low the individual tree to grow above a 6 percent value growth rate until the next cyclical harvest. Aggregations stocked at levels above or below that range were characterized as "dense" or "sparse" respectively.

In practice

A tree with its crown in the overstory (top tier) is visually grouped with adjacent trees of similar diameter and spacing class. Basal area spacing classes are translated into square-foot spacing rules. For example, at sample point "A" all trees between 12 and 18 inches DBH within 15 to 20 feet of each other would constitute one aggregation in the "adequate" small-sawtimber type. Additional sophistication can be introduced by recognizing groups defined by two different diameter classes (existing in different canopy levels).

Analogy to even-aged management theory suggests that if each aggregation type occupies equal (productive) areas the compartment will be maintained in a regulated condition. As previously stated, individual aggregations are not mapped; instead, a simple transect or sample grid is utilized to estimate the percent of area occupied by groups of each type. This process is accomplished simultaneously with the "familiarization walk" customarily taken by the forester.

Cutting cycle length was determined by the usual marginal analysis. The length of time that an adequately stocked aggregation will continue to increase in value at an acceptable rate was found to be six years. Given growth rates common in Blodgett Forest, individual aggregations will move from one type to the next every second cycle with large sawtimber conifers ranging from 60 to 70 years old. This maximum size and age range compares well with even-aged stands managed to maximize cubic volume wood production as well as satisfy economic decision criteria.

Marking rules were specific for each aggregation type and designed to achieve two basic objectives. First, the areas occupied by each type had to be balanced. This was accomplished by prescribing regeneration harvests (group selections) in the large-sawtimber type and some overstory removal cuts in dense medium-sawtimber aggregations with releaseable sapling understories. Second, dense merchantable types were reduced to adequate stocking levels. If economically justified, rules may be developed to guide pre-commercial thinnings or other cultural activities. The correct amount of area must be occupied by seedling, sapling, and pole aggregations to sustain future yields.

In each case the rules are simple and are directly tied to the specific aggregation requiring treatment, not to some hypothetical "average acre." Furthermore, relatively complex silvicultural prescriptions may be translated into simple rules which can be efficiently implemented by work crews.

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Forest fuel management

Ronald H. Wakimoto

The forest residues that accumulate as a result of logging, road construction, and natural mortality are an important source of stored nutrients, wildlife habitat, and insect and disease habitat. They also represent a fire hazard, as well as a potential source of energy or additional fiber, and the size and intensity of many recent wildfires are linked to these residues. Long-term fire exclusion has also greatly increased fuel loadings in highly productive mixed conifer forests, further adding to wildfire intensity and fire management problems.

In response to these problems, researchers have found that the quantity and quality of harvest residues from regulated forests differ from residue from old growth stands. One ideal regulated forest is at the University of California's Blodgett Experimental Forest, where residues production and fuel management are studied. Until recently these subjects had been neglected in California in favor of fire suppression technology.

Currently U.C. is cooperating with the California Department of Forestry to study the feasibility of utilizing logging residues for energy. Cull logs and slash material down to pieces, 4 feet long and 4 inches in diameter at the large ends, are being gathered by grapple skidders and chipped on-site. A before-and-after treatment fuel inventory is being analyzed. Damage to the residual stand of trees is also being studied.

The effort that is put into preharvesting decisions and operations is probably more important than any stop-gap treatment that can be applied after harvesting. To make sound *a priori* decisions in fuel management, ways must be developed to estimate the quantity and quality of residue production before harvesting.

The use of broadcast burning to manage forest residues has been widely practiced in the Pacific Northwest by public and private forest organizations. Prescribed fire has proved economical and effective in proper ecological settings. In California insufficient research has been conducted. Furthermore, there exist no areas where the use of broadcast burning for slash management has been demonstrated and related to economic, ecological, and social information.

Fuel-loading additions from small nonmerchantable understory trees crushed by logging equipment are frequently excluded from preharvest fuel estimation techniques. This will be closely analyzed at Blodgett. Efforts will concentrate on white fir and incense-cedar *(Calocedrus decurrans)*, two shade-tolerant species that appear to contribute great quantities of post-harvest fuels.

Additional prescribed burning research involves the effects of fire on forest pathogens and insects, wildlife populations, and forest stand structure and species composition. Burning prescriptions and guidelines are being developed for forest harvest residue management and silvicultural manipulation. The quantity, quality, and distribution of slash fuels left from both even-aged and uneven-aged management differ greatly from the fuels of the natural forest floor. Burning prescription research will identify fuel consumption and fire-intensity controlling variables so that replication of a desired fire will be possible.

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