Chapter 5. Lessons Learned From the Analysis Process

We learned a great deal during this project about connectivity assessments and working with diverse partnerships. Our objective in this chapter is to share these insights and lessons in the hope of increasing the efficiency of future connectivity analyses. We believe this is best accomplished through an unvarnished discussion of what worked for us and which mistakes we encourage others not to repeat.

5.1. Working Group Composition

Large-scale connectivity analyses are complex and require an organized, skilled, and diverse team to complete. One of the underlying objectives that influenced the composition of the WHCWG was to include stakeholders with high capacity to implement connectivity solutions on the ground. The intent was to share ownership in the analyses guiding conservation actions. We anticipated that stakeholders would be more likely to implement aspects of the analyses if they had been involved in their development.

A consequence of this objective was the formation of a group with diverse backgrounds representing a wide variety of organizations. This diversity both strengthened and limited team productivity. We realized many benefits of diversity in terms of dynamic exchange of ideas and sufficient depth in the team to allow simultaneous progress on multiple fronts. We were also extremely fortunate to have generous support from state agency leads and to compete successfully for external grant funding. However, a significant limitation imposed by our diverse composition was that all team members were typically squeezing connectivity analyses into already overcrowded schedules, particularly as our organizations endured budget cuts and downsizing.

The lessons we want to share about team composition are that it’s important to recognize constraints on productivity, set objectives, expectations, and schedules accordingly, and realize that substantial encouragement, persuasion, and patience will be required to get the analyses done. At this point, we believe implementation benefits associated with shared ownership of the analyses will more than compensate for the associated slower pace of progress that occurs in large collaborative efforts.

Lastly, we found it useful to engage university faculty as well as students in our analyses. Doing so allowed our project to benefit from cutting-edge work in modeling and climate change research. These are efforts that will ultimately lead to new applications we otherwise would not have had time to explore. We believe there may be broader opportunities to engage students in ways that enhance efficiency and allow us to tap novel approaches, ideas, and current research in fields that support or can be adapted to wildlife conservation and connectivity.

5.2. Working Group Structure

The working group structure we developed served us well. We established subgroups to manage spatial data, select focal species and lead focal species analyses, develop a communications strategy, conduct a landscape integrity analysis, develop and automate modeling, and incorporate climate change into our connectivity analyses. We found that this array of subgroups enabled us to specialize sufficiently to make focused progress on the variety of topics relevant to meeting our objectives. A core team assisted with maintaining communication, integration and cohesion among the sub-groups. Individuals often participated in more than one subgroup which further helped communication and cohesion. As well, the working group co-leads interacted with all subgroups to support and funnel information to specific subgroups as needed.

5.3. Accomplishing the Analyses

Planning our work and keeping it on schedule proved to be a constant challenge. The nature of connectivity analyses is rapidly evolving and subject to constantly changing ideas and newly realized constraints. We attempted to address this issue by writing a detailed study plan and having this plan peer reviewed by experts in wildlife habitat connectivity. We recommend study plan development as a reliable way to save time. But we add the cautionary note that we found it impossible to anticipate many of the idiosyncratic difficulties and unintended consequences associated with decisions we made about our analyses. The most efficient way to troubleshoot our analysis sequence and overall process was to conduct pilot analyses using a small subset of focal species before initiating the full analysis.

Still, while pilot analyses and other time- and labor-saving strategies are helpful, meeting firm deadlines presumes everything is proceeding according to schedule, and this is not often the case. When our best-laid plans proved to be inadequate and needed revision, we sometimes struggled to redirect multiple team members working in parallel on similar tasks. We learned that well-organized decision processes, clearly articulated written guidance, and redundant communication are essential for enabling all team members to respond to inevitable changes in direction.

We cannot overstate the importance of clear guidance and explicit definition of key terms as a constructive means for avoiding “do-overs,” and for minimizing inconsistencies among team members due to differences in interpretation. From our experience, the sooner an explicit and detailed understanding of key terms and concepts can be achieved, the better. For example, our connectivity analyses are typical in their heavy reliance on expert opinion. In the context of attempting to address the “subjective translation” problem (Beier et al. 2008), we tried to reach a shared understanding of what “resistance” means among multiple focal-species leads. We attempted to use landscape genetic information from a study of mountain goats as a reference and to help “calibrate” resistance estimates across focal species. This proved challenging, until the author of the mountain goat study (and a member of the WHCWG) presented to the focal-species leads clear conceptual and practical guidance about how to translate resource selection information into resistance values. A similar scenario played out regarding delineation of habitat concentration areas.

5.4. Communications

We benefited greatly by using a broad array of internal communication tools to help coordinate our efforts. In particular, a shared internal website for posting documents allowed team members to track new developments and provided a clearinghouse for interim products needing review. This tool, in combination with traditional conference calls and meetings worked well to maintain effective internal communication. The ability to rapidly share GIS data and analysis results via FTP and web services proved valuable in the iterative collaboration between analysts and focal-species leads. Sharing PDF versions of GIS analyses and using Adobe Acrobat to activate layers facilitated collaboration between analysts and leads with limited GIS expertise.

5.5. Making Choices

Throughout all stages of modeling as well as map cartography, we encountered a multitude of challenges and choices. For example, should resistance values for cost-weighted distance analyses be calculated by combining factors using arithmetic, multiplicative, or geometric means? How should different factors be weighted when they are combined? We reviewed literature (e.g., Beier et al. 2008; Singleton et al. 2002), and work from other states (e.g., California, http://www.dfg.ca.gov/habcon/connectivity/) and at each step made choices we felt best incorporated species needs while being simple, transparent, and easily understood.

For instance, our linkage maps are products built in five steps: (1) GIS data layers, (2) focal species selection and model development or landscape integrity model development, (3) resistance surface development, (4) identification of habitat concentration areas or landscape integrity core areas, and (5) linkage modeling. Each step had associated choices and potential pitfalls. In addition, cartographic presentation had its own set of unique challenges.

Working collaboratively and in partnerships was of immense importance for sorting through a series of issues needing consideration. Based on these experiences we do not expect our products to remain static but instead anticipate that they will evolve to incorporate new methods, data, and planning needs.

5.5.1. GIS Data Layers

The connectivity models use GIS data layers which are the "building blocks" of the analyses. Substantial GIS staff time was devoted to developing the base layers for the project primarily because we did not anticipate the mapping inconsistencies we encountered in the U.S. vegetation layers. In particular, LANDFIRE crown-cover overestimation and data gaps along the international border were a problem. We hope these mapping issues will be mitigated in future LANDFIRE data releases.

We expected difficulties in melding the Canadian and U.S. vegetation layers. But we did not anticipate the substantial effort required to integrate the Vegetation Resource Inventory (VRI) and Baseline Thematic Mapping layers into a single base for use with the British Columbia Biogeoclimate layer. Making data development even more difficult were the large data gaps in the VRI; these areas are under tree farm license and owners are not required to publically report forest attributes. Some of the tree farm license blocks are within 50 km of the international border and are important for connectivity between Washington and Canada. Once we had the Canadian and USA 11-class map layers prepared, it required several days of effort to blend the Canadian map with wet forest, dry forest, and shrub in the U.S. portion. Overall, we found extra time must be allowed for cross-border vegetation compilation, which is especially challenging due to differences in compilation data sources, standards, and mapping purposes between the countries.

As well, data may be collected at different scales, times, and for different purposes. Care must be taken when using and/or combining such data to ensure conclusions drawn from the map results are valid. For example, we found the National Wetland Inventory maps for Washington, Oregon, and Idaho to be highly inconsistent in the application of mapping densities. Their use would likely have produced erroneous results for at least one of our focal species, the western toad.

Road networks were also challenging to represent across multiple jurisdictions. Classification systems varied and fully developed data layers for local roads, particularly forest roads associated with logging, didn't exist for some areas. Consequently, our local road category included very busy county roads connecting sizeable cities as well as narrow forest roads accessible only for administrative purposes. Although we recognized the potential value of partitioning the local road data layer into more meaningful categories, we lacked the resources to do so.

Many decisions to keep data layers "simple" were necessary to accommodate the broad extent of this statewide analysis. Nonetheless, as the project proceeded we identified compelling reasons to try to adjust or add to our base layers: as there were GIS layers that, based on hindsight and/or better availability, would have benefitted our analyses. However, such additions can be very time consuming, and expended efforts may not be fruitful. For example, given the number and scale of wind farm developments in Washington, and the extensive number of transmission line corridors, these layers could have significant impacts on HCAs and linkages of several focal species. Yet, when we examined the possibility of including these spatial data we found cohesive quality layers for our study area did not exist. The extensive work to research and piece together these layers was outside our capacity. Additionally, we did not differentiate Conservation Reserve Program (CRP) lands from agricultural lands and therefore lost resolution for this key habitat category within the Columbia Plateau where there is considerable agricultural development. One of our objectives is to address these important lands, as well as energy development and transmission layers, in our upcoming ecoregional analyses.

5.5.2. Species Choices, Resistance Surfaces and Parameters

Criticisms can be leveled against many of the focal species we selected. Some might believe that widely distributed and relatively common focal species such as mule deer and black bears provide limited insight into connectivity conservation needs relative to the effort required to complete linkage modeling. Other focal species, like badgers, may be attracted to elements of infrastructure such as highway and railway embankments that fragment habitat for many non-focal species. The current distributions of some focal species, for instance the western gray squirrel, are so disjunct and isolated that connecting existing populations may be unrealistic.

We accept that all focal species have flaws; however, we found that walking critics through our selection process mitigated concerns, and we recommend not letting such criticisms overwhelm the value of focal species analyses. The strength of the focal species approach derives from thoughtful consideration of what each focal species contributes to our understanding of connectivity at a particular scale of analysis. It is also proportional to the number of focal species analyzed. Including as many focal species as resources allow will increase chances of adequately representing biodiversity.

The amount and quality of information relevant to our modeling varied greatly among focal species. For the mountain goat, we had detailed survey information about current distribution, as well as landscape genetic information that could be used to calibrate resistance of different landscape features that subdivided the population in our analysis area. But for most species, we had a patchwork of information about habitat associations, resource selection, current distribution, and movement patterns. Based on recommendations and advice from previous connectivity modeling projects, we tried to fill in the information gaps for focal species using expert opinion. We used a workshop approach to gather species experts, educate them about our overall approach, and gain their expertise regarding information we needed about focal species to parameterize resistance surfaces and delineate HCAs. This approach worked well, and set the stage for ongoing collaboration between focal species leads and species experts throughout the remaining connectivity analysis process.

Recognizing that model parameterization using expert opinion carries a high level of uncertainty, our intention was to conduct sensitivity analyses to investigate the effects of varying parameter values based on expert opinion. We conducted informal sensitivity analyses for many species as we received expert opinion and sought best solutions to improve model outputs. However, we have not formally conducted these species sensitivity analyses and acknowledge this is an uncompleted element of our work. We continue to pursue approaches for combining focal species analyses, and this objective certainly warrants future work.

5.5.3. Habitat Concentration Areas (HCAs) and Landscape Integrity Core Areas

In delineating habitat concentration areas and landscape integrity core areas, our goal was to identify those areas of substantial size and quality to be included as targets for linkage modeling. For some species we used habitat polygons previously identified in recovery plans (e.g., Greater Sage-Grouse) or management plans (e.g., bighorn sheep). For most species, however, we used habitat modeling to identify HCAs.

There are numerous factors to be considered regarding HCAs. Combining habitat concentration area minimum size with maximum linkage values could mean losing sight of stepping stone habitats which can serve as bridges between more distant habitats. For some species the convoluted shapes of HCAs—in tandem with linkage modeling rules we used that allow one linkage per HCA pair—will identify the shortest, highest quality linkages, but could miss other important linkages. In addition, we did not include all known population locations of focal species in HCAs. For example, the American badger occurs in an area southeast of the Potholes Reservoir that was not included in our modeled HCAs. We could have adjusted the minimum HCA size parameter in our badger model to allow inclusion of this location; however, adjusting the minimum HCA size for this species would have flooded the landscape with additional HCAs, losing definition useful for identifying linkages. Another alternative was to manually include the HCA as a known important area. In the end we were reluctant to add an HCA outside of our standard protocols, and chose instead to note this discrepancy in the focal species appendix.

5.5.4. Linkages

One of the challenging aspects of the linkage modeling was determining the appropriate modeling approach for the statewide extent. We chose to use cost-weighted distance linkage modeling, and to relegate other options—such as the use of Circuitscape (McRae et al. 2008)—to ecoregional modeling, local-scale modeling, or products that might eventually be developed to provide greater detail for the statewide analysis in the future. Nonetheless, the very large numbers of linkages that would need to be run for our analyses began to loom as a daunting challenge. To address this challenge, we developed a linkage mapping tool (Appendix D). While this was an enormous and time consuming endeavor, this work ultimately made us more efficient. We believe it provides an advance for our future modeling efforts as well as for those that may be undertaken by others.

5.6. Transboundary Collaboration

Challenges with travel, budgets, and the time it takes to build working relationships all come into play when collaborating across state and federal boundaries. However, wildlife habitat connectivity analysis and effective implementation necessitates considering important issues beyond administrative borders. In this analysis, our relationships with the adjacent states of Idaho and Oregon and the province of British Columbia were particularly important. Early on, we identified the need for incorporating bordering jurisdiction datasets and obtaining their review of our model results.

To address this need, we engaged in data sharing and review discussions with wildlife experts through conference calls, and conferences (e.g., Wildlinks 2009). We also hosted a transboundary summit to increase partnering across borders (April 2010). Finally, the Western Governors' Association Wildlife Corridors Initiative and the USFWS Landscape Conservation Cooperatives continue to provide important frameworks for broad, transboundary collaboration.