Predicting Changes In Grizzly Bear Habitat Quality Using Geoprocessing Scripts

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Abstract

This presentation describes how a Python geoprocessing script enables resource planners to predict changes in grizzly bear habitat quality caused by forestry development.

Since 1999, the Foothills Model Forest Grizzly Bear Research Program (FMFGBRP) has been studying grizzly bears (*Ursus arctos*) in order to provide land managers with the knowledge and tools to ensure the long-term conservation of this species in Alberta. Raster-based GIS maps have been created, covering 55% of the grizzly bear range in Alberta, that combine GPS locations with Remote Sensing imagery to model two aspects of grizzly bear habitat quality – resource availability, and security – as a function of landscape variables such as vegetation, terrain, and human access. The FMFGBRP has developed a script that incorporates proposed development scenarios into landscape variables and regenerates the habitat models based on these new inputs.

1.0 Introduction

Resource extraction, whether from logging, mining, or oil and gas drilling, often has serious effects on wildlife. Land managers are often faced with the dilemma of having to maintain critical wildlife habitat while extracting resources as efficiently as possible. Minimizing the impact of building resource infrastructure on wildlife habitat requires a rapid assessment of various scenarios, and this in turn requires the ability to predict future landscape conditions in terms of habitat quality.

To meet this need, the Foothills Model Forest Grizzly Bear Research Program (FMFGBRP) has developed a geoprocessing script, written in the Python language, that incorporates planned landscape changes into habitat models for grizzly bears (*Ursus arctos*).

2.0 Background

The FMFGBRP was initiated in 1998 as a result of environmental hearings into a planned open-pit coalmine southwest of Hinton, Alberta. The goal of the FMFGBRP was to provide practical tools for land managers to ensure the long-term conservation of grizzly bears in Alberta. This species is under severe pressure; despite being a generalist species, adaptable to a wide variety of habitat types, grizzly bear range in North America has shrunk by two-thirds in the last 200 years, due to unsustainable mortality rates in the face of encroachment by European settlers (Fig. 1). It is estimated that only a few hundred grizzly bears remain in Alberta[1].

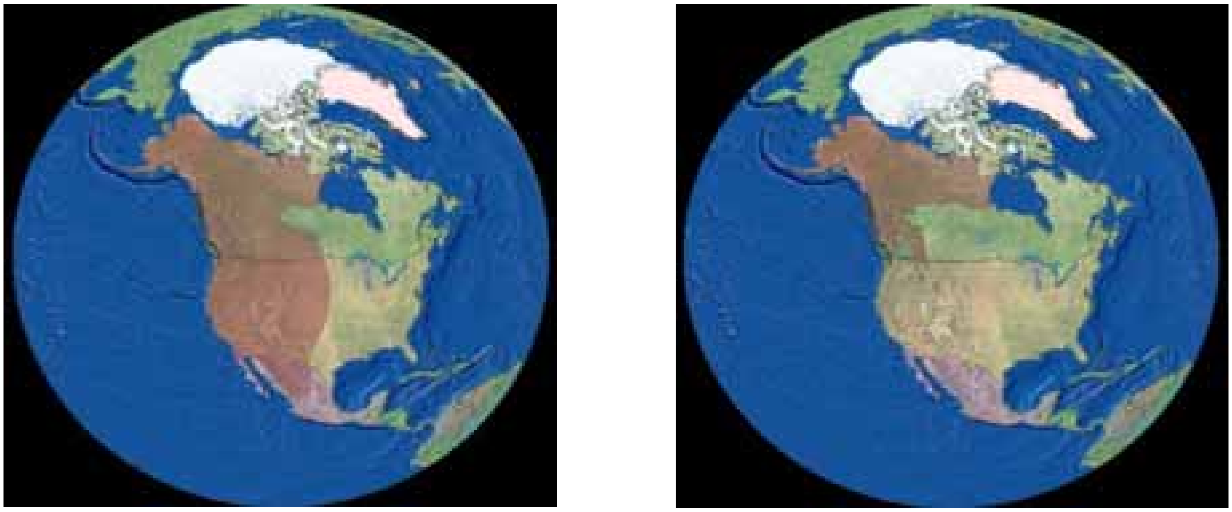


Fig. 1: Reduction Of Grizzly Bear Habitat Range In North America, 1800 - 2000

Since 1999, the FMFGBRP has captured 98 grizzly bears, either by aerial darting or in leg-hold snares, and fitted them with GPS radiotelemetry collars (Fig. 2). To date, over 95,000 locations have been collected (Fig. 3), and these form the basis of habitat models developed by the program. These models are GIS layers that describe two critical aspects of grizzly bear habitat quality: resource availability, and security.

Fig. 2: Captured Grizzly Bear and GPS Collar

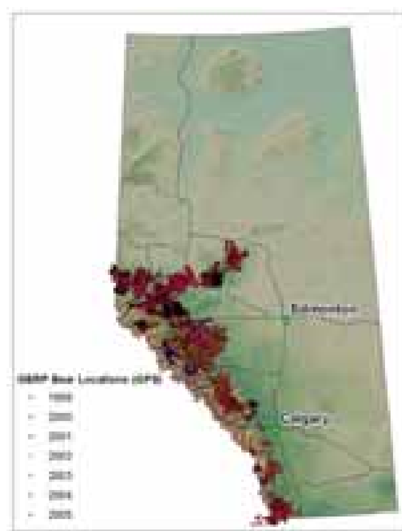


Fig. 3: GPS Locations

3.0 Habitat Models

The first model describes resource availability. The Resource Selection Function (RSF) model is a 30m raster surface where pixel values represent the relative probability of grizzly bear occurrence[2]. This model can be used as a surrogate for resource availability, under the assumption that grizzly bears are attracted to particular areas by the presence of some resource, whether food, water, thermal cover, or denning sites. The model uses multivariate regression analysis of bear locations overlaid with habitat maps derived from 30m resolution Landsat TM5 imagery to describe the distribution of bears as a function of landscape variables. For example, bears are more likely to be found close to streams than would be expected by random distribution (Fig 4), and therefore areas close to streams have higher pixel values (Fig.5).

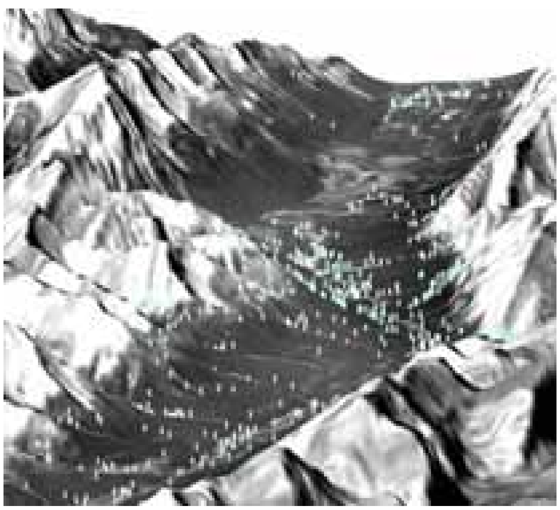


Fig. 4: Grizzly Bear locations

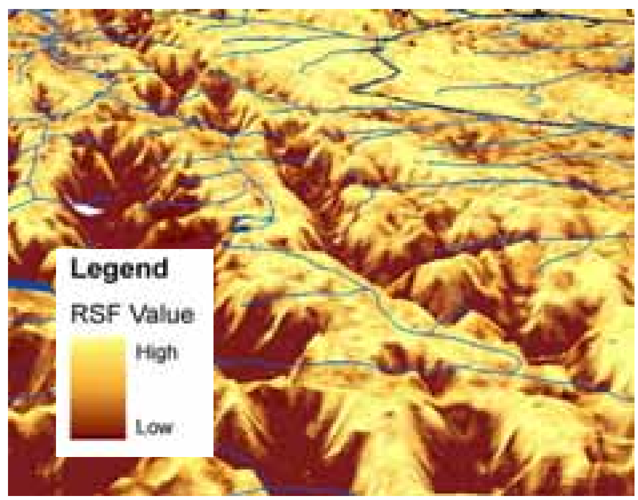


Fig. 5: RSF Surface

The factors that determine probability of grizzly bear occurrence are elevation, habitat class (vegetation), solar radiation, slope position, soil wetness, and forest characteristics such as age, canopy closure, leaf area, and distance to edges. Each of these variables can be represented by raster surfaces and combined using Spatial Analyst Raster Calculator.

The second model describes security, another critical aspect of habitat quality[3]. This model is based on a study of 280 anthropogenic grizzly bear mortalities in the Central Rockies ecosystem, and represents the relative probability of human-caused grizzly bear death as a function of six landscape variables: habitat class, terrain ruggedness, greenness (a measure of vegetation abundance), and distance to open motorized roads, water, and forest edges.

Each model is the product of a MapAlgebra expression in which the base GIS layers are combined to calculate the linear predictor, which is then exponentiated to derive a value for each pixel. Mathematically, the function can be expressed as

$$w(\boldsymbol{x}) = \exp(ß_0 + ß_1 X_1 + ß_2 X_2 + ß_3 X_3 . . . ß_n X_n)$$

where X_n are the values of the environmental variables (e.g., land cover attributes, terrain, etc.), and $ß_n$ are the coefficients for those variables determined through logistic regression.

Fig. 6: Model Extents

These models have been developed for an area of over 125,000 sq. km of grizzly bear range in western Alberta (Fig. 6). They are empirical, high-resolution, extensive, and have been statistically validated. Their limitation, however, is that they are only as current as the GIS layers they are derived from. Resource planners need a quick and easy way of incorporating new or planned features and regenerating the models. Fortunately, the Python scripting tools included with ArcGIS version 9 have made this task very simple.

4.0 Habitat Model Regeneration Using Scripts

For each of the habitat models, a Python script was written to apply the MapAlgebra expression to the GIS input layers and, optionally, integrate new or planned features into those layers before processing.

The interface for both scripts allows the user to first choose a shapefile or feature class as an analysis extent, as regenerating the model over a chosen portion of the total area saves considerable processing time. The user can then add planned features such as roads, and forest disturbances such as cut blocks and fires (Fig. 7).

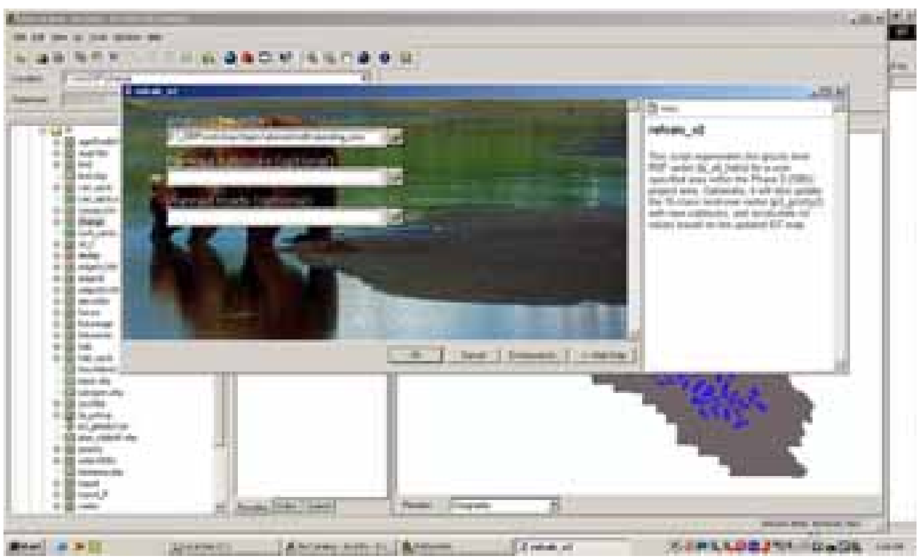


Fig. 7: User Interface

Linear vector features such as roads or other linear access structures (seismic cutlines and pipelines, for example) are appended to a geodatabase so that distance-to rasters can be recalculated. They are also buffered to represent their actual footprint. The habitat class raster is then updated with these buffers, along with other polygon features such as cut blocks, through the use of the Spatial Analyst Pick tool.

In the following scenario, an island of over-mature timber bounded by two streams (Fig. 8a, upper center) is scheduled for harvesting. Current RSF values in this area are relatively low (Fig. 8b). When the RSF model is regenerated with a harvest pattern of blocks (in blue) and access roads (in green) (Fig. 8c), the output model shows significantly higher RSF values for the first 10-year period following logging (Fig. 8d). This is to be expected, as logging creates openings that stimulate the growth of understory vegetation that comprises the bulk of a grizzly bear's diet[4]. However, the new road will also increase the chance of bear-human interactions, causing a corresponding rise in mortality risk, unless some form of access control is imposed.

Fig. 8a

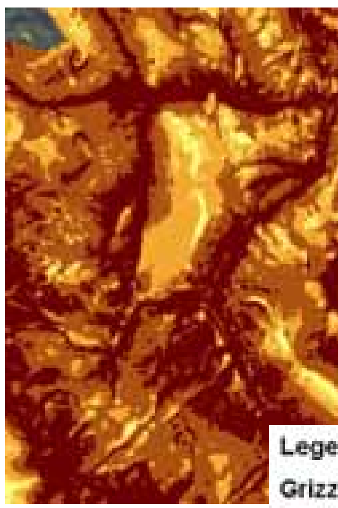
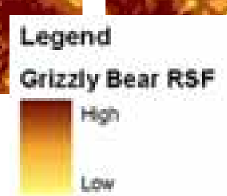


Fig. 8b



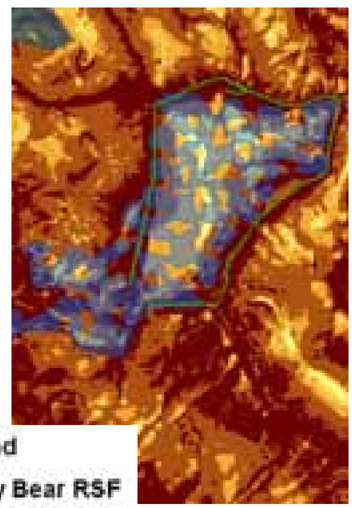


Fig. 8c

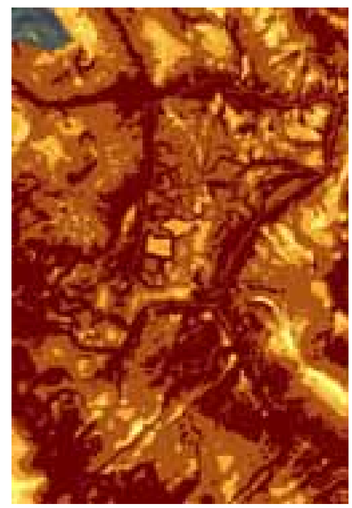


Fig. 8d

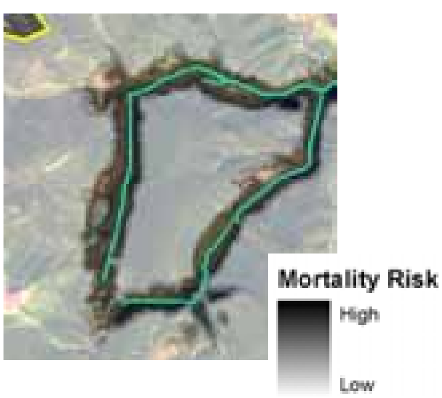


Fig. 9: Mortality Risk

5.0 Conclusion

Regenerating habitat models is one example of how the scripting and geoprocessing capabilities of ArcGIS 9 can be applied to wildlife conservation. Although these scripts were written to regenerate grizzly bear habitat models, they can be easily adapted to regenerate habitat models for other species. For example, a similar script was written by the FMFGBRP to regenerate seasonal RSF and survival models for wolf (*Lupus lupus*) and elk (*Cervus elaphus*). Another version of the grizzly bear RSF script is also being developed to provide long-term scenario modeling by incrementing changes in landscape variables over time, such as forest age and crown closure. This will allow planners to explore how various harvest scenarios will impact grizzly bear habitat many years in the future.

In much the same way that a reliable forecast of tomorrow's weather is more valuable than a report of yesterday's weather, the ability to predict changes in habitat quality through the use of GIS scripts can greatly benefit wildlife conservation efforts.

6.0 Acknowledgements

I am grateful to Gordon Stenhouse, Coordinator of the FMFGBRP, for his outstanding leadership and dedication in promoting grizzly bear conservation in Alberta through research and innovation.

7.0 References

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