Identifying Core Habitat and Connectivity for Focal Species in the Interior Cedar-Hemlock Forest of North America to Complete a Conservation Area Design

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Abstract--*To identify the remaining areas of the Interior Cedar-Hemlock Forest of North America and prioritize them for conservation planning, the Craighead Environmental Research Institute has developed a 2-scale method for mapping critical habitat utilizing 1) a broad-scale model to identify important regional locations as the basis for a Conservation Area Design (CAD), and 2) fine-scale models for analyzing habitat quality and connectivity at site-specific locations targeted by the broad-scale analysis. The basic assumption is that if we can maintain healthy populations of focal species, we can protect biodiversity and healthy ecosystems. A habitat modeling approach was used that can be adapted to any landscape in the U.S. and Canada for almost any wildlife species.*

The initial phase of this project was a CAD for the Canadian portion of the Interior Cedar-Hemlock Forest that utilized existing conservation plan data combined with original analyses to address the conservation needs of: 1) Focal terrestrial 'umbrella' species and the prey and habitats they depend upon; 2) Focal aquatic 'umbrella' species and aquatic species at risk; and 3) Biodiversity as captured by representation and special element analysis.

A broad-scale regional-level modeling approach for the Interior Cedar-Hemlock Forest of British Columbia (BC) was completed that identified 47.5 percent of the region to be prioritized for a high degree of protection in order to ensure the persistence of our focal terrestrial and aquatic species for several hundred years. An optimization of these core areas is underway that may reduce the overall area needing protection and still meet thresholds for each species. In 2005, a similar process was begun for the U.S.; in 2006 a seamless, transboundary CAD will be completed. To date, the CAD has formed the basis for an effective environmental coalition and issue campaign in BC.

INTRODUCTION

A Conservation Area Design (CAD) is a science-based architecture for identifying and prioritizing areas for sustainable conservation. Much current conservation planning includes the generally accepted elements of representation, special elements, and focal species analysis (Noss and others 1997, 2001). However, most current CADs do not adequately identify core areas sufficient for long-term viability of focal species or networks of habitat for movement.

Forest carnivores and other wide-ranging species such as grizzly bear (*Ursus arctos*), wolf (*Canis lupus*), wolverine (*Gulo gulo*), lynx (*Lynx canadensis*), cougar (*Felis concolor*), and woodland or mountain caribou (*Rangifer tarandus caribou*) all need large landscapes to maintain viable populations. Other wildlife species need less space overall, but they need to move across the landscape as well to survive and reproduce. A major problem facing conservation efforts is to accurately identify critical habitat, and to maintain or restore it, in order to ensure that wildlife populations can persist as human activities and developments continue to destroy and fragment natural habitat. Most current conservation planning efforts do not prioritize sufficient habitat necessary to maintain viable populations and metapopulations, and they do not address or identify adequate habitat for wildlife movement; or connectivity. Once completed, conservation plans are seldom validated.

Using appropriate techniques, computer habitat suitability model results can be an effective first step to identify core and connectivity habitats in order to direct land development, highway construction, and mitigation so that wildlife are protected as they move across the landscape to meet their daily, seasonal, and lifetime needs.

STUDY AREA

The overall study area extends roughly from Prince George in British Columbia, Canada, to the Clearwater River in northern Idaho, United States (fig.1). In general it encompasses the lowlands comprised of interior cedar-hemlock forest as described by the Province of British Columbia Ministry of Forests (DeMarchi 1996). At higher elevations this area is comprised primarily of Engelmann spruce-subalpine fir forest and alpine tundra. The boundaries of this area include pockets of sub-boreal spruce forest, ponderosa pine forest, and montane spruce. For this initial project we restricted the analysis to the Canadian portion of this region. In order to incorporate The Nature Conservancy (TNC) Canadian Rocky Mountains (CRM) Ecoregional Plan, we restricted this analysis to that portion of Interior Cedar-Hemlock Forest region that is within the CRM boundary because equivalent datasets were not available for areas outside that analysis area. We also expanded the boundary slightly to the west for this analysis to include the known range of the woodland (or mountain) caribou.

Figure 1. The Interior Cedar-Hemlock Forest Study Area.

METHODS

The methodology for the CAD includes three areas of focus following current scientific consensus: focal species analysis, representation analysis, and special elements analysis (Noss and others 1997, 2001). We paid particular attention to focal species analysis by developing computer-based habitat suitability models of core habitat areas for sustainable populations of grizzly bear, wolf, wolverine, lynx, cougar, and woodland caribou. We chose this suite of terrestrial focal species because we felt they met most of the desired criteria and there were adequate data and scientific understanding to develop habitat suitability models (Carroll and others 2001, 2003; Lambeck 1997; Roberge and Angelstam 2004). Landscape and habitat suitability characteristics were evaluated for the interior cedar-hemlock forest region in terms of Land Cover Class, Human Population Density, Road Density, Slope and Elevation for each species. Relative suitability rankings were assigned to classes in each of these five landscape characteristic categories for each of the six focal species (table 1). Results were mapped at 1 km^2 resolution based upon the BC Broad Ecosystem Classification (BEC) data. Results identify habitat concentration areas (cores) for each of the six focal species that were then merged into composite areas that could satisfy needs for several species. Relative habitat values for 'core' habitat were subjectively chosen using expert opinion and thus threshold values vary between species. We then used the least-cost-path connectivity methodology of Singleton and Lemkuhl (1999, 2000) and Singleton and others (2002, 2003) to identify probable movement corridors between core areas. We modified Singleton's 'cost surface' approach to reflect local habitat preferences. We thus prioritized core protected areas and zones of interconnection that should be sustainably managed: critical ecological foundations that have been inadequately addressed in previous planning efforts. We then incorporated other existing conservation plan results to develop a comprehensive plan encompassing both Canadian and U.S. regions.

To address aquatic focal species we utilized available BC government data on salmon (*Salmo spp*.) escapement and distribution. Native salmon species found in the study area are Coho (*Onchorhynchus kisutch*), Chinook (*Onchorhynchus tshawytscha*), Steelhead (*Onchorhynchus mykiss*), Sockeye (*Onchorhynchus nerka*), and Pink Salmon (*Onchorhynchus gorbuscha*). A quantitative measure was created based on salmon escapement figures using an index algorithm developed by Round River Conservation Studies (RR) and a Shannon Diversity Index. The RR index algorithm (Sanjayan and others 2000) provides a normalized mean abundance (calculated by mean abundance for each stock) by stock which accounts for both the abundance of salmon and individual stocks while the diversity index gives a relative value of variability within each system. The final value applied to the subwatersheds was a result of adding the RR normalized mean abundance score (as values from 1 to 10) with the diversity values (as values from 1 to 10). To rank subwatershed salmon values, drainages containing fish species-at-risk were obtained from Dr. David Mayhood and the Yellowstone-to-Yukon Science Program and were added to the priority salmon drainages to complete the aquatic focal species analysis.

To address representation analysis and special elements for the Canadian Inland Temperate Rainforest (ITR), we adapted the TNC/NCC representation analysis (coarse filter) which resulted from the Canadian Rockies Ecoregional (CRM) Assessment (Rumsey and others 2003). Results of the composite focal species core and connectivity analyses plus the salmon priority watersheds identified by the aquatic analysis were overlain with the TNC Tier 1 and Tier 2 summed solution for the Canadian Rockies Ecoregional plan to produce an initial prioritization of conservation areas.

To evaluate our results we are continuing to compare them with other modeling approaches, conduct rigorous statistical and optimization analyses, and validate them on-the-ground through workshops and field surveys.

RESULTS

Core areas and connectivity for each terrestrial focal species are shown individually in figures 2 to 7.

Figure 2. Grizzly Bear Core Habitat and Connectivity Areas.

Figure 3. Wolverine Core Habitat and Connectivity Areas.

Figure 4. Lynx Core Habitat and Connectivity Areas.

Figure 5. Cougar Core Habitat and Connectivity Areas.

Figure 6. Wolf Core Habitat and Connectivity Areas.

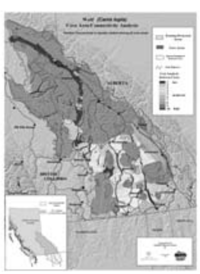
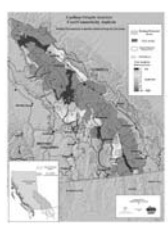


Figure 7. Woodland Caribou Core Habitat and Connectivity Areas.

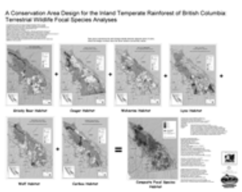


Overlapping of core areas resulted in composite core areas as shown in figure 8.

Figure 8. Composite Terrestrial Focal Species Core Habitat and Connectivity Areas.

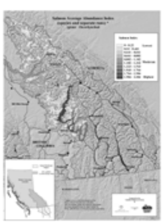
The overall process is summarized in figure 9.

Figure 9. The Conservation Area Design Terrestrial Focal Species Process and Components.



Salmon priority watersheds were mapped as illustrated in figure 10.

Figure 10. Salmon Average Abundance Index: aquatic focal species priority areas.

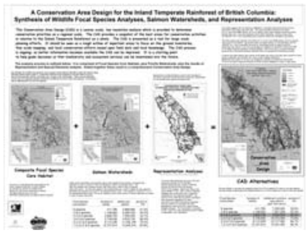


Finally, the TNC Tier 1 and Tier 2 results, which include representation analysis and special elements, were added to the final CAD, illustrated in figure 11.

Figure 11. The Conservation Area Design: priority terrestrial and aquatic habitat.

The complete CAD process is summarized in figure 12.

Figure 12. The Overall Conservation Area Design Process and Components.



The total area that we feel needs protection is thus derived from three analyses that overlap to some degree:

1. Core habitat for terrestrial focal species (grizzly, wolf, wolverine, cougar, lynx, and caribou). Identified priority areas for 4+ species take up 2,699,759 ha (6,671,250 acres), or 19 percent of the BC ITR area.
2. Aquatic priority areas (salmon priority areas and drainages supporting fish at risk). Priority areas for aquatic species require 33 percent of the BC ITR area.
3. The Tier 1 and 2 results from the TNC/NCC Canadian Rocky Mountains Ecoregional Plan.

Each of these priority areas may overlap other priority areas. Adding the 4+ species cores, TNC Tier 1 & 2 areas, and salmon and aquatic species at risk areas, results in a total of 7,873,543 ha (19,455,949 acres) or 55 percent of the ITR which should be 'protected'. Of this, about 1,070,650 ha (2,645,634 acres) (7.5 percent of the ITR area) is already under Protected Area status leaving 47.5 percent, which needs to be protected to ensure maintenance of biodiversity, focal species, and species at risk.

To address the question of 'protection' we would suggest an Ecosystem Based Management approach as outlined by the BC Coast Information Team (Cardinall and others 2004; Rumsey and others 2003). This is an approach for timber harvest, mining, and other development that identifies and maintains the best wildlife habitat in those areas on a watershed scale. This process designated areas by "risk thresholds" to define the amount of development or habitat alteration acceptable. Areas with no acceptable conservation risk (areas of high irreplaceability or conservation value) are given high priority for complete protection. Areas where some risk is acceptable were assessed at a finer scale of analysis and planning processes designated some areas for development and some areas for protection within those planning units. Using a similar approach with the ITR CAD, we would suggest the darker gray (purple) core areas on the final map (the areas with more focal species present) are "high risk" areas and should be given the highest protection. All old growth forest should be highly protected, and roads that are constructed should be removed quickly.

Connectivity, or movement habitat, the light gray (green) 'corridor' areas on the final map (fig. 10), should have habitat that is 'friendly' enough for animals to travel through from one core area to another, but individuals don't necessarily need to be resident and/or reproduce in those areas. In both the connectivity and medium risk areas, roads should be restricted as much as possible. The connectivity areas represent 2,884,900 ha (7,128,743 acres) or 20 percent of the ITR. In some places these connectivity areas overlap Tier 1 and 2 results and/or aquatic priority drainages. Some movement routes without man-made barriers should be maintained by management actions and/or habitat protection somewhere in those corridors. The lighter gray (purple) core areas (habitat for three or less focal species) could be considered "medium risk" areas where ecologically sensitive development can be allowed.

We feel that this combination of results adequately addresses, respectively, the conservation needs of: 1) Focal terrestrial 'umbrella' species and the prey and habitats they depend upon; 2) Focal aquatic 'umbrella' species and aquatic species at risk; 3) Biodiversity as captured by representation analysis.

In summary, the CAD is just a broad blueprint. Concerned residents and managers need to look closely at local areas, see what species or other conservation targets exist there, and try to guide development accordingly. Similar mapping projects at a finer scale can help make those decisions, but much of the analysis needs to be done on-the-ground in the real landscape. The broad-scale CAD type of analysis should help to put local conservation values in perspective and add support for local efforts by showing that a given area is part of an important core or corridor. Additional information concerning this project and future iterations can be found on the Craighead Environmental Research Institute website at www.craigheadresearch.org. The results of this CAD should constitute a defensible scientific basis for implementation of conservation planning and for campaigns to facilitate such implementation.

DISCUSSION

The initial results of the CAD process are broad-scale maps and generalized conservation guidelines over large areas. Our results identified habitat concentration areas (cores) for each species that were then merged into composites of these areas that could satisfy needs for several terrestrial species. Next, we modeled priority habitat for aquatic focal species: salmon and threatened fish species. We supported these results with local knowledge and empirical data.

The subsequent products of the CAD process will be fine-scale maps and site-specific conservation plans. The fine scale is most effective for a 'bottom-up' approach where local residents and groups use the data to guide on-the-ground efforts to secure conservation easements, purchase land, provide input into land management planning processes and otherwise work to ensure that conservation priorities are met. The results, over a wide landscape, are solutions for pieces of the larger puzzle that are important to people at a local level.

The overall objective is to serve four well-accepted goals of conservation: 1) represent ecosystems across their natural range of variation; 2) maintain viable populations of native species; 3) sustain ecological and evolutionary processes within an acceptable range of variability; and 4) build a conservation network that is resilient to environmental change. We feel that this CAD meets those goals, and in particular provides adequate guidelines to maintain viable populations of native species. We feel that this approach meets the needs of focal species better than previous conservation plans which we have built upon. In so doing, this CAD should also adequately meet the other three goals of conservation.

To ensure viable populations of focal species, at a minimum, we feel that the areas with habitat for four or more focal species should be protected as parks (or the equivalent of 'designated wilderness areas' in the U.S.). The same level of protection should be given to priority aquatic habitat (priority salmon streams and species at risk) and the TNC Tier 1 & 2 areas.

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