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Arc/Info Macro Language (AML) scripts for mapping susceptibility and risk of volume losses to mountain pine beetle in British Columbia

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Background

Attacks by mountain pine beetle (*Dendroctonus ponderosae*) on pine trees are an ongoing problem in British Columbia forests. The characteristics of some stands tend to make them more susceptible to volume losses than others. Forest managers are expected to calculate stand susceptibility as a component of provincial beetle management requirements (B.C. Ministry of Forests 1995). However, they can also reduce the damage in their license area by incorporating stand susceptibility into their management plans (Whitehead et al. 2001). When mountain pine beetle populations are at incipient or epidemic levels, a risk rating value can also be estimated. The risk rating is calculated by combining stand characteristics with beetle infestation characteristics.

Mountain pine beetle devastation in British Columbia.

A rating system exists to calculate susceptibility and risk for each stand in a forested area (Shore and Safranyik 1992). The calculation may be done simultaneously on multiple stands if they are represented within a digital geographic information system (GIS) database. The current operational standard of GIS format for forest inventory databases and beetle surveys represents an opportunity for rating susceptibility and risk. To take advantage of this opportunity, while ensuring efficiency and comparable results among different forestry professionals, an open-source approach is suggested. This technology transfer note describes three Arc/Info Macro Language (AML) scripts that GIS professionals can adapt to most forest inventory databases. The three AML scripts described are a susceptibility script, a legacy susceptibility script for use with older forest inventory datasets, and a risk script. A web address is included at the end of the document indicating where the scripts are available for download.

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The Susceptibility Scripts

The susceptibility script is fundamentally based on the calculations presented by Shore and Safranyik (1992). Some modifications were made to the rating calculations to make index values more consistent among stands. Continuous functions, rather than discrete classes, are integrated into this script for the age, density and location variables. These continuous functions are used to minimize relatively large differences in ratings caused by shifting from one class value to another. For example, in the original system an 80-year-old stand would be rated significantly lower than an 81-year-old stand, all other things being equal. The resulting script can be implemented with Vegetation Resource Inventory (VRI) data for British Columbia after latitude and longitude (in decimal degrees) and elevation (in metres) are added for each polygon (script name: *mpb_susc_vri.aml*).

Some forest managers are working with Forest Inventory Planning (FIP) databases that do not have all the variables required by the Shore and Safranyik (1992) model. Therefore, the susceptibility model was also adapted to the variables available with FIP databases. Although not ideal, this adaptation allows the AML to be implemented by a wider number of forestry practitioners. An FIP adaptation (adapted after Howse 1995) replaces the percent of pine by basal area with the percent of pine by stand volume. Also, density is replaced using mean diameter as a surrogate. The original variables of basal area and stand density relate to aspects of mountain pine beetle behaviour and ecology. Therefore, it needs to be recognized that the index will be less sensitive and accurate when these variables are substituted with surrogates that may be only weakly related to the original variables. In addition to the forest characteristics captured in the FIP database, the latitude and longitude (in decimal degrees) and elevation (in metres) must be added for each polygon prior to implementation (script name: *mpb_susc_fip.aml*).

The Risk Script

The risk model integrates susceptibility and the characteristics (including size and proximity) of the beetle infestation, termed beetle pressure (Shore and Safranyik 1992). The AML script to calculate risk was developed to accommodate aerial surveys that collect infestation location points using helicopters and Global Position Systems (heli-GPS). Prior to implementing the script, the infestation dataset must be in the same spatial projection as the susceptibility data and contain attack code information (script name: *mpb_risk.aml*).

Results and Discussion

For each forest stand, the susceptibility AML calculates indices (in terms of host suitability) of the percentage of pine, age, density and location. From these four indexes, the AML then calculates the susceptibility rating (Figure 1). The legend and map display are not part of the AML script, so they remain flexible for integration with other mapping information.

The susceptibility is a relative ranking from 1 (low susceptibility) to 100 (high susceptibility). The output should be interpreted as the potential for loss of volume in a stand (Shore et al. 2000). A low susceptibility stand could be infested, but because it was dominated by spruce, only a small volume is lost. A study in the Cariboo, Kamloops and Nelson forest regions validated the correspondence between susceptibility and the percent of basal area killed (Shore et al. 2000).

The risk AML calculates the beetle pressure from the number of infested trees inside the stand, the number of infested trees outside the stand but within 3 km, and the distance from the stand to the nearest infestation. It then calculates the risk using susceptibility and beetle pressure (Figure 2). The risk rating ranges from 0 (low risk) to 100 (high risk) but should not be interpreted as a probability of attack. Rather, it is an indicator of the short-term expectation of tree mortality (Shore and Safranyik 1992). A high risk rating indicates both a high proportion of susceptible pine and a close proximity of beetles. A moderate risk rating could be a consequence of high susceptibility and low beetle pressure, or low susceptibility and high beetle pressure. An on-going study in the Morice forest district found a tendency for stands with higher risk rating to more likely be infested. These results reinforce the usefulness of the risk rating model for beetle management.

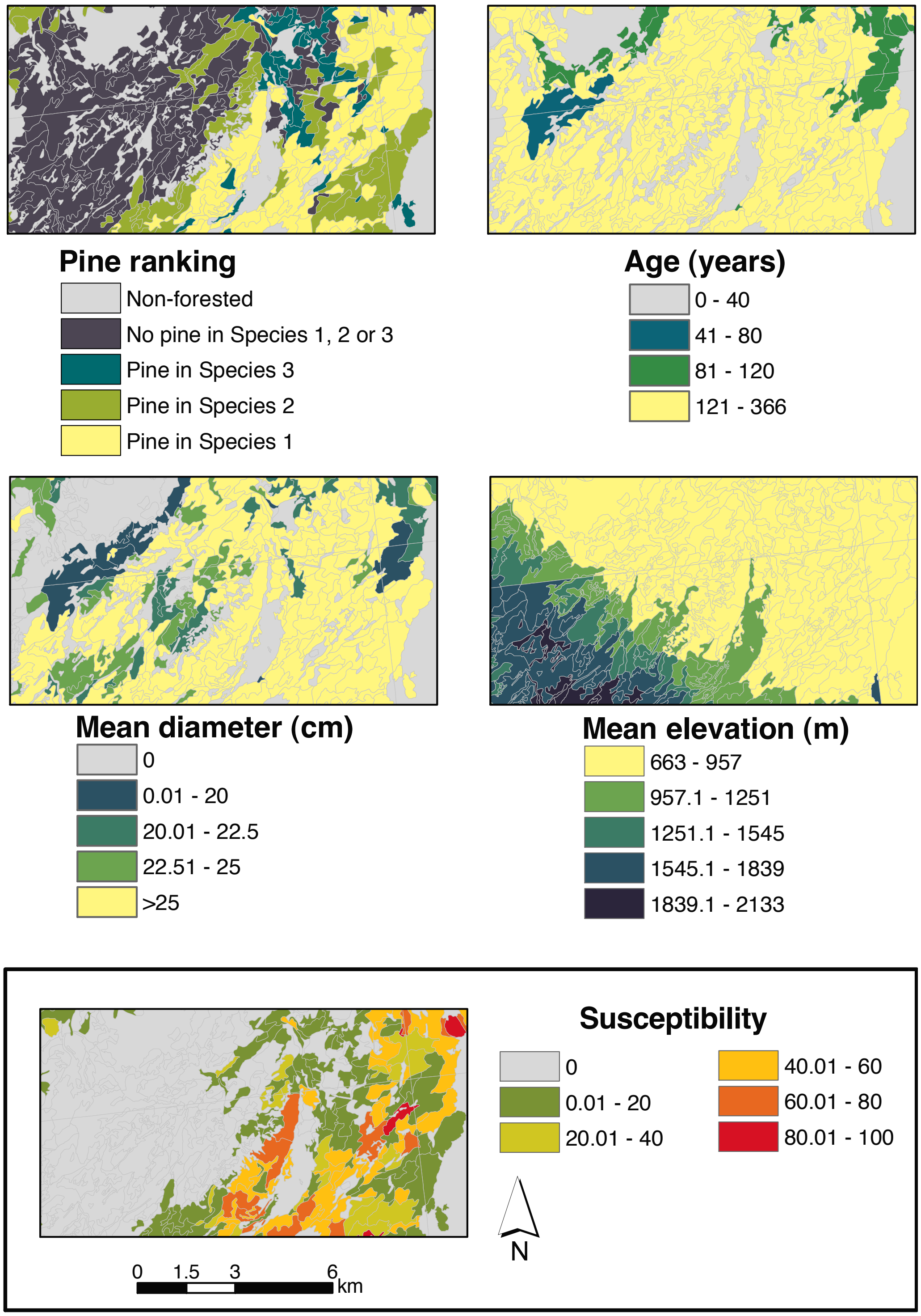

Figure 1. Forest inventory and elevation components plus the resulting susceptibility. For pine ranking, age, diameter and elevation, blue colour indicates lower contribution to susceptibility; yellow indicates high contribution to susceptibility.

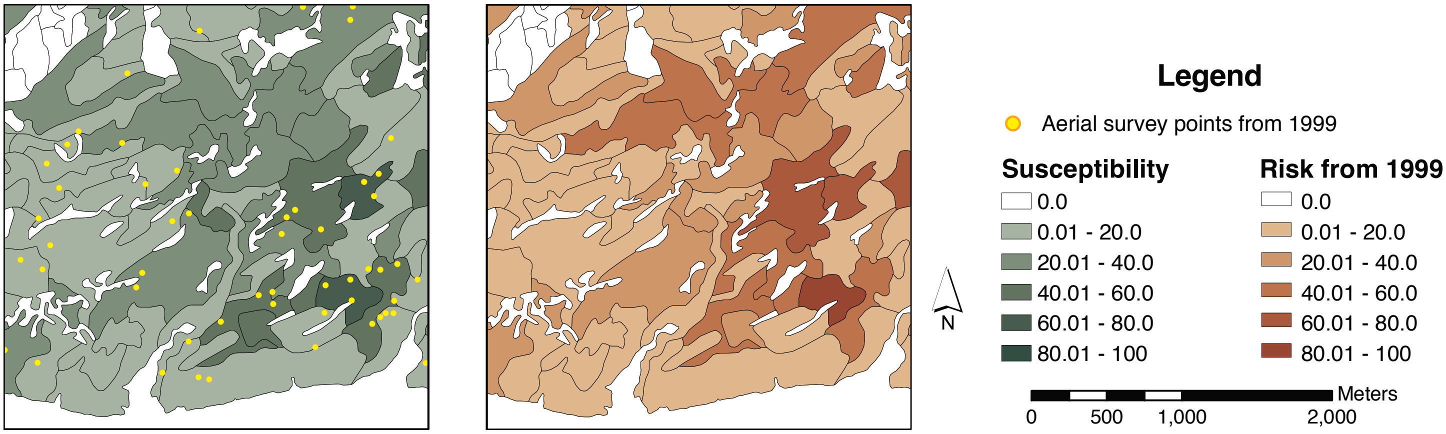

Figure 2. Illustration of the interaction between susceptibility and beetle infestation (captured as survey points) that results in risk.

Conclusions

Three AML scripts are available for digital download to facilitate the calculation of stand susceptibility or risk to mountain pine beetle. Common use of a shared script results in standardization, comparable results, and operational efficiency.

The scripts are available in digital format from the web site on Forest Geomatics Mountain Pine Beetle Research at the Canadian Forest Service:

www.pfc.cfs.nrcan.gc.ca/entomology/mpb/detection/remote/tools_e.html

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