FOOTHILLS FISH FINDER

Predictive modeling and spatial mapping of fish distributions in small streams of the Canadian Rocky Mountain Foothills

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bull trout (Salvelinus confluentus)

Introduction:

For almost 100 years, land and forest managers have been responsible for conserving water as well as providing a source of timber within the foothills of Alberta - a region that contains 100,000 km of stream. Conserving native fish populations requires a knowledge of fish distributions and the effects of industrial activities on their habitats. Budget constraints, short development timelines and remoteness have limited the utility of traditional field-based inventories to support fish conservation. Given these difficulties, an automated procedure derived from remotely sensed data was needed to predict spatial fish distributions at reach and drainage basin scales in small streams.

Objective:

We sought an automated process that would help us:

- map distributions for individual species and for all fish regardless of species
- determine the most important variables for explaining distributions
- compare distributions of native bull trout and rainbow trout and non-native brook trout
- determine how land use affects distributions of individual species

The Need for Innovation:

The common model treats the stream as a continuum from source to mouth, in which channel gradient decreases as drainage area increases. This relationship does not transfer to the glaciated landscapes of the Alberta foothills, however. The region supports discontinuous systems that include plateau bench-lands and hanging valleys, both with sections of increasing gradient along watercourses. This complex terrain negates the use of stream size as a one-dimensional model to predict fish occurrence.

Project Location

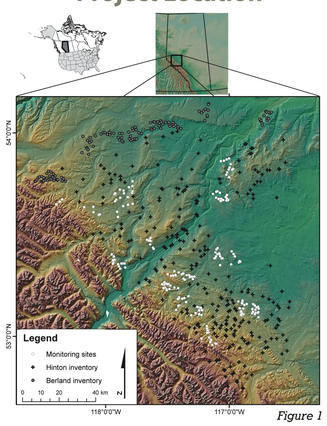

Figure 1

Map of the fish sampling locations by project including monitoring watersheds (model training data set), Hinton inventory (model testing data set) and Berland inventory (model testing data set).

Methods:

The study area covers a 12,000 km^2 portion of the Rocky Mountain Foothills in west-central Alberta (*Figure 1*). Approximately 1% of the land base (120 km^2) is harvested annually. By 2004, approximately 500 wells were producing natural gas with 150 new wells drilled between 2000 and 2004. A network of gravel roads and pipelines is expanding across the area to access the natural resources.

Surveys were conducted between 1996 and 2002 in 15 watersheds representing the range of biophysical and land-use characteristics for the study area. The focus was on small streams (5m bankfull width). Trained technicians used single-pass backpack electro-fishing over a 300m reach of stream to determine fish presence/absence. Sample sites were randomly selected from the various stream order and stream slope combinations.

To map predicted probabilities of target fish species we developed a system to extrapolate the findings from specific sample points across the entire study area.

Independent model parameters were limited to those that could be calculated with GIS analyses of existing data. Based on the information-theoretic approach, which advocates the incorporation of prior considerations into the parameter selection process, we identified six ecological variables and three land-use variables.

Three separate model selection exercises were undertaken:

1. modeling for all individual variables;
2. modeling using ecological variables only;
3. modeling for combinations of the best ecological model and the three land-use variables.

Species Maps

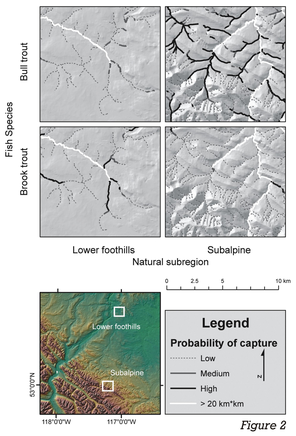

Figure 2

Maps of predicted capture probability for bull trout and brook trout within representative areas of the Lower Foothills and Subalpine natural subregions.

Application Maps

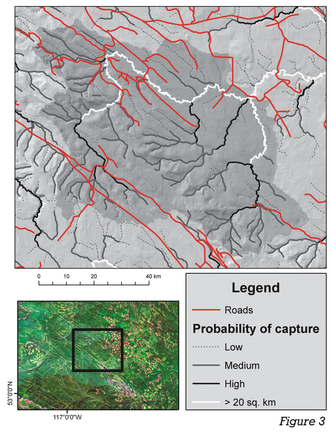

Figure 3

Map of Erith River Watershed with probability of fish capture and roads. Inset - satellite image showing harvested areas.

Conclusions and Discussion:

- Our reach-scale maps had intermediate accuracy (brook trout = 81%, bull trout = 80%, rainbow trout = 72% and all species = 71%) for correctly predicting fish-present and fish-not-present reaches (*Figure 2*). Forest and energy companies are using these maps in stream crossing remediation and fish conservation planning (*Figure 3*).

- Drainage area and basin slope parameters were included in all "best" models (*Figures 4 and 5*). Optimal values for these two variables differed by species (*Figure 5*). Investigations into the effects of land use on aquatic resources in the transitional landscape between the mountains and plains should include mean basin slope.

- Catchment-scale maps summarized preferred bull trout habitat across the study area. The best model for bull trout indicated artificial migration barriers were related to reduced occurrence of the species in upstream reaches.

- With regional calibration, this automated modeling and mapping procedure could apply in headwater catchments wherever similar ecological factors influence fish distribution.

Parameter Importance

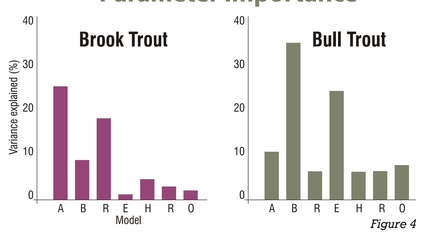

Figure 4

Variation explained from single variable models for predicted capture probability of brook trout and bull trout. Models include: basin area (A), mean basin slope (B), reach slope (R), reach elevation (E), percent harvest (H), road density (R) and presence/absence of a downstream barrier (O).

Optimal Habitats

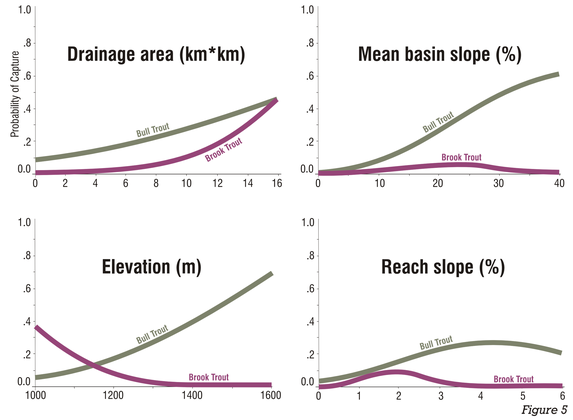

Figure 5

Predicted probability of capture by habitat variable for brook trout and bull trout. The range of the x-axis represents the approximate observed range of each variable. For predictions, all values for other variables were standardized to mean values.

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