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Landscape and Urban Planning 72 (2005) 49–63
LANDSCAPE AND URBAN PLANNING
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Predictive mapping for tree sizes and densities in southeast Alaska

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Abstract

The Forest Service has relied on a single forest measure, timber volume, to meet many management and planning information needs in southeast Alaska. This economic-based categorization of forest types tends to mask critical information relevant to other contemporary forest-management issues, such as modeling forest structure, ecosystem diversity, or wildlife habitat. We propose the joint distribution of tree density and mean tree diameter as a more comprehensive set of forest measures. Focusing on those measures, we build a predictive-mapping model by using existing geographic information system data resources and existing ground-sampled inventory data. The utility of our predictive-mapping model will need to be tested with additional intensive ground-sampled data and in applications that involve forest managers, planners, and biologists. Such tests will reveal the model's utility in addressing contemporary forest-management problems and information needs.

Keywords: Old-growth forests; Forest structure; Forest measurement; Predictive mapping; Stand density index; Southeast Alaska; Tongass National Forest

1. Introduction

A basic challenge in forest inventory and management is distilling complex, multidimensional, multiscaled, forest ecosystems into a small number of attributes that are easily measurable in the field and have practical value for planners, scientists, and the public. For decades, the USDA Forest Service (F.S.) has relied on a single economic measure (timber volume or net-board-foot-volume per acre) for most information needs and decision making in the Tongass National Forest (NF)[1]. Although volume measures may meet certain management information needs, such as resource inventories, timber-sale layouts, and economic modeling, they do not provide adequate information on forest structure, ecosystem diversity, or wildlife habitat.

Contemporary forest management can no longer rely exclusively on measures of timber volume. The problem is that forested stands measuring the same timber volume tend to include a wide range of structures, tree sizes, tree densities, tree ages,

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0169-2046/$20.00 © 2004 Elsevier B.V. All rights reserved.
doi:10.1016/j.landurbplan.2004.09.012

[1] The Tongass NF comprises 80% of the land area of southeast Alaska.

and site conditions. Timber volume alone is not well suited for today's broader forest-management missions that require consideration of diverse values and ecological relationships. Unfortunately, decades of timber-volume inventorying and mapping have left the Tongass forest managers and biologists highly dependent on timber-volume measures. The history of Tongass timber-volume inventory maps reveals the limitations of this approach.

1.1. History of timber-volume maps on the Tongass NF

In the early 1980s, photo-interpreters used stereo aerial photographs to delineate the Tongass NF into roughly 300,000 polygonal units of relatively homogenous land and forest character (ESCA-Tech, 1979). Roughly two-thirds of the Tongass NF was photo-classified as non-forested or unproductive forest. The remaining one-third, classified as productive forest, was delineated further based on visible differences in the forest canopy including texture, crown sizes, species, heights, density, and dead trees. These polygons were labeled according to age (greater than or less than 150 years), species composition, crown density, and timber-volume class (VC), VC4 = 8000–20,000 net board-foot per acre (nbf/a), VC5 = 20,000–30,000 nbf/a, VC6 = 30,000–50,000 nbf/a, and VC7 > 50,000 nbf/a).

All photo-delineated polygons were digitally transferred into computerized geographic information system (GIS) databases and made available for mapping. Most maps highlighted differences among timber-volume classes (VC4-7). These maps were used in several management and planning applications, including (1) forest stratification for ground-sampling inventory programs; (2) site-specific information for critical forest-management issues, such as wildlife-habitat modeling and timber-sale planning; and (3) administering the federal proportionality law (Tongass Timber Reform Act, 1990), designed to protect forest diversity by limiting the amount of logging in higher timber-volume classes.

In 1989, inventory specialist Jim Brickell conducted a statistical analysis of the photointerpreted (mapped) timber-volume classes by using ground-sampled inventory data (Brickell, 1989). Finding that the differences in timber-volume classes were not statistically different

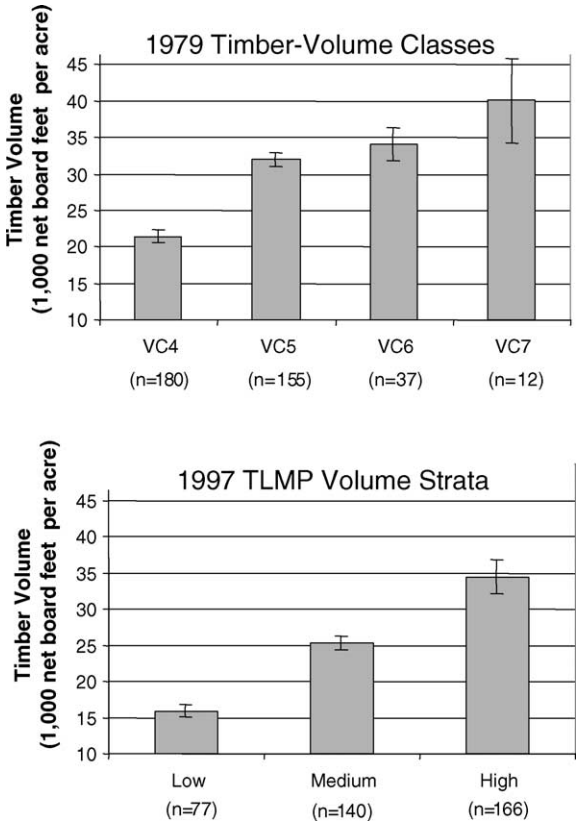

Fig. 1. Forest-wide timber-volume means and one standard error from 1980s inventory.

on the ground (Fig. 1), Brickell concluded that continued use of mapped timber-volume classes to represent distinct volume categories could not be justified statistically, and the three highest timber-volume classes (5, 6, and 7) could be lumped together without any appreciable loss of precision in the overall volume estimate. Brickell's conclusions, along with corroborating evidence from a timber sale in Kelp Bay, AK, provided the basis for a lawsuit that challenged the use of mapped timber-volume classes. A U.S. District Court judge ruled that the Forest Service's timber-volume classes represented arbitrary and capricious information for meeting the requirements of the proportionality law (U.S. District Court for the District of Alaska, 1994).

In preparing for the 1997 revision of the Tongass Land Management Plan (TLMP), FS staff found itself with a legacy of forest-management issues and federal regulations related to timber volume, but no