is going to give land managers some level of comfort.
    - In uncertain situations there are some “no regret” actions that can be taken.
    - In areas where futures are clearer, we can take more pointed actions.
- Tribal lands can’t make a decision based on a specific species, so need to address the whole system.
- There is some concern about modeling all species except humans. What is going to happen when it is too hot to live in the southwest? People will migrate north to cooler climates and Increase the population in the northwest.
- A suggestion was made to stop comparing things to historical standards because these may never be achievable (i.e. Salmon runs or herding animals on the plains).

CONNECTIVITY BREAKOUT GROUPS:
CLIMATE CHANGE CONTINUED

QUESTIONS	RESPONSES
How good is the modeling on extreme events? *To what level of certainty do you need this information?*	- Some were not sure about extreme events, but models on downstream effects, snowpack, fire etc. are fairly good. You can use a GCM to get fine resolution about what will happen to fire or snow. - We have papers that consider climate and try to extrapolate what is going to happen in the future. Have these papers been criticized as overreaching? - The biggest stumbling block is uncertainty
What would be helpful?	- It would be nice to have more predictive information. - When do you stop trying to refine the minutia and get on with the negotiation about tradeoffs since you can only get so much protected? When is enough information enough to act rather than further analyze? - We don't want to just be winnowing in on the science, given what is available how to we provide a product that you can take to your decision makers? - A map that says these areas are certain these are uncertain, here are some suggestions for what to do in certain vs. uncertain areas. - Specifically what is the level of comfort in a climate change model or scenario, a model that clearly states its level of comfort versus uncertainty? - Models through the grid of changes in forest cover. Forestry is leading the charge on climate research. - Recovery team for Oregon Spotted Frog in BC identified a lake or pond that would be a good candidate for reintroduction but is just slightly out of range. It points to the need for some modeling. - Dispersal range maps. - Thresholds of risk and uncertainty. - We need more tools in the toolbox - Uncertainty is real and always will be, here is the toolbox and how we use these tools to deal with a future full of uncertainty. - PNWVS is taking into account dynamic vegetation movement

Connectivity Breakout Groups:
Geographic Information Systems (GIS)

QUESTIONS — **RESPONSES**

What data is available?

- Vegetation in BC – data from aerial photography
- Vegetation in U.S. – LANDSAT data, National GAP data
  - Fundamentally different data sets: photo-interpretive in BC, LANDSAT in U.S.
- Vehicle counts – possible problem, finding a good way to find vehicle count data
- Other layers looked at: Dwelling units, Roads, Soils, Hydrography, Elevation, Land status, Generalized land cover
- Okanogan-Wenatchee National Forest – using aerial photos to get very detailed data for watersheds
- There is a lot of disturbance information available in WA (ie. fire perimeter maps, insects).
- In BC - Forestry companies have a ton of information
  - Update their models faster than the government
  - Species modeling
  - Every forest district – quality of the data is different
    - Issue of applying smaller-scale data to a larger scale map
- Issue of First Nations interests on both sides of the border – same difficulty of not having good data sets
- Agricultural layers
  - ALR and private ownership
  - Not high quality
- What may be happening in the future
  - Land cover map being developed in Corvalis, OR – will be all of WA
  - UBC and UVic - climate change work

What are some of the issues we deal with in regard to GIS data?

- Recognize the importance of ecological gradients – <u>eco-regional classification</u> above bio-classification system. This could be a useful layer to add to connectivity issues.
- Data needs to be available for different scales – local, mid, and large
- Topographic complexity layer – coming up with one way to do this is needed but there have been issues doing that because certain features are not modeled correctly
- Human population and land use are the more challenging layers and are very different across the border
- Vegetation maps are usually not useful at all for on the ground work
- There is an access issue for some datasets (ie. "Terrain" – no public access)

How do we fill in the gaps?

- People need to share data, including survey data, but need to know that data is wanted
- There are some regional data sets – smaller geographies
- There is a conservation center based in Victoria that distributes data through generalized buffer points (non-sensitive and sensitive points)
- Roads – in BC aerial photo data is not reliable when talking about use
  - Many roads there, but not necessarily passable, just seeing the roads doesn't convey traffic use, conditions, washouts, etc.
  - Virtual road checking – google earth, looking at dates to determine if roads still exist or not
- Some data sets just need to be updated manually – like land cover
- A vision was shared to create new data rather than digging through older data that uses different scales

What can the LCCs do to help?

- LCCs span the border – seems like it would be a good way to get funding and bring the right people together to get that data
  - Maybe a way to generate support for creating new transboundary data layers
  - Need to determine what data we ask for
  - Need to write a proposal describing missing data

Appendix B. Inventory of Available GIS Datalayers

Table A.1. Available data sources for connectivity analyses of the transboundary region between British Columbia and Washington State.

Vegetation/ Land Cover	**Extent**	**Dataset**	**Format**	**Compilation Source**	**Comments**
Ecosystem Type	British Columbia	VRI	Vector	Aerial photography	data holes
Forest crown cover	British Columbia	VRI	Vector	Aerial photography	data holes, need expert info concerning cc percent
Forest size/structure	British Columbia	VRI	Vector	Aerial photography	data holes, over representation of shrub?
Ecosystem type	British Columbia	BEC ver 8	Vector	Multiple scales	The standard for bio geo climate designations; adjust for precip gradients?
Forest crown cover	Canada	EOSD	Raster	Landsat	CC not continuous
Forest crown cover	USA	GNN	Raster	Landsat	
Forest size/structure	USA	GNN	Raster	Landsat	
Ecosystem Type	USA	Landfire	Raster	Landsat	Gap at international border
Forest crown cover	USA	Landfire	Raster	Landsat	Gap at international border/CC over est?
Forest size/structure	USA	Landfire	Raster	Landsat	Gap at international border
Forest crown cover	USA	NLCD	Raster	Landsat	
Ecosystem Type	USA	ReGap	Raster	Landsat	
General Landcover	USA	NLCD	Raster	Remote sensing	
General Landcover	British Columbia	Baseline Thematic Mapping	Vector	Multiple sources	really old
Wetlands	British Columbia	Freshwater Atlas	Vector	Aerial photo/other	Riparian?
Wetlands	USA	NWI	Vector	Aerial photo/other	Inconsistent mapping
Infrastructure	**Extent**	**Dataset**	**Format**	**Compilation Source**	**Comments**
Roads	British Columbia	Digital Road Atlas	Vector	Aerial photo/other	High quality/large scale
Roads	USA	TIGER/Line 2010	Vector	Aerial photo/other	Variable completeness and geometry
Roads	Washingto n, Idaho	Fed DOT Functional Road labels	Vector	Aerial photo/other	
Transmission lines	British Columbia				
Transmission lines	USA				May not be public data
Soils	**Extent**	**Dataset**	**Format**	**Compilation Source**	**Comments**
Soil units	British Columbia?		Vector and hard copy	Aerial photo/other	Large scale / relatively high resolution
Soil units	USA	STATSOG/SSUR GO	Raster	Aerial photo/other	WHCWG Columbia Plateau

table continued on next page

Human Population	**Extent**	**Dataset**	**Format**	**Compilation Source**	**Comments**
Dwelling Units	USA	Acres/DU	Raster	Various model sources	Theobald data
Dwelling Units	Canada	Dwelling counts	Vector/Raster	Various model sources	Statistics Canada; areal processing required
Private Ownership	British Columbia	parcels	Vector	Aerial photo/other	Large scale/high resolution
Other Data	**Extent**	**Dataset**	**Format**	**Compilation Source**	**Comments**
Land status	British Columbia	Tree Farm License Area	Vector	Aerial photo/other source	