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MAPPING VEGETATION ACROSS THE NORTHWEST FOREST PLAN AREA: INTEGRATING TWO REMOTE SENSING APPROACHES

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The Northwest Forest Plan (NWFP, or Plan) was the result of a contentious socio-economic and environmental debate that constrained forest management options during the late 1980s and early 1990s. The Plan included strategies to protect the environment, provide economic assistance to affected communities with timber-based economies, and facilitate collaboration among federal agencies in managing natural resources of the area. Monitoring its implementation and effectiveness was recognized as an important component of the Plan. Key to monitoring was the establishment of consistent baseline maps of existing vegetation across all land ownerships of the Plan area. This paper describes that mapping effort.

The NWFP area consists of 56.9 million acres (23.1 million ha) of land in western Washington and Oregon and northern California. Of this, 24.4 million acres is administered by federal agencies included in the Plan (Forest Service, Bureau of Land Management, and National Park Service). The total area has been stratified into12 physiographic provinces, with four in Washington, five in Oregon, and three in California. The Forest Service in California (Region 5) has been using remote sensing to map vegetation cover on National Forest lands for nearly 25 years. During this period, they established an advanced digital remote sensing applications lab where they developed and applied a variety of vegetation mapping techniques in close collaboration with remote sensing scientists from academia. The Forest Service in Washington and Oregon (Region 6) had little experience with digital remote sensing until the late 1980s, at which time they began contracting with a private remote sensing consulting company to map vegetation on National Forest land within the region. Starting from these different regional mapping histories, the two separate mapping efforts were revised and expanded to provide NWFP baseline mapping across all ownerships.

For their effort, Region 6 joined forces with the local regional office of the Bureau of Land Management that had initiated its own remote sensing mapping program for its lands. This integrated mapping partnership became known as the Interagency Vegetation Mapping Project (IVMP), and was directed at developing a single, consistent set of final maps for the Washington and Oregon portions of the Plan area. The Pacific Northwest Research Station (PNW), which had developed significant experience in regional vegetation mapping with remote sensing, joined IVMP in an advisory capacity. Region 5 joined forces with a variety of national and state agencies, several of which had existing mapping programs. That partnership maintained unique mapping needs, but integrated those needs for regional mapping consistency across all California ownerships within the Plan area. The Region 5 effort became known as CALVEG (Classification and Assessment with Landsat of Visible Ecological Groupings).

To ensure consistency between IVMP and CALVEG baseline maps, a set of vegetation mapping standards was developed (i.e., Vegetation Strike Team, VST, Standards). These standards identified classes of tree cover (%), lifeform (conifer, hardwood, and mixed), size (quadratic mean diameter, QMD), and structure (single v. multi-story). Landsat image, digital elevation, airphoto, and field plot data were used in both projects.

IVMP conducted their mapping (ca. 1996) on a province-by-province basis to improve the relationships between image data and vegetation attributes. A mask was created to isolate forest land from non-forest land, with further detailed mapping only on forested land. Cover (by lifeform—conifer/needleleaf and hardwood/broadleaf—and total) and size were modeled as continuous variables using regression procedures. This was done to maintain maximum flexibility in defining classes by a variety of end users. The broadleaf class included hardwood trees, shrubs, grasses, and forbs, as these were not separable with the data and approaches used. In forested areas with low tree cover, a weak relationship between image data and size often resulted in poor size predictions. Under these conditions, QMD was mapped into broad size groups using standard image classification procedures. Cover by lifeform and size were mapped at the pixel level (i.e., 25 m). Because structure was considered more of a stand-scale rather than a pixel-scale phenomenon, it was modeled spatially (i.e., within derived polygons) by incorporating the cover by lifeform and size data in conjunction with other data sources.

CALVEG mapping (ca. 1994) was based on the integration of existing maps, with augmentation using new analyses. The first step involved development of polygons derived from the Landsat imagery that represent intuitively recognizable landscape patterns. Classification of thematic attributes was done separately for each attribute, such that they nested hierarchically. Lifeform was determined for each polygon by careful editing of existing maps, with reference to airphotos and plot data. Within tree and shrub lifeforms, several vegetation types (i.e., species alliances) were identified and each polygon labeled accordingly. Types were modeled using expert knowledge, as a function of geoclimatic location. Crown closure of each polygon was determined using a geometric-optical remote sensing model, the results of which were binned into 10% classes. Within vegetation type, the Landsat data were clustered into crown width classes that were subsequently translated into stem diameter classes. Structure was modeled within type-closure-size classes with the aid of plot data.

Assessment of a map's accuracy is necessary to inform users of the map's quality and, consequently, its suitability for intended uses. IVMP and CALVEG both used a quantitative assessment involving the comparison of predicted values or classes of places on the maps against reference observations for the same places on the ground, the values of which were considered to be true.

IVMP used a traditional error matrix approach to calculate proportions of reference plots correctly classified. Error matrices were provided for all mapped variables. Accuracies were reported for VST Standard classes and for a broader set of classes more relevant to monitoring. Overall map accuracies for IVMP ranged from about 40% to 80% percent for 20% canopy cover by lifeform classes, 60% to 80% for two QMD classes, and 55% to 90% for the 2-class structure map.

Accuracy assessments for CALVEG were reported for lifeform, canopy closure, and size classes using both traditional and "fuzzy" class membership rules. Overall map accuracies within lifeform classes for four classes of canopy closure range from about 75% to 85% using fuzzy rules and from 50% to 70% using traditional rules. For tree size, accuracies for six classes ranged from about 70% to 80% and 40% to 60% using fuzzy and traditional rules, respectively. Structure accuracies were not reported.

Each map user group had specific needs with respect to the IVMP and CALVEG map products. Consequently, integration of these products was done informally by each group. For example, to create a spatially consistent map for the late successional and old growth status and trends analysis, the original, more specific map data were uniformly aggregated into a total of 22 broader classes, based on lifeform, cover, size, and structure. Then, three "older forest" maps were created using different rules sets to examine effects of these rules on amount and distribution of mapped older forests at the start of the Plan. Other monitoring programs used IVMP and CALVEG maps and user-specific rulesets to model, for example, amount and distributions of habitat suitability for the northern spotted owl and marbled murrelet.

Given differences in history and experience by the various agencies involved in mapping vegetation prior to the NWFP, two separate, but coordinated efforts were directed to develop baseline vegetation maps for the Plan area. Similar data sources were used by the two groups, but methods were different. To encourage uniformity and consistency in the final map products, a set of standards were derived and each group was directed to meet those standards. As a result, for many (if not most) monitoring applications the two sets of map products could be readily combined and effectively used. However, the team that developed the standards could not foresee implications for all possible uses of the map products. As such, for some monitoring applications, inconsistencies between the maps had meaningful impacts. For example, for the owl and murrelet monitoring efforts, models were able to exploit the spatial variation in the pixel-level IVMP maps. The polygon-based CALVEG maps did not contain this level of spatial detail, as their was no VST standard for this map characteristic.

The remote sensing derived maps for the NWFP are key to monitoring the effects of the Plan on forest characteristics and wildlife habitat within the Plan area. This largely successful effort has facilitated the success of important analyses designated at the start of the Plan. The role of remote sensing in the future of the Plan must now be considered.

STATUS & TREND REPORTS CONCURRENT SESSIONS- Old Growth and Late Successional

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