Priority areas for grizzly bear conservation in western North America: an analysis of habitat and population viability.

Carroll, C. 2005. Klamath Center for Conservation Research, Orleans, CA. Revised February 2014.

INTRODUCTION

This report summarizes results from an analysis of grizzly bear habitat and viability within western Canada and the United States by Carroll et al. (2003, 2004). Further details on the models used are presented in Carroll et al. (2001, 2003, 2004). The purpose of the current report, in contrast to earlier publications presenting results for individual regions (Carroll et al. 2001, 2003, 2004), is to provide documentation for modeling results encompassing the entire analysis region in the western United States and Canada.

METHODS

Static habitat model

Carroll (2001, 2003, 2004) created a conceptual habitat model for the grizzly bear based on published information on species-habitat associations. Specifically, the conceptual model (Carroll et al. 2001) combined surrogates of productivity, as measured by a satellite-imagery derived metric (tasselled-cap greenness (Crist and Cicone 1984)), and human-associated mortality risk, as measured by road density and human population (Merrill et al. 1999). Because the analysis covered a very large and ecologically diverse region, the GIS models for fecundity and survival for grizzly bear used very general habitat data that is available in every province and state. This is a lesser problem for the survival input layer, because roads and human population have a similar negative effect on large carnivore survival in diverse habitats. Estimating large carnivore fecundity (reproductive rates) across such a large region is more difficult. Although they cannot utilize the more detailed habitat data available at the local scale, broad-scale analyses such as this one that encompass all components of the regional metapopulation provide important insights as to the underlying drivers of species vulnerability that can make conservation policy more effective.

Analysis using the spatially-explicit population model PATCH

After developing the static habitat suitability models, the authors performed population viability analyses using the program PATCH (Schumaker 1998). PATCH is a spatially-explicit population model that links the survival and fecundity of individual animals to GIS data on mortality risk and habitat productivity measured at the location of the individual territory. The model tracks the demographics of the population through time as individuals are born, disperse, reproduce, and die, predicting population size, time to extinction, and migration and recolonization rates.

Adult organisms are classified as either territorial or floaters. The movement of territorial individuals is governed by a site fidelity parameter, but floaters must always search for available breeding sites. Source-sink behavior is tracked during a PATCH simulation as the difference between a hexagon's emigration and immigration rates. Movement decisions use a directed random walk that combines varying proportions of randomness, correlation (tendency to continue in the direction of the last step), and attraction to higher quality habitat. However, there is no knowledge of habitat quality beyond the immediately adjacent territories (Schumaker 1998).

PATCH allows modeling of environmental stochasticity, but does not consider genetics. We used PATCH simulations to evaluate long-term persistence probability, i.e., the capacity for an area to support a carnivore species over 200 years, rather than transient dynamics such as time to extinction. Separate static models for fecundity (Figure 1) and mortality risk (Figure 2) were derived from the conceptual models for grizzly bear (Carroll et al. 2003). The relative fecundity and survival rates expected in the various habitat classes were estimated based on values reported in similar habitats (Pease and Mattson 1999). Survival and reproductive rates in the form of a population projection matrix were scaled to the rankings of the habitat classes, with poorer habitat translating into lower scores and, thus, higher mortality rates or lower reproductive output.

RESULTS AND DISCUSSION

Habitat and viability modeling results for the western United States (Figure 3 and 4) identify four major areas in the northwestern United States as potentially suitable for grizzly bear persistence given current landscape conditions (Greater Yellowstone Ecosystem, Northern Continental Divide Ecosystem, central Idaho and North Cascades). These results largely agree with previous research. The predicted potential distribution of grizzly bear in the southwestern United States is more speculative given the lack of detailed information on historical distribution and ecology in that region. Prediction of suitable habitat in areas outside known historic range, such as Vancouver Island and potentially the Olympic Range of Washington state, reflects the fact that the PATCH model predicts that current habitat conditions would allow grizzly bears to persist in those areas if they were to reach them.

Habitat and viability modeling results for western Canada and Alaska should be interpreted in a somewhat different context than the results for the western U.S. Many species, including large carnivores, are limited at the northern edges of their range by abiotic conditions (e.g., climate) while southern range is limited by biotic interactions (predation and competition) or human impacts. In this landscape context, the PATCH results are useful to help identify key source habitats and threatened linkage zones that must be conserved to halt the northward retreat of the species' range. Although western Canada holds some of the largest protected areas on the continent, they are largely biased towards low productivity habitats. Therefore, despite their protected status, these areas must experience very low human-caused mortality in order to persist (Garshelis et al. 2005.

The PATCH results suggest a high value and vulnerability for cross-boundary linkages from British Columbia to the U.S. in the north fork of the Flathead river, and south of the B.C. Selkirks and Granby Wilderness and in the transboundary North Cascades. Already vulnerable due to its low proportion of productive habitat and naturally low connectivity across rugged terrain, the central Canadian Rockies may be at risk of becoming a biotic island similar to the Greater Yellowstone Ecosystem, due to loss of its connections to the west, east, and north.

Robust grizzly bear source populations require habitat that is not only productive but also large (intact) and connected. If we believe that similar habitat fragmentation and isolation trends may eventually affect a suite of less-sensitive species, then carnivore source habitat may be a useful umbrella for broader conservation goals.

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FIGURES

Figure 1. Ranking of habitat in terms of grizzly bear fecundity rate, as used in the PATCH model for western Canada and the United States. Fecundity rate was modeled as a function of vegetation and greenness (a satellite-imagery derived metric associated with plant productivity).

Figure 2. Ranking of habitat in terms of grizzly bear survival rate, as used in the PATCH model for western Canada and the United States. Survival rate was modeled as an inverse function of human population and roads.

Figure 3. Potential distribution and demography of grizzly bears as predicted by the PATCH model in western Canada and the United States under current landscape conditions (i.e, potential long-term viability given current habitat conditions). Those areas with a predicted probability of occupancy of less than 25% are shown as "low occupancy". Key potential habitat linkages for grizzly bear are labeled as follows: A) Centennial Mountains; B) Crown of the Continent/Crowsnest Pass; C) Okanagan to North Cascades; D) North Cascades northward to BC Coastal and Interior Ranges (low connectivity due to Fraser Valley); E) Rockies to southern BC Coastal Ranges; F) Wells-Gray area to Chilcotin; G) Jasper northwards to Muskwa-Kechika; and H) Jasper northeastward to Swan Hills.

Figure 4. Potential distribution and demography of grizzly bears in the northwestern United States as predicted by the PATCH model under current landscape conditions (i.e, potential long-term viability given current habitat conditions).

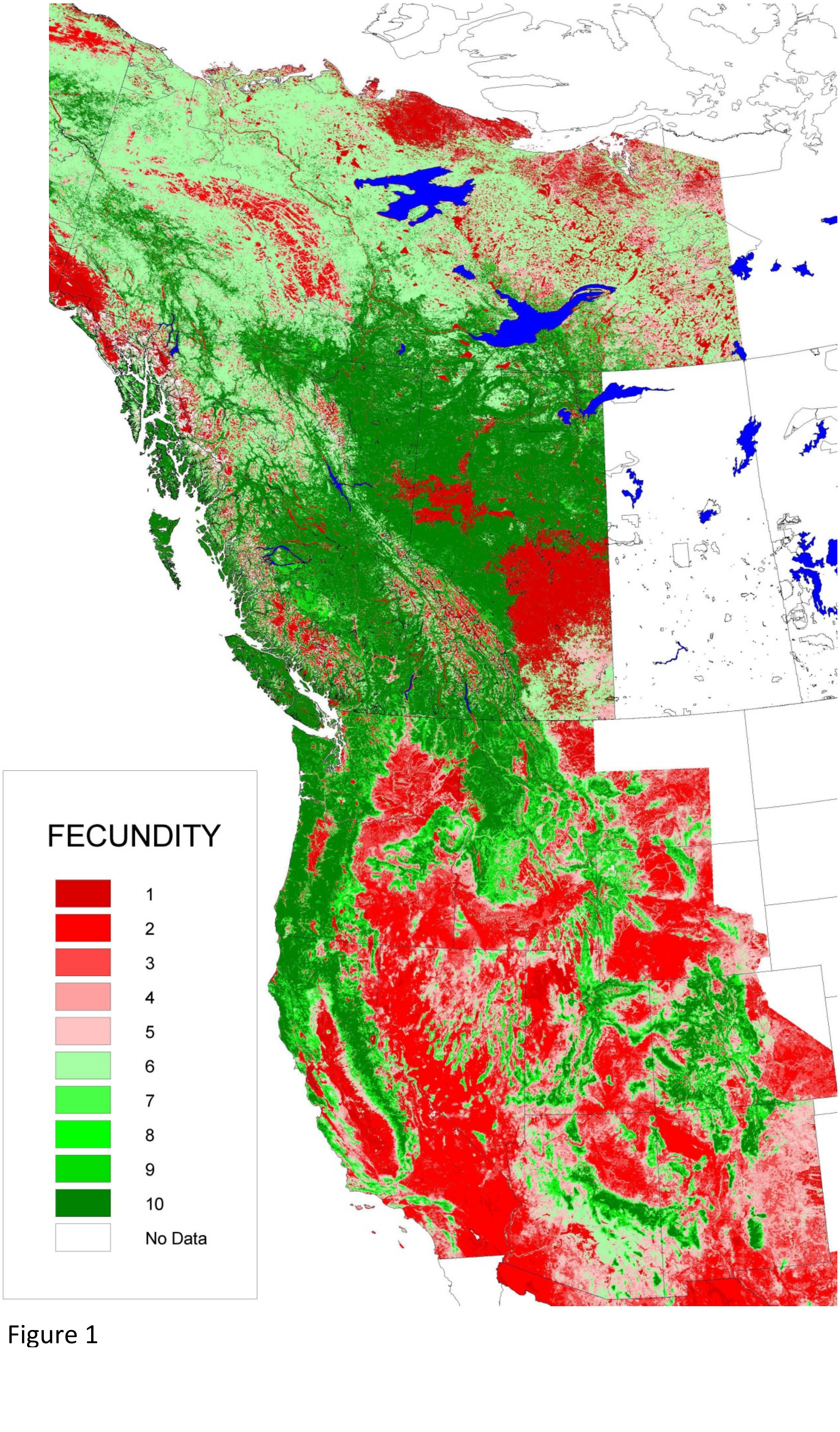


Figure 1

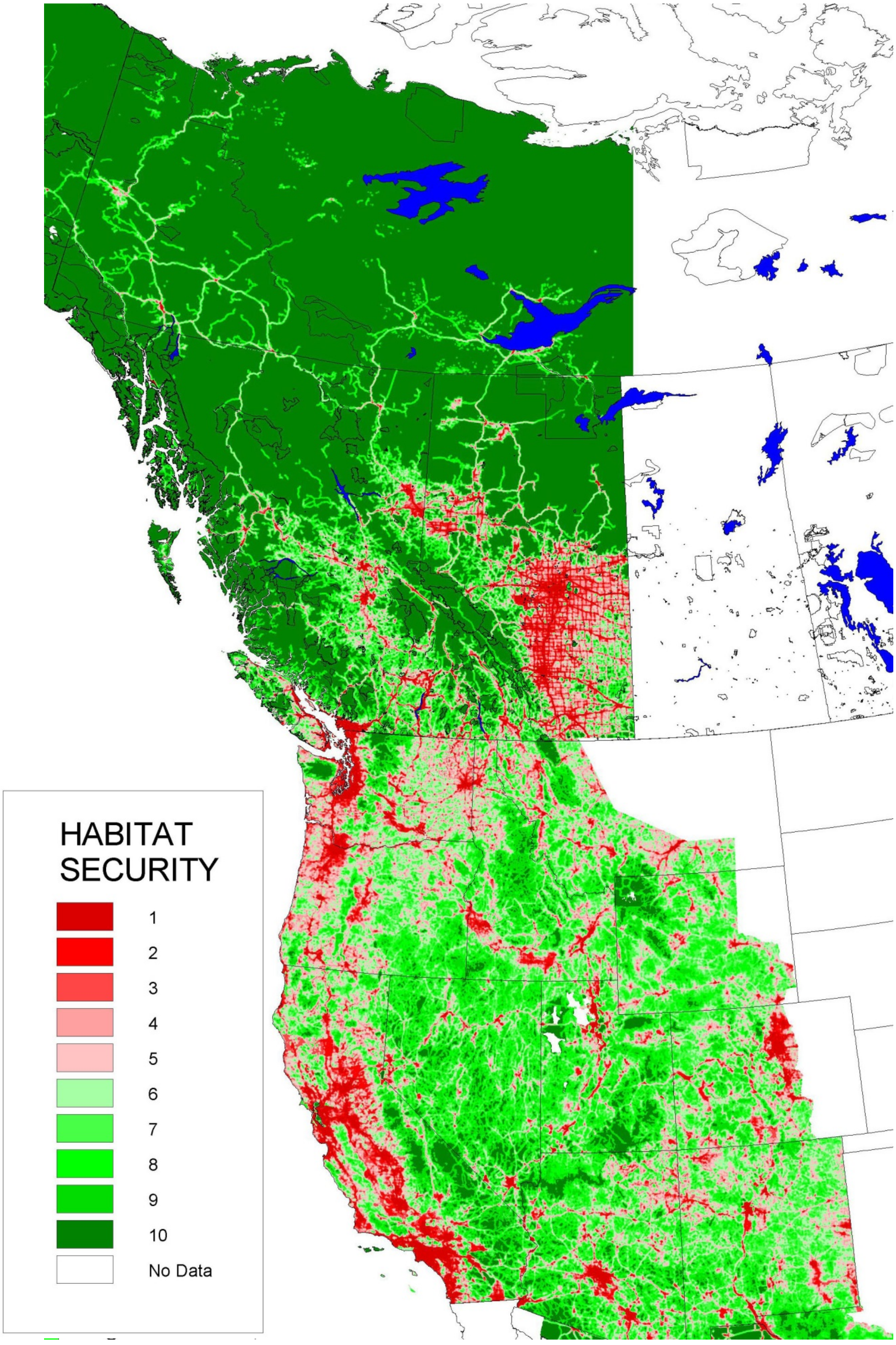
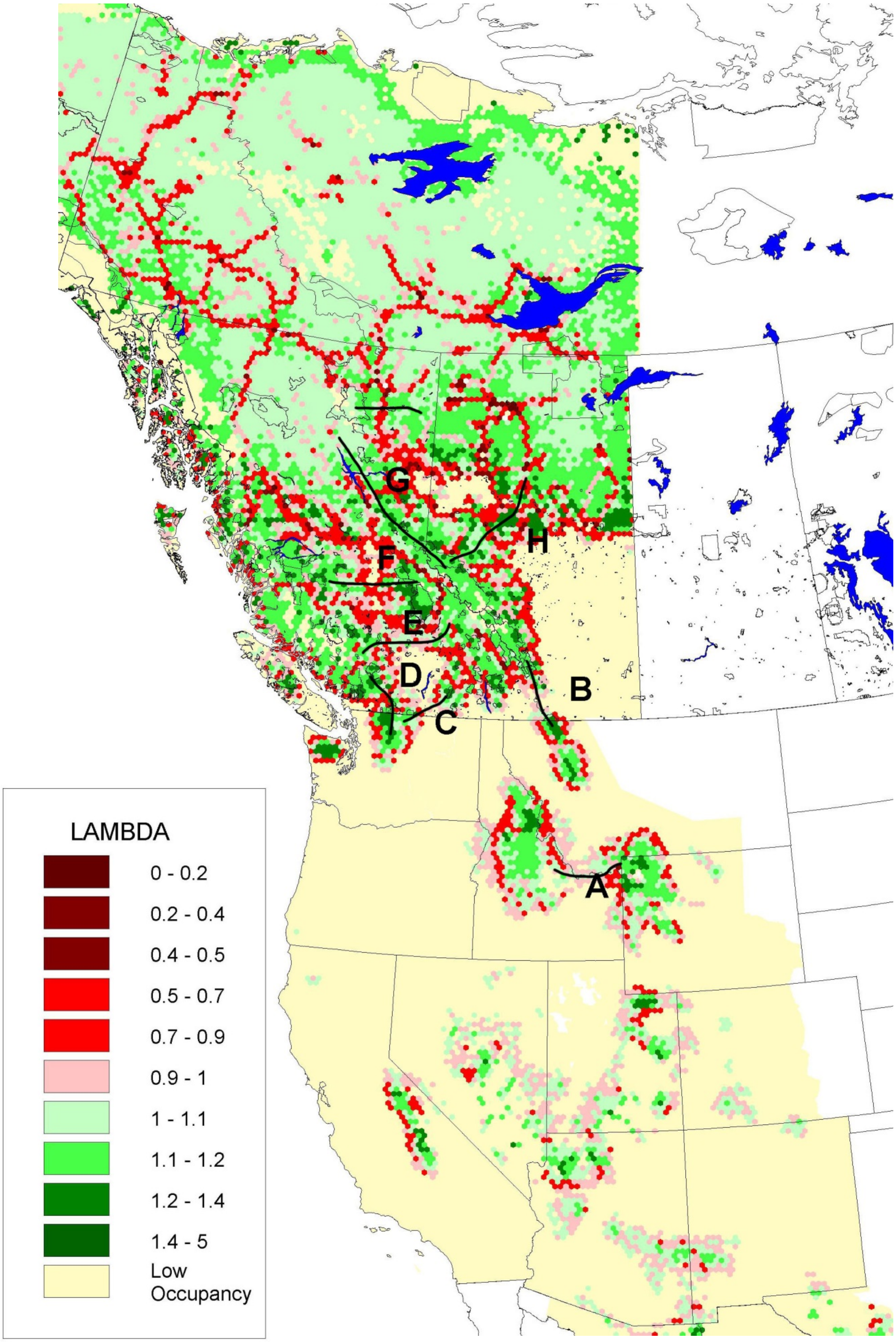


Figure 2



G
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D
C
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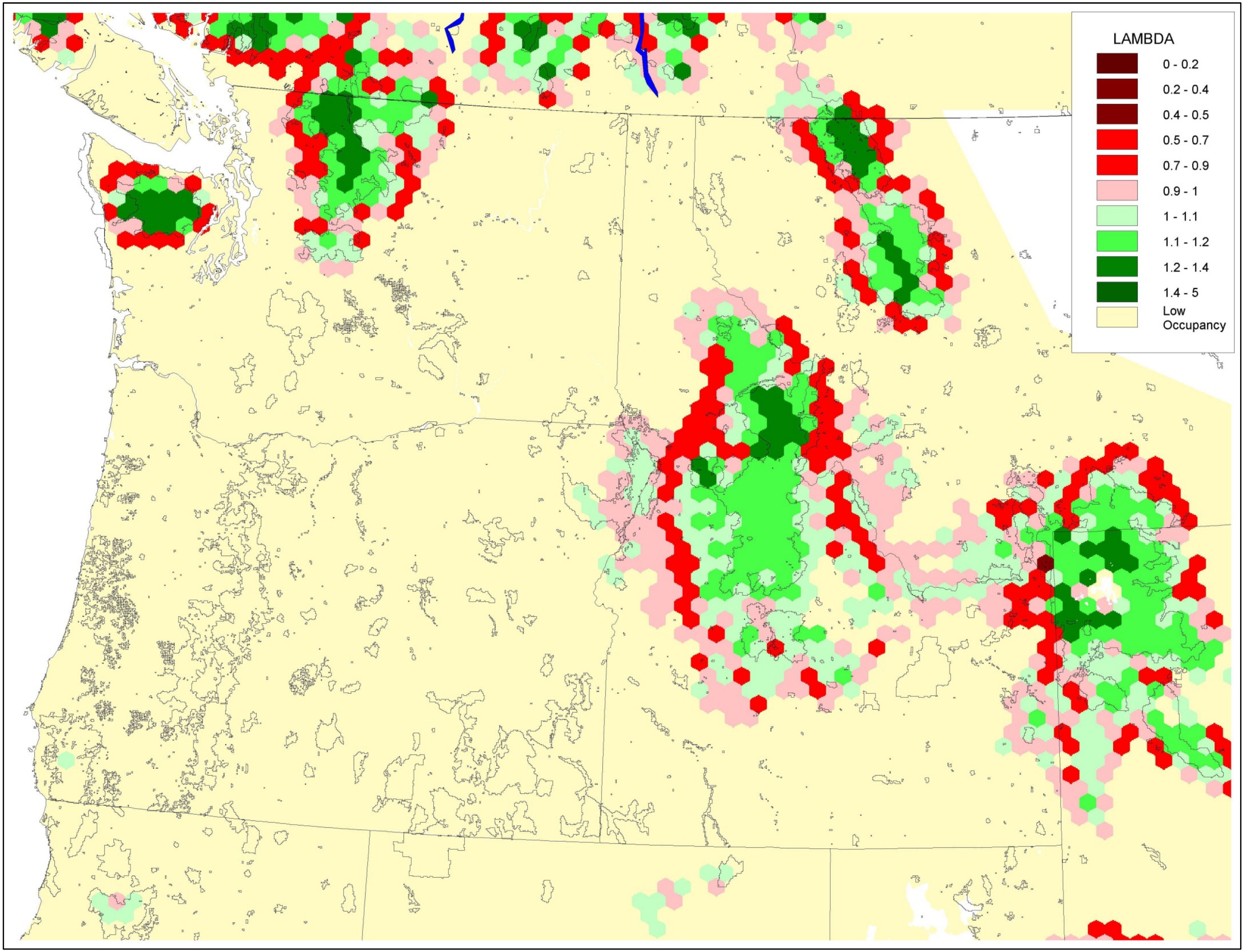
H
A
LAMBDA
0 - 0.2
0.2 - 0.4
0.4 - 0.5
0.5 - 0.7
0.7 - 0.9
0.9 - 1
1 - 1.1
1.1 - 1.2
1.2 - 1.4
1.4 - 5
Low Occupancy

Figure 3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Low Occupancy

Figure 4