**IDAHO DEPARTMENT OF FISH AND GAME**

**Steven M. Huffaker, Director**

**Progress Report**

# RESOURCE SELECTION FUNCTION MODELING OF GRIZZLY BEAR HABITAT IN THE SELKIRK MOUNTAINS AND CABINET-YAAK RECOVERY AREAS


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## TABLE OF CONTENTS

# INTRODUCTION

Conservation of grizzly bears (*Ursus arctos*) within the contiguous United States has been a litigious issue for nearly 4 decades (Primm 1996). Recovery programs have been implemented to increase the population of grizzly bears within the 'recovery zones' and to successfully manage their habitats by maintaining or improving conditions (Mace et al. 1996). By gaining a better understanding of the habitat selection and the effects that human activities have on valuable habitat, wildlife managers can continue to improve the status of the recovery zones.

The purpose of this project is to develop an empirical model that can predict seasonal habitat selection of grizzly bears in the Selkirk and Cabinet-Yaak recovery zones. Empirical models examine relationships between habitat conditions and species occurrences based on field-collected data. Since this type of model is based upon actual species distribution and habitat use, it provides valuable information to assist in management. In 1982, a similar approached was used by Christensen and Madel (1982) to develop a cumulative effects model (CEM). This type of model was developed to assess the cumulative effects on grizzly bears based on 2 criteria: habitat and human occurrences. This process examines changes in the environment due to human activity through space and time and how it affects grizzly bears (Christensen and Madel 1982).

Previous research using CEM examined habitat based on various land cover classification schemes (Christensen and Madel 1982, Weaver et al. 1986, and Mattson and Knight 1989). Creating a land cover for any given study area can be expensive and time consuming. In the previously mentioned studies, this type of habitat analysis was effective because a land cover layer existed within the respective study areas. A problem that the Selkirk and Cabinet-Yaak recovery zones face is that ample portions of each zone exist in British Columbia. To date, a compatible land-use classification scheme does not exist for this portion of the United States and British Columbia. Dealing with cross-jurisdictional boundaries has led researchers to examine new methods for assessing habitat quality (Mace et al. 1999, Gibeau 2000, Stevens 2002). The latest method for determining habitat quality is from performing a tasseled cap transformation on a LANDSAT TM satellite image to derive a vegetation index called 'greenness.' Previous research has found that grizzly bears illustrate a strong selection for areas of increased greenness within the Central Canadian Rocky Mountain Ecosystem, Eastern Slopes of Alberta, and the Northern Continental Divide Ecosystem (Mace et al. 1999, Gibeau 2000, Stevens 2002).

My approach will use greenness as a variable to determine habitat quality within the recovery zones. The following variables will also be used: road densities, human occurrence points, elevation, slope, and aspect. I will use logistic regression to model relative probabilities of grizzly bear resource selection (Mace et al. 1999). In the first stages of this analysis, a model will be developed to examine each recovery zone. Once the model is developed, each recovery zone will be validated with data from the respective zone. Since there is a lack of sufficient data locations at corresponding times among recovery zones, "study area" and "time period" variables will be used. The model will then be examined to determine similarities and differences among the Selkirk and the Cabinet-Yaak recovery zones in respect to time period and area.

Preceding modeling approaches have used similar criteria to examine grizzly bear habitat selection. Mace et al. (1999) developed a CEM to study the landscape and the impact of human activities on grizzly bears in the Northern Continental Divide Ecosystem (NCDE). Their approach used TM satellite imagery (greenness), elevation, road densities, and human activity points. Using logistic regression, they found that grizzly bears were positively associated with elevation and greenness for spring, summer, and fall. Furthermore, grizzly bears were negatively associated with human activity sites, road, and trail variables. They examined seasonal resource selection with telemetry data from 1987-1996. However it used only 1 TM satellite image (28 Aug 1988) to examine the variability of greenness throughout all 3 seasons (spring, summer, and fall). The assumption with this is that the individual summer image is representative of the fluctuation of all seasonal and annual greenness values from 1987-1996. Since these images are snapshots in time, and I am examining differences in seasonal resource selection, an image for each season should be used to account for the seasonal variations in greenness.

Stevens (2002) investigated whether or not LANDSAT based imagery could be used to predict grizzly bear habitat quality. They examined greenness, density of greenness, and distance to greenness. They also examined cumulative effects from elevation and human access densities. They found grizzly bears were positively associated with density of greenness (best predictor), distance to greenness, and elevation. However, they used only summer images and, therefore, did not account for seasonal variation of greenness.

I am not aware of any published research that has taken into account seasonal variation of greenness when examining seasonal habitat quality. This study will analyze seasonal fluctuations of greenness by using a LANDSAT TM satellite image that was acquired within the respective season. Because the focus is to evaluate seasonal habitat selection, a satellite image for each season was in the analysis. Delineated seasons are: spring from den emergence to 15 June, summer from 16 June to 15 August, and fall from 16 August until den entry. Imagery that was captured during specific seasons should more accurately identify resource selection of grizzly bears in the study area.

**Problem Statement**

The Selkirk Mountains and the Cabinet-Yaak ecosystem are important grizzly bear recovery areas and appropriate sites to continue this resource selection function analysis. The relationship of grizzly bears and road densities have been studied in these 2 recovery zones (Wakkinen and Kasworm 1997). Wakkinen and Kasworm (1997) found that bears strongly preferred areas with no open or gated roads (core areas). To date, there has not been a study that defines multivariate influences (e.g., elevation or greenness) on the core areas (as well as the remaining area) in both recovery zones.

Although previous studies have provided insightful information on road influences on bear distribution, examining other contributing factors (e.g., trail density, elevation, and greenness) may help to better assess resource selection by grizzly bears. By defining valuable habitat (e.g., seasonal range or high quality foraging sites), this habitat analysis should help to effectively represent certain habitat types in all bear management units (Wakkinen and Kasworm 1997). In turn, this model should lead to better management of these recovery zones.

Currently, managers need a technique to identify and display grizzly bear habitat quality in these recovery zones. A methodology and map layers would aid in:

1) Determining location and timing of access management based on habitat quality. The Selkirk / Cabinet-Yaak subcommittee of the Interagency Grizzly Bear Committee identified this as a high priority in their 2005 Action Plan.

2) Selection of replacement habitat for area lost to development. The Rock Creek Mine mitigation plan has identified over 2,000 acres of replacement grizzly habitat necessary to permit the mine. A biologically-based means of selecting these lands is needed. Having a guideline of suitable habitat will ensure adequate habitat is replaced and available for the bears.

3) Identification of quality habitat for linkage zones. The future of both these small populations will depend upon providing linkage for demographic and genetic purposes. The Selkirk / Cabinet-Yaak subcommittee of the Interagency Grizzly Bear Committee identified this as a high priority in their 2005 Action Plan.

4) Identification of areas for population expansion outside of current recovery zones. If recovery is successful, bears will occur outside the current recovery zone boundaries. Identification of these areas can target hazard analysis and reduction that will reduce future human conflicts.

5) Assessment of recovery zone sufficiency. An objective means of determining habitat quality would allow assessment of the amount and sufficiency of habitat within the recovery zones. This may allow options such as identification of high quality habitat outside the recovery zone boundaries or exchange of poor habitat inside recovery zone boundaries.

## OBJECTIVES

The objectives of this project are to:

1) Develop a grizzly bear habitat quality mapping strategy based on habitat use in the Selkirk and Cabinet-Yaak recovery zones.

2) Use mapping components that can be easily updated via remote sensing as habitat conditions change.

3) Compare and contrast strategy to mapping efforts in other recovery zones.

4) Produce and provide data layers to agencies to assist management.

5) Develop a habitat model that may be applicable to other areas and species with minor adjustments.

## METHODS

Between both recovery areas, there is approximately twenty years (1982-2002) of radio telemetry data of grizzly bears. Due to a lack of sufficient telemetry data for each year and each area, the model is being developed using data over a 4-year block of time. The model will be developed and tested in each recovery zone and validated independently. Analyzing the stated variables will enable us to determine the similarities and differences among the 2 recovery zones. For the Selkirk recovery zone, the model will be developed from data locations in 1988-1991. Model development of the Cabinet-Yaak recovery zone will occur with data points from 1990-1993.

Due to their comparable environmental conditions, it is expected that there will be similar model results among the Selkirk and Cabinet-Yaak recovery zones. The intention is to create an empirical model based on cumulative effects. One of the goals for model development will be to analyze area affects in each recovery zone. This investigation of area affects will help to determine if this model can be applied to other areas. Before area affects can be analyzed, 4 steps must occur:

1) Conduct home range analysis,

2) Develop habitat layers,

3) Develop human activity layers, and

4) Analyzing model fit using logistic regression.

### Home Range Analysis

Areas for model development within each recovery zone will be determined by estimating the home ranges of the grizzly bears using a 95% fixed kernel technique along with the Animal Movements extension in ArcView that contains a smoothing parameter (Hooge and Eichenlaub 1997). To minimize the effects of autocorrelation, radio-locations will be at least 24 hours apart (White and Garrott 1990). Locations collected this far apart are considered independent because a bear can travel throughout its entire range during this 24-hour period.

### Habitat Layers

For the habitat analysis, I will use a Digital Elevation Model (DEM) and greenness. DEMs will be used to create 3 variables: elevation, slope, and aspect. Greenness from a LANDSAT TM satellite image will be used to develop a pseudo-habitat map for both recovery zones. One of the goals of management is to create suitable habitat maps for each season in both recovery zones. A LANDSAT image for each season within each recovery zone will be used for 1 time frame (e.g., 1988-1991). The goal is to select an image that is not in an abnormal vegetative cycle due to physical processes such as El Nino. From a management standpoint, the product of the model will provide a static guideline (approximately 5 years) for habitat suitability within each recovery zone. This will be with the assumption that each seasonal image is representative of the annual variation in greenness among the time frame. Since it is not feasible from a management standpoint to update the maps annually, an average representation of seasonal vegetation will be most suitable.

### Human Activity Layers

Human activity points and road densities will be used to assess displacement of grizzly bears based on human disturbances. Human activity points will include areas in which human occurrence is likely, such as campgrounds, fishing areas, residential housing, and outlook towers.

The road density layers will be digitized based on Forest Service maps showing road networks during the respective time periods in each recovery zone. Road layers will be classified into 3 categories: open, gated, and closed. Open roads are those that are always open to the public. Gated roads are those that are closed (gated) to the public but are open for administrative use. Closed roads are those that are impassible in a motorized vehicle. This is with the understanding that there is the probability that ATVs and motorbikes may access this restricted area.

### Analytical Methods

Logistic regression will be used to model the relative probabilities of grizzly bear resource selection (Mace et al. 1999). Logistic regression will provide coefficients that will explain the variability of habitat selection among grizzly bears. Coefficients that prove to be statistically significant will be included in the final model. Next, the final model will be ready for validation. Each recovery zone will be validated with data from a more recent block of time. Location data for 1999-2002 will be used to test/validate the Selkirks model. The Cabinet-Yaak model will be validated with 1995-1998 data.

Upon determining model similarities and differences among recovery zones in the final validation stages, the Mace et al. (1999) CEM will be tested on both recovery zones.

Managers are interested in knowing how effective this empirical modeling approach is in comparison to the CEM developed by Mace et al. (1999). I expect that the current approach will more accurately show seasonal selection of greenness because I am using individual images for each season as opposed to 1 image for the entire year (Mace et al. 1999). This will take into account seasonal variation in greenness. Furthermore, the addition of analyzing slope and aspect could potentially improve predictability of seasonal habitat selection.

Once the assessment model fit has occurred, maps will be created to show areas of quality habitat for each active season within the recovery zones. Ultimately, this should lead to improved management in both recovery zones. It is also hoped that this model will become a baseline for all grizzly bear recovery zones.

## PRELIMINARY RESULTS

Efforts have focused on developing the data layers needed for the RSF modeling. Development of the topological layers (slope, aspect, and elevation), vegetation layer (tassel-capped transformed LANDSAT image) and human disturbance layers (roads and human occurrence points) is nearly complete.

All topological layers have been developed. Appropriate DEMs for Canada and the United States were assembled and converted to a slope, aspect, and elevation layer.

LANDSAT Satellite Imagery was used to conduct a tasseled cap transformation (using ERDAS Imagine software) to display the varying degrees of vegetation throughout the study areas.

Developing the human disturbance layers has proven to be the most time consuming. To develop the roads layer for each time frame and area, current digital road layers were used to provide a base road network for each time frame. During each time period, dated hard copy maps were used to aid in the altercation of the base road network to accurately display historical road conditions (closure types). To date, I have created 3 road closure type layers (open, closed, and restricted) for each study area and time period.

The final layer that is not complete is the human occurrence points (HOP). I am currently using Digital Orthophoto Quads to pinpoint HOPs such as houses, buildings, and fishing docks. Local biologists provided additional detail and insight.

**Future Plans**

Once the final HOPs are accounted for, the model development stage will be complete and the analytical phase will commence. I plan to use logistic regression to model the resource selection function. Upon determining model fit, maps will be created to show areas of quality habitat for each active season within the recovery zones. My thesis will serve as the final report which is expected to be completed by 1 February 2007.

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