A new approach to uneven-aged silviculture and management of mixed conifer-oak forests

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Wherever timber is part of the many forest values to be utilized, foresters are expected to choose between two broadly defined silvicultural and management systems: *even-aged management,* popularly characterized by clearcutting, shelterwood, or seed tree regeneration harvests, and *uneven-aged management,* employing either individual tree or group selection harvests. Harvesting is merely one component in a particular silvicultural system. Continuous controversy has been generated over each system's merits.

The selection system, as classically defined, is not practiced in California's mixed conifer-oak forests. National forests are generally committed to gradual conversion to even-aged management; most private industrial forests cut to diameter limits or use some type of partial cutting, dictated by a fluctuating market and taxation policies, as well as silvicultural concerns.

This situation reflects the difficulties in simultaneously converting from old growth pine to a young growth, mixed-species economy and from unmanaged to regulated forest. Regulation involves control of growth and yield by periodic harvests to maintain ideal stocking levels. The principal dilemma is that "ideal" uneven-aged tree diameter distribution, adopted by western foresters from European and eastern United States literature and applied to mixed conifer-oak forests via individual tree selection harvesting, has not fostered sufficient regeneration or adequate growth of younger and small diameter trees.

Furthermore, to date, no method has proved useful for regulating small group selection harvests with the result that foresters today have neither the complete theory nor the practical skills required to sustain intensive uneven-aged management of young growth, Sierra-mixed conifer-oak forests.

Blodgett studies

To help resolve the biological and economic problems associated with intensive forest management, studies are in progress at U.C.'s Blodgett Forest Research Station in Eldorado County. The forest, at between 3900 and 4800 feet (1188 and 1462 meters) elevation, has 2961 acres (1186 hectares) arranged in 78 management compartments, which average 40 acres (16 hectares). The various compartments are operated under either even-aged or uneven-aged silvicultural systems or remain unmanaged, and comparisons are being made about timber output, economic feasibility, soils, wildlife, visual quality, pest management, and fuel management.

Past efforts to implement intensive uneven-aged management at Blodgett have concentrated on methods to achieve specific stocking goals: species composition, maximum diameter limits, residual growing stock volume levels, and inverse J-shaped diameter distributions. These "ideal" goals were based on marginal analysis of projected growth and yield (cubic or board foot) in relation to residual stocking levels and cutting cycle lengths. The overall objective was to achieve a given rate of return on the capital (timber and land value) investment.

Operationally, the desired residual growing stock volume was converted to a basal area level with compartments marked for cutting by square-foot spacing guides for broad (4-inch) diameter classes. Species were ranked in order of preference and minor deviations from general spacing guides were allowed to reconcile discrepancies between existing and desired diameter classes. An intensive network of inventory plots was required to produce reliable data about the "average acre" in any given compartment.

This relatively complex method appeared workable and each silvicultural prescription writer and timber marker gained in sophistication. Markers began to rely on their own perception of pattern of "clumpiness" in vegetation to resolve apparent discrepancies between "average acre" inventory data and actual conditions which vary considerably from acre to acre. Furthermore, poor regeneration of intolerant species necessitated locating (½-1-acre) openings suitable for pine seedling establishment in each compartment. These results led to the development of a regulation control method based on the "aggregation" approach to characterizing tree vegetation.

Aggregation approach

This approach recognizes that the mixed conifer-oak forest has many discrete homogeneous vegetation aggregations (groups) ranging from less than 1/100 acre (.004 hectare) to more than 1 acre (.4 hectare) and distinguished by different height or diameter classes, species composition, and density. Because each develops differently over time, accurate prediction of growth, yield, and future age and size class distribution requires aggregation-based analysis. Specific "recognition variables" can be utilized to insure that different managers will consistently recognize the same aggregations. Finally, many widely scattered aggregations with similar characteristics can be assigned to one aggregation type for analysis.

Thus, a limited number of aggregation types becomes the basis of silvicultural analysis, compartment regulation, and marking guides. Compartment regulation is developed from a summation of discrete even-aged analysis units (aggregation types), each with predictable growth and yield. With a simple rapid step-point transect each aggregation type's total area is estimated. Volume, growth, and yield data are developed from inventory plots located in a sample of aggregations from each type. Location, size, volume, and growth of each aggregation is *not* recorded; instead, a simple marking guide is written for each type.

This approach can be varied according to economic realities and desired management intensity merely by selecting "recognition variables" of suitable ranges and employing different degrees of lumping into aggregation types.

Application

A description of how this approach was applied to a 40-acre compartment (230U) on Blodgett Forest should prove useful. Slopes range from 10 to 30 percent on a north to northeast aspect between 4,300 feet to 4,600 feet elevation. Current volumes average 25 thousand board feet (Scribner)/acre (385 M^3/hectare) at 240 $ft.^2$/acre (55 M^2/hectare) basal area of mixed conifers and oak. Growth averages 1.2 MBF/acre (14 M^3/hectare). The recognition variables used to identify plant aggregations included a plant descriptive element and a spacing element.

The descriptive element employed was tree diameter (DBH). Utilizing marginal physical growth analysis it was determined that 26 inches (66 cm) DBH trees were the largest (actual range was 22 to 30 inches, depending on species) that could remain after cyclical harvest and continue to grow above 6 percent value growth rate. Next, merchantability standards in the Blodgett Forest area and the economics of various cultural activities were examined. As a result six diameter classes were recognized: trees less than breast height, *seedlings; saplings,* 0 to 6 inches (0 to 15 cm); *poles,* 6 to 12 inches (15 to 30 cm); *small sawtimber,* 12 to 18 inches (30 to 46 cm); *medium sawtimber,* 18 to 26 inches (46 to 66 cm); and *large sawtimber,* more than 26 inches.

The spacing element was based on previously determined desirable basal area stocking levels. "Adequate" stocking for each aggregation type was defined as a basal area range that would al-

Livestock grazing in national forests

Innovative research completed in annual forage production and begun in forest grazing practices during the past half-decade by U.C.'s Department of Forestry and Resource Management will benefit users of California's rangelands.

Research into site-specific management of annual range production, begun by Harold Heady and continued by James W. Bartolome, have significantly refined methods for defining variations in the productive capability of annual rangelands. Results have shown how management of plant residue can, within the limits of site potential, maximize forage productivity the following year.

The 6 million hectares of annual rangeland in California vary tremendously in site potential. Three major zones of annual rangeland require differing management for optimal productivity. Proper use by livestock leaves no less than 1100 kg/ha of plant residue at the end of the season in the zone of highest mean annual rainfall (more than 100cm), 800 kg/ha in the extensive zone with between 100 and 25 cm of mean annual rainfall, and about 500 kg/ha in the zone with less than 25 cm mean annual rainfall. These guidelines are the first site-specific, quantitative aids to proper use on annual rangelands.

Bartolome and researcher Barbara H. Kosco are changing the traditional views concerning grazing use of mixed conifer forests. Opportunities for the simultaneous use of forested ranges by timber and livestock producers to their mutual benefit have not been studied in California, but research at Blodgett Forest shows that carefully controlled cattle grazing has potential as a silvicultural tool, reducing the need for other forms of brush control in conifer plantations, not as a cost, but as an additional productive output. Logging practices and silvicultural treatments strongly influence the amount and quality of forage produced in openings created by harvest. Forage for wildlife or livestock can be enhanced through the use of improved techniques in prescribed burning, slash disposal, and seeding and planting.

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

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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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