

## RESIDUE MANAGEMENT IN THE EASTSIDE PINE TYPE

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### ABSTRACT

Several characteristics of the eastside pine type in northeastern California have significant implications for residue management. A net result of these characteristics is that residue management, at least for reducing fire hazard, is more cost-effective in the eastside pine type than in most other California forest types. Residue management decisionmaking should be based on economic criteria that consider all land management values and costs. Expanding opportunities for increased wood fiber utilization in the eastside pine type will provide multiple benefits, including added incentives to improve and intensify forest management. Where utilization opportunities are not yet available, alternative residue treatments may be needed.

### INTRODUCTION

Forest residue has been defined as "the unwanted accumulation in the forest of living or dead, mostly woody material that is added to and rearranged by man's activities such as forest harvest, cultural operations, and land clearing. Forest residue includes slash materials, excessive litter on the forest floor, unwanted living brush and weed trees, and standing dead trees and snags" (Cramer 1974). Use of the term residue in this paper differs in two significant respects from the definition given: Living plants are excluded from residues--although they obviously are important in many aspects of land management; "unwanted" is omitted, so that at least some residues can be viewed as useful--whether removed for utilization or left on the site to help meet resource management objectives.

"Residues" and "fuels" often are used interchangeably. Strictly defined, fuels are viewed only from the standpoint of fire management--that is, how they will burn, and the implications thereof for various resources. Residues and methods for manipulating them,

however, potentially have both fire-related and nonfire-related effects on virtually all forest resources. To emphasize this more comprehensive viewpoint, the term residues is used mainly in this paper.

Several characteristics of the eastside pine type in northeastern California have significant implications for residue management. The first relates to past management practices, and is common to most major California (as well as other Western United States) forest types: fire exclusion and inadequate treatment of activity-produced debris have resulted in excessive accumulations of residues. This material can increase wildfire hazard, adversely affect a number of resources, and complicate current management activities, including residue management.

Other relevant attributes are more distinctive to the eastside pine type. Climatic regimes favor slower residue decomposition rates (Wagener and Offord 1972) and higher conflagration potentials than those in other California types. Compaction of fuelbeds by snow, with attendant reduced fire hazard and enhanced decomposition, is less effective than in the adjacent mixed-conifer and true fir types. Volumes of slash produced are generally less, however, because of lower stocking levels and less cull material in eastside pine. Moreover, several factors collectively make more options available and tend to reduce costs of residue management in the eastside pine type: (1) The mostly gentle terrain and relatively low stocking levels provide easier access into stands for both utilization and machine treatment of residues; (2) mechanical damage to pine boles from logging and residue treatment activities, while certainly undesirable, is less likely to lead to decay or other problems than in many other species, notably the true firs; and (3) the type has developed in the presence of frequent periodic fires, and is better adapted than most other types to use of fire as a management tool. These attributes imply that residue management, at least for fire hazard reduction, is more cost-effective in the eastside pine type than in most other California

forest types.

One result of fire exclusion during the past several decades has been the increased prevalence of tolerant conifers, especially California white fir (Abies concolor var. lowiana [Gord.] Lemm.), in the understory of higher-elevation eastside pine stands. To the extent that California white fir is featured in management, use of prescribed fire for residue management or other purposes usually must be restricted. Young California white fir is extremely susceptible to fire damage.

Utilization of previously unused woody material for fiber products and fuel is becoming an increasingly significant component of residue management. Although this trend certainly is not unique to the eastside pine type, current and projected demand for such uses, particularly fuel for heating homes and generating power, is growing rapidly compared with many forest areas in the state. As economic considerations favor increasingly intensive utilization, we may expect residue treatment problems gradually to disappear for much of the eastside pine type, to be supplanted by problems of determining the amounts and kinds of residues that should be retained on the site.

#### RESIDUE MANAGEMENT DECISIONMAKING

The critical step in residue management is the decisionmaking process, through which the most cost-effective mix of utilization, treatment, and retention is determined. A clear definition of overall land management objectives for an area is an essential prerequisite to residue management planning, as it is to other land management components. Objectives for private and public lands differ, and residue management practices tend to differ accordingly. Methods used by the Forest Service, U.S. Department of Agriculture, will be emphasized in this paper because: (1) Residue management activities of the Forest Service are more diverse than those of most other landowners and, therefore, probably encompass the needs of other landowners; (2) the economic criteria emphasized in current Forest Service fuel management policy should be applicable to all landowners; and (3) Federal lands comprise a large portion of the eastside pine type in northeastern California.

A number of fire and fuel management tools developed during the past 10 years have facilitated planning by lending objectivity and consistency to the fire-fuels data on which residue management decisions are partly based. The tools include methods to inventory existing residues (Brown 1974, Maxwell and Ward 1976) and to predict slash (Brown and others 1977, Snell and Brown 1980) that will result from timber harvests or other activities.

With time, money, and manpower constraints, many eastside pine fuel management specialists are leaning away from the more accurate but more time-consuming planar intersect method (Brown 1974) for routine inventory needs. In its place they often use the photo series--that by Blonski and Schramel (1981) for natural residues, and by Maxwell and Ward (1976) for activity residues. These specialists believe that the photo series yield cost-effective inventory data of adequate accuracy, considering the sensitivity of relevant decisions to errors in residue data. (Fuel specialists, however, ought to periodically calibrate their photo series estimates against the planar intersect method for their specific fuel complexes.) Also, the photo series provide an excellent means of communicating with specialists in other disciplines about desirable amounts and types of residues to leave on a site.

Residue inventory data (including slash prediction data) are used in at least three general ways:

1. They help define the wildfire hazard attributable to current fuel complexes and to those projected to result from alternative treatment methods. Based partly on inventory data, these fuel complexes are given resistance-to-suppression ratings, and are assigned to the appropriate stylized fuel models (Albini 1976, Deeming and others 1977). For each fuel model, the accepted fire-spread model (Albini 1976, Rothermel 1972) predicts spread rate and intensity as functions of fuel moisture and wind-speed. With the help of historical weather and fire occurrence data, ignition probabilities, and suppression force capabilities, alternative residue management plans are translated into alternative probabilities of fires of given sizes and intensities (Hirsch and others 1981). These results, when applied to known values at risk and available information on fire

effects, yield estimates for probable net resource value loss from wildfire for each alternative treatment.

2. Estimates of residue weights by size classes provide a basis for assessing effects that are nonfire-related--for example, nutrient capital and cycling, wildlife habitat, and access for management activities.
3. Inventory data indicate utilization potential and suggest types of treatment methods that operationally may be practicable.

Timber and other resource specialists should be involved in residue management planning to the extent of ascribing resource values--positive or negative--both to the retained residues and to the treatment methods. As residues are utilized more extensively, it will become more important to be able to define the benefits of retaining portions of the material on the site. Environmental effects of residues and methods of residue management form an extremely broad and complex subject that relates to virtually all forest resources. The residues compendium (Cramer 1974) offers the best available compilation of such information. Much of its extensive coverage of the eastside pine type of Oregon and Washington can be applied to the type in northeastern California.

A companion publication (Pierovich and others 1975) provides specific residue management guidelines designed to optimize environmental effects. Among the criteria by which guidelines are sorted are type of ownership (public and private), management activity (including silvicultural operations), and timber species association (including equivalents of the eastside pine type). The guidelines represent a consensus of many experts, and warrant use at least as checklists of significant considerations for residue management.

From the standpoint of wildfire hazard, resource specialists should be aware of the tradeoffs among benefits accruing from management activities, costs and effects of treating residue generated by the activities, and costs attributable to probable loss from wildfire. Ideally, they should define acceptable wildfire losses for their resource areas (for example, tolerable burned acreage within a given time frame by degree of resource damage and productivity class) as a basis for

deciding on residue management strategies.

Formalized procedures designed to facilitate various aspects of residue management decisionmaking (Hirsch and others 1981, Pierovich and others 1975, Weatherhead 1977) have not been used to any extent in California's eastside pine type. The Forest Service uses the interdisciplinary team process. Whatever the process used to develop them, residue management plans should be compatible with overall management objectives, and should be based on economic criteria that consider all land management values and costs, both current and within reasonable planning horizons.

Forest Service fuel management policy requires that evaluation of alternative fuel treatments (including utilization) culminate in a plan that minimizes costs (fuel treatment plus other fire program costs) plus net resource value change (including probable loss from wildfire). The appropriate degree of detail and explicitness for such an economic analysis (Schweitzer and others 1982) may differ considerably, depending on objectives and complexity of management. And assigning common dollar values to diverse resources is difficult at best. Economic criteria, however, can provide a sound conceptual framework for analysis of residue management alternatives for both public and private forest managers.

## UTILIZATION

In considering alternative methods of residue treatment, utilization clearly should be given first priority for disposition of material excess to on-site resource needs. For eastside pine managers, several items are pertinent.

Increased utilization provides multiple benefits, including effectively increasing forest productivity, bringing additional revenues to the landowner, helping to meet demands for energy and fiber products, encouraging more intensive silvicultural practices, reducing management problems associated with excessive residues and their treatment, and reducing public perception of waste. Strictly speaking, previously unutilized material that now is removed as part of a timber harvest or precommercial thinning is simply additional product, and never becomes residue. As merchantability limits for small trees drop from 8 or 10 inches to 3 or 4

inches d.b.h.--a change actually beginning to take place in a few areas of the eastside pine type--precommercial thinnings can become commercial thinnings. Besides alleviating residue problems, such a change obviously improves the economics of thinning in young stands.

Economics of increased utilization depend strongly on accessibility of residues and availability of local markets. As indicated earlier, terrain in most of the eastside pine type is relatively accessible, and current and projected demand is increasing rapidly. Home-use fuelwood represents the greatest current demand for residues in much of northeastern California. Woodcutters from Reno, Nevada, and vicinity dominate a large area, but demand from smaller communities also has grown rapidly as costs of other means of home heating have risen. Fuelwood cutters on many Forest Service ranger districts are directed to specific areas in which their activities help to meet residue management objectives. In some instances, the demand is harnessed to accomplish thinning in young leave-tree-marked stands.

Demand for chips and hog fuel from forest (as opposed to mill) residues is limited and fairly localized at present. If proposed power generation facilities at Burney, Wendel, Bieber, and elsewhere in northeastern California come on line as planned, however, an annual demand of several hundred thousand dry tons of hog fuel will develop during the next 5 to 10 years. Much of it will come from the eastside pine type. Plants utilizing hog fuel from forest residues will have to compete with other, usually higher value uses, such as poles and chips, the demand for which should rise steadily. And public land managers probably will continue to make fuelwood available to the public, despite the development of competing uses of higher dollar value.

Considerable information is available concerning planned residue-using facilities in northeastern California (for example, Sverdrup/Sverdrup Technology, Inc. and Resource Management Services, Inc. [1981]). Eastside pine managers should be knowledgeable about present and planned residue utilization facilities in their market area, and view these as opportunities to intensify and improve land management.

The economic analysis for residue manage-

ment planning referred to earlier can be helpful in this context. Theoretically at least, in areas where the economics of utilization are marginal, land managers should be able to subsidize the removal of residues for utilization to the extent of avoided treatment and resource costs. The Forest Service is exploring ways to use such subsidies equitably, along with other means--for example, long-term contracts to ensure stable supplies of material--designed to encourage development of markets for previously unutilized wood.

National Forests in California have for a number of years included yarding unmerchantable material (YUM) provisions in many of their timber sale contracts. One purpose is to encourage increased utilization. Most ranger districts in northeastern California put YUM provisions in their sales that include old-growth ponderosa (*Pinus ponderosa* Dougl. ex Laws.) and Jeffrey pine (*Pinus jeffreyi* Grev. & Balf.), even though incidence of cull in these species is relatively low. Almost invariably, YUM decks on these sales disappear promptly. They may be removed by the purchaser, sold competitively, or made available to the public for fuelwood.

Larger residues are less expensive to harvest and have more potential uses than small branches and foliage. Improved utilization thus tends to reduce the amount of large material differentially. Significantly, this size bias fits nicely with some land management concerns. Most nutrients contained in trees are concentrated in foliage and small branches. Removal only of material larger than, say, 3 inches in diameter, therefore, removes relatively little of the nutrient capital of the site. From the standpoint of fire hazard, removal of larger material with limbing on site would not affect the amount of more flammable small fuels. Fuelbed depth would be expected to decrease, however, thereby reducing fire intensity and rate of spread. Also, removal of larger material reduces resistance to suppression, probability of spotting, and fire holdover problems. Further treatment in some instances will be unnecessary. If additional residue treatment--probably prescribed fire or crushing-mastication--is considered necessary, the job will have been simplified by prior removal of large material.

As suggested earlier, a principal management problem associated with increased utilization is to ensure that adequate material is retained on site. Feller-bunchers or other whole-

tree yarding methods probably will be favored for harvesting small trees because of their greater efficiency. Regardless of whether whole trees are chipped and utilized or limbs are removed and disposed of at landings, the small, nutrient-rich component of biomass is lost from the site. Managers will need to develop contract provisions, therefore, to ensure retention of enough such material to maintain site productivity. Also, retention of some larger material may be necessary for purposes such as wildlife habitat, soil protection, site amelioration for regeneration, and maintenance of essential mycorrhizal and other microbiological relationships.

### TREATMENT METHODS AND PRIORITIES

Where utilization opportunities are not yet available, managers should consider alternative residue treatments using the economic criteria cited earlier. This section briefly describes the major residue treatment methods used in California's eastside pine type. The methods, which are widely used in many forest types, are not expected to be replaced significantly by other treatment techniques, because the need for treatment gradually should lessen as utilization increases. Properly chosen treatment methods can accommodate needs to retain specified types of residue on the site. The discussion is organized by silvicultural methods of cutting, with primary emphasis on precommercial thinning.

Use of prescribed fire is mentioned only in passing because it is the subject of a separate paper in this symposium. The point should be made here, however, that because eastside pine is so well adapted to periodic fires, prescribed fire has perhaps greater potential as a tool for residue management and ecosystem maintenance than in any other California forest type.

#### Precommercial Thinning

The guides that follow are adapted from the Forest Service's Pacific Southwest Region Silvicultural Practices Handbook (1979 draft). Based primarily on considerations for fire management, they are recommended as an aid to setting priorities for residue treatment needs in precommercially thinned stands of the east-

side pine type. They assume no current or imminent prospects for utilization; however, they could be used also in deciding where to concentrate utilization activities.

Characteristics of stands having high priority for thinning slash treatment are these:

1. Larger trees. Stands of trees at least 15 to 18 feet in height<sup>1/</sup> generally have canopies sufficiently high that fuel treatment offers a reasonable chance of keeping a fire on the ground and permitting most trees to survive. Also, the greater age of such stands represents a larger investment to protect from wildfire loss.

2. Little shrub cover. The few shrubs contribute little to overall flammability, so slash treatment alone will substantially reduce fire hazard.

3. Flat or gently sloping terrain. Equipment can be used to treat slash more cost-effectively and control wildfires more quickly than on steep slopes.

4. Nearby areas of high value or high hazard.

Characteristics of stands with lower priority for thinning slash treatment are these:

1. Smaller trees. Most trees in stands less than 15 to 18 feet in height<sup>2/</sup> are likely to be killed by a wildfire burning under moderate conditions, regardless of fuel treatment.

2. Abundant shrub cover. In stands with highly flammable dense mature brush, slash treatment alone will do little to reduce overall fire hazard. However, such stands in which concurrent slash and brush treatment (perhaps with mechanical thinning) is planned, for both fire-hazard reduction and release, warrant a higher priority for treatment.

3. Steep slopes. High rates of spread and severe stand damage from wildfires are more probable. Mechanical slash treatment and fire suppression within the stand are more difficult.

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<sup>1/</sup> Tree size threshold is a rough estimate only, and should be adapted to specific stand conditions and probable fire behavior.

<sup>2/</sup> Ibid.

4. Nearby areas of low value and low hazard.

These guidelines suggest two related management inferences concerning fire hazard in precommercially thinned stands: (1) Stands should be thinned as early as possible consistent with expression of dominance and suppression of competing vegetation. This recommendation applies to areas with no immediate prospects for utilization of small poles. (2) Competing shrubs should be controlled for purposes of fire-hazard reduction as well as for improved tree survival and growth.

The most widely used slash treatment method in precommercially thinned eastside pine stands is lopping and scattering. Often this is accompanied by bucking of boles to reduce resistance to suppression. Used alone, lopping-bucking is the least expensive, but also the least beneficial slash treatment with respect to hazard reduction. It can be an effective pretreatment, however, to facilitate subsequent use of prescribed fire in stands where the latter is practicable. In contrast with other residue rearrangement techniques and prescribed fire, lopping has little or no value in reducing susceptibility of pine thinning slash to Ips attacks.

A variety of slash treatment equipment--machines that rearrange residues by chipping, crushing, or masticating--has been evaluated (Harrison 1975, McKenzie and Miller 1978). McKenzie and Miller (1978) dealt exclusively with equipment for treating precommercial thinning slash and accomplishing combined mechanical thinning and slash treatment. They cited operational costs, production rates, terrain conditions, and related data for a number of machines and locations, including some in north-eastern California. The practical size limit for effective treatment by most of these methods is about 4 to 6 inches. Also, leave-tree spacing must be wide enough to permit satisfactory machine operation. Overall use of machines for crushing and mastication in north-eastern California appears to be declining, apparently the result mainly of increasing utilization.

Crushing by tractor trampling and Tomahawk<sup>3/</sup> have been the most widely used of these

methods in California's eastside pine type. They produce significantly better fuelbed compaction than lopping. Both require a period of drying of residues to get adequate breakage. Managers seem about evenly split in their assessments of the relative cost-effectiveness of the Tomahawk and tractor trampling. Machine crushing can provide an effective pretreatment for prescribed burning in some stands.

Vertical shaft cutters such as Trakmac (now Shar) and Hydro-Ax treat residues more completely than tractor or Tomahawk crushing, at somewhat greater cost. They are much more effective in reducing brush, and have been used on several occasions in plantations for simultaneous fuel treatment and release from brush. Both machines are capable of mechanical thinning, although the Trakmac/Shar can exercise more selectivity and, therefore, is better suited for this purpose. A potential drawback to use of these machines in precommercial-sized stands is the fact that they hurl wood fragments at high speed, which may damage young trees (McKenzie and Miller 1978). Actual experience of users in this regard has varied considerably, evidently depending upon the specific type of machine, operator skill, and stand and site conditions.

Chipping in precommercially thinned stands is expensive and usually limited to roadsides, fuelbreaks, or recreation areas. Hand piling and burning, also expensive, may be applied in the same types of areas in which chipping is used, as well as on slopes too steep for machines.

#### Commercial Thinning

Commercial thinning is not widely practiced in the eastside pine type. Where such cuttings are made, slash is treated mostly by lopping and scattering and tractor piling (including concentration piling). In some areas tops are removed from the woods with the last merchantable log for utilization or disposal at the landing. Some prescribed burning is done where slopes are too steep or stand densities too high for machine access. Crushing and mastication treatments could be used, but evidently have not proven cost-effective.

#### Overstory Removal

Overstory removals comprise much of the commercial cuttings in the eastside pine type. Size of understory varies from seedlings to small sawtimber, and density and distribution

<sup>3/</sup>Trade names and commercial enterprises or products are mentioned solely for information. No endorsement by the USDA is implied.

of overstory and understory vary widely. These and other variables influence feasible residue treatment methods. Most Forest Service sales include YUM provisions. Most of the remaining material is treated with the old standbys--lop and scatter, and pile and burn. Prescribed burning enjoys some use in stands with larger understories. Special care must be exercised in carrying out residue management activities in overstory removal stands to avoid unnecessary damage to understory crop trees if, indeed, the understory is manageable.

#### Regeneration Cutting

Relatively little regeneration cutting is practiced in the eastside pine type at this time. Most of these cuttings are clear-cuts, including some small openings approaching group selection cuttings. Residue treatment usually consists of YUM followed by tractor piling and burning.

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