

INTRODUCTION

Yellow-cedar is a culturally, economically, and ecologically important tree in coastal Alaska that has been experiencing a widespread mortality known as yellow-cedar decline for about 100 years. Mapping during annual aerial detection surveys has identified nearly the entire geographical distribution of the problem, which totals over 500,000 acres in Alaska (Lamb and Wurtz 2009) and additional acreage in adjacent British Columbia (Hennon and others 2005). This broad-scale approach to detection has been useful in determining the general occurrence of this forest decline, but mapping from aircraft produces large polygons that are too coarse to evaluate some associated landscape features. Examining yellow-cedar decline at a finer spatial scale is needed to test associations of factors such as slope, elevation, and aspect.

We conducted a mid-scale analysis of yellow-cedar decline on Mount Edgecumbe on Kruzof Island near Sitka, AK (fig. 10.1). Mount Edgecumbe is a dormant volcano with radial symmetry and wet plant communities that likely support abundant yellow-cedar at a range of elevations. Thus, it is a model landscape for this project. Our objectives were to compare the occurrence of yellow-cedar decline as mapped by aerial survey and from aerial photographs, determine the association of elevation, aspect, and slope on the presence of yellow-cedar



Figure 10.1—Photographs of (A) Mount Edgecumbe and (B) dead yellow-cedar forests at lower elevation. (Photos by Dustin Wittwer, U.S. Department of Agriculture Forest Service)

CHAPTER 10.

Evaluating Key Landscape Features of a Climate-Induced Forest Decline (Project WC-EM-07-01)

PAUL HENNON AND DUSTIN WITTWER¹

¹Research Plant Pathologist and Geospatial Services Specialist, U.S. Department of Agriculture Forest Service, State and Private Forestry, Forest Health Protection, Juneau, AK 99801.

decline, and develop methods to detect healthy yellow-cedar populations. New information indicates a tight relationship between snow and the health of yellow-cedar forests (Beier and others 2008, Hennon and others 2010, Schaberg and others 2008); thus, a second phase of this project was to model snow accumulations to identify future suitable habitat on Mount Edgecumbe for yellow-cedar.

METHODS

Aerial survey methods and photo interpretation documented yellow-cedar decline in similar locations (fig. 10.2), but with widely different spatial results. Photo interpretation produced about 25 times the number of polygons of yellow-cedar decline, but only about 25 percent of the acreage compared to aerial survey. Thus, the two methods differ in their spatial resolution of the problem with aerial photography producing a more resolute map, which we used in the analyses below. We are unaware of similar efforts to validate results from aerial detection surveys using other forms of remote sensing such as aerial photograph interpretation.

Using raster analysis, the occurrence of decline was classified and quantified according to the terrain derivatives of elevation, aspect and slope, each calculated from a 30-m digital elevation model (DEM). The decline area was classified in equal intervals and normalized based on the total land area in the study area corresponding to the terrain derivative class categories.

RESULTS AND DISCUSSION

Histograms of the normalized data revealed elevation, aspect, and slope all were associated with the occurrence of yellow-cedar decline. The decline problem is restricted to low elevations, with considerably less decline above about 600 feet. We detected an elevation-aspect interaction, where yellow-cedar decline occurred higher in elevation on the warmer southerly aspects than northerly aspects. Also, yellow-cedar decline was associated with gentle slopes compared to steep slopes. These results are consistent with results from other evaluations of elevation (Hennon and others 2010, Lamb and Wurtz 2009) and slope-drainage (D'Amore and Hennon 2006, D'Amore and others 2009).

Helicopter surveys produced a reliable method for detecting yellow-cedar in the apparently healthy forests at higher elevations. This is the first successful remote sensing approach for verifying the occurrence and amount of yellow-cedar in healthy forests. A kriged map produced from the helicopter survey points illustrates the substantial population of healthy yellow-cedar above the decline zones (fig. 10.3). Ground checks verified the results from helicopter surveys. Our field observations above the dead zones indicate differences in the “quality” of yellow-cedar crowns of live trees where yellow-cedars on the north side of the mountain had full, green crowns and those on the south side often had thin crowns. Thus, our sampling approach to detect live and dead yellow-cedar forests included the increasingly detailed methods of aerial detection survey from an airplane, aerial photographs, helicopter surveys, and ground plots.

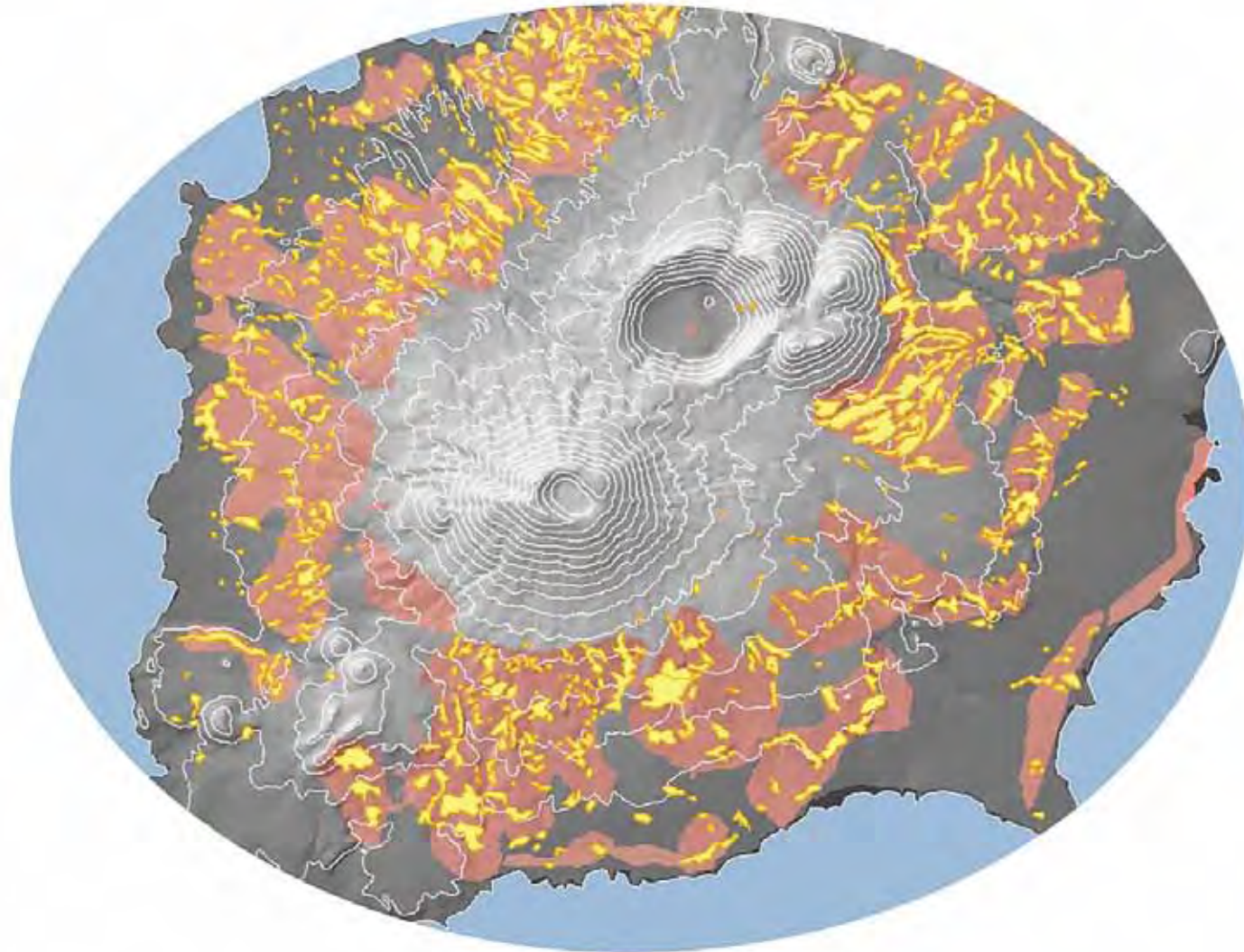


Figure 10.2—Map of Mount Edgecumbe depicting the occurrence of yellow-cedar decline as detected by aerial survey (orange) and analysis of aerial photography (yellow).

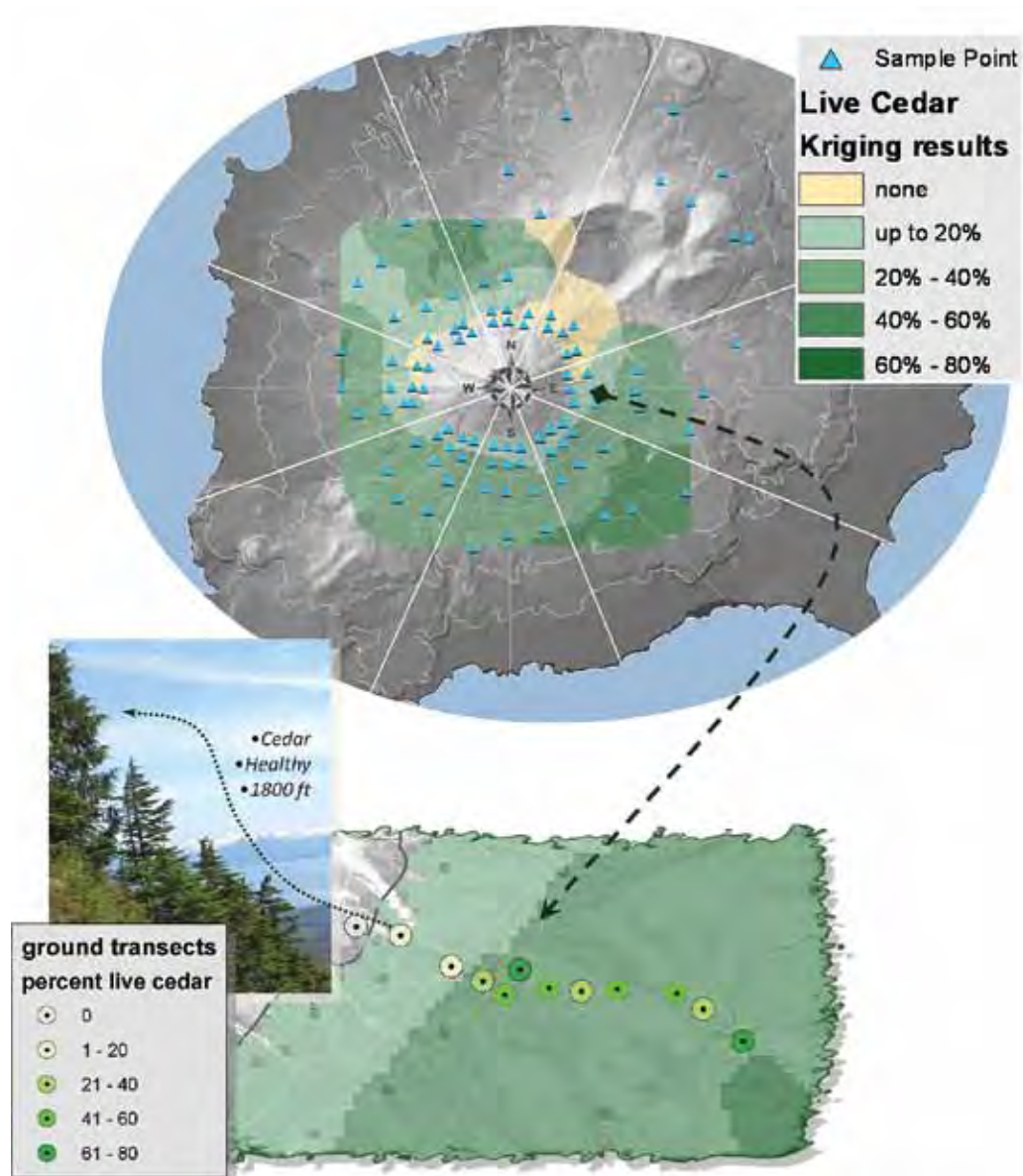


Figure 10.3—A helicopter survey was used to construct forest tree composition in the healthy higher elevation forests. The map above displays the percent occurrence of yellow-cedar by kriging the helicopter survey data. Ground surveys confirmed the abundance of cedar there.

These results support the contention that patterns of snow accumulation dictate the health of yellow-cedar forests (Hennon and others 2008). In the second phase of our project, we used GIS PRISM (Parameter-elevation Regressions on Independent Slopes Model) tools (Daly and others 1994), a new elevational adjustment technique (Wang and others 2006) for downscaling, and global circulation models to produce snow accumulation models for Mount Edgecumbe. Output maps show estimated snow patterns in the early 1900s to the present using weather station data in PRISM. Future predictions of snow accumulation to 2080 were made using PRISM and a conservative global

circulation model (we used Coupled Global Circulation Model, Second Generation, B2 scenario) (IPCC 2001). The amount of annual snow accumulation sufficient to protect yellow-cedar is displayed as shades of blue on the maps (fig. 10.4). We used the current distribution of yellow-cedar decline (red) as a benchmark to determine the critical snow accumulation threshold. The maps show substantially more snow in the early 1900s, but shrinking zones of adequate snow to the present and into the future. By 2080, only a small area near the cone of the volcano is predicted to have sufficient snow to protect yellow-cedar from the root freezing injury.

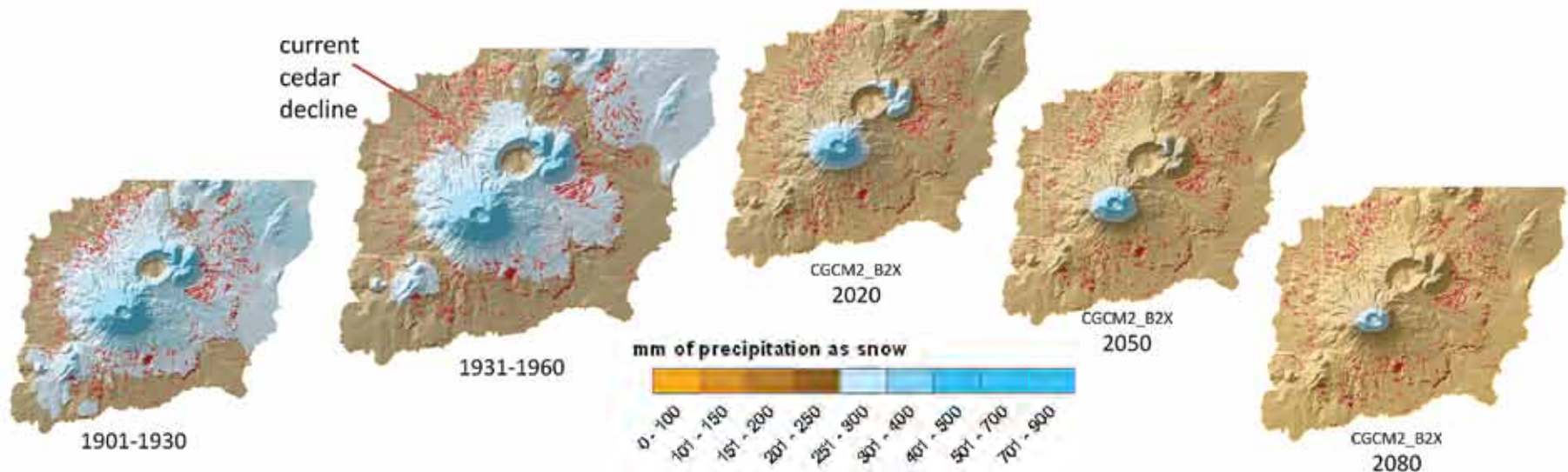


Figure 10.4—Past and projected (CGMC2 B2 scenario shown here) annual snow accumulations using PRISM data, with downscaling by an elevational adjustment (Wang and others 2006). Light blue zones represent sufficient snow to protect cedar from spring freezing injury (annual precipitation as snow = 2500 mm); current areas of cedar decline mapped from aerial photographs are shown in red. Note the abundance of habitat protected by snow (shades of blue) in the early 1900s and progressive shrinking of this habitat through this sequence, to being nearly absent by 2080. (Data sources: PRISM Group, Oregon State University; IPCC 2001)

CONCLUSIONS

We hope to extend these approaches to the entire geographical distribution of yellow-cedar in coastal Alaska. In another project, extensive use of forest inventories are being used to build a general distribution map and habitat models of healthy yellow-cedar, because we still do not currently have adequate knowledge of where healthy cedar populations exist. Snow modeling will be expanded geographically in an attempt to identify current and future suitable habitat for yellow-cedar throughout the entire region. This search for suitable habitat is a key component to developing a conservation and management strategy (Hennon and others 2008) for promoting the valuable yellow-cedar tree into the future.

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