1973
USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-7

CHOOSING Forest Residues Management ALTERNATIVES

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PORTLAND, OREGON

This paper was presented before Commission VII, "The Industrialists," at the Seventh World Forestry Congress, Buenos Aires, Argentina, October 4-18, 1972,

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SUMMARY

Forest residues include logging, road construction, and silvicultural slash or debris and all living or dead woody fiber which may be unwanted because of management problems in the forest ecosystem.

Residues must be managed **with** forest resources. Management involves disposal, modification, or utilization for wood products. The costs and benefits of the several alternatives available to forest managers must be evaluated in relation to land management goals and constraints. The need for a decisionmaking framework for this purpose is demonstrated by problems and opportunities categorized in four areas: **(1)** unused wood fiber, **(2)** conflagrations, **(3)** impairment of forest resources, and **(4)** opposition to treatment of residues.

Whether much of the wood fiber left on timber sale areas is truly not usable depends on many economic factors, including direct costs of delivery to a processor and the local supply of similar wood. Public concern over environmental pollution or resource depletion from processing competing nonrenewable resources may, in time, radically increase **wood** demand, but this is uncertain.

If residues are to be removed and used, incentives must be identified and provided to timber buyers. Buyers and sellers both will benefit if sellers will make residues available at a reduced stumpage charge and thus write off a portion of yarding costs for inclusion in subsequent cleanup. Buyers need assurances of reliable supplies of **wood** and predictable prices. Processing feasibility studies made by landowners themselves could help with development of such assurances.

Advance modification of fuels or installation of fuelbreaks on strategic locations may be the best residue management for fire control, but probable loss must be weighed against cost. Examples of impairment of forest resources by residues include obstruction to access, esthetic deterioration, and decreased water quality. Objections to residue treatment originate in concerns ranging from the need to meet air-quality standards to the potential for depletion of plant nutrient reservoirs.

To encompass the spectrum of considerations necessary for choosing the best residue treatment, a simple framework is proposed--essentially a formalization of systematic thought processes used by forest managers. This framework provides for comparisons between anticipated consequences of residue treatment alternatives and established land management ***goals***; it **will** make possible a dialog with a concerned public.

The proposed framework will use quantitative data on costs, benefits, and probabilities, but the opportunity exists to use qualitative data until research results become available. Current research and development related to residues include a recently published conflagration control guide (Dell 1972) and a review of the state-of-knowledge on the biological and physical effects of residues and residue treatments. Other data will result from studies in progress and from a simulation model for determining the feasibility of residue utilization for specific areas.

Keywords: Wood residues, forest management.

INTRODUCTION

Choosing an optimal alternative for forest residue management involves more than merely pursuing an acceptable method of solid waste disposal, or setting a level of expenditures for logging slash disposal, or determining how much wood fiber utilization is feasible. Management of most forest properties, particularly public forests, is increasingly based on the concept of multiple use. Multiple use means balancing the output of several major goods and services: wood, water, recreation, wildlife, and forage. Accumulations of woody residues in the forest can cause protection problems and will frequently interfere with efficient use or enjoyment of the forest. It is apparent that residue management must become part of the overall scheme of forest management.

The purpose of this paper is to suggest a framework for making residue management choices compatible with the often multiple forest management goals established for a given forest area. In order to develop the framework, we have defined forest residues more broadly than is commonly encountered:

> Forest residues include logging, construction, and silvicultural slash or debris, and all living or dead woody fiber which can pose management problems because these may be detrimental to the forest ecosystem as used by man.

This definition permits a systematic appraisal of man-caused slash along with litter and other woody fiber as potential sources of management problems concerned with unused space, undesirable vegetative competition, and conflagrations. Including woody fiber other than logging debris can coordinate residue management opportunities for a forest property as a whole, rather than by piecemeal considerations of the several, separate management functions which may reduce or accelerate rates of residue accumulation.

In the discussion which follows, we will progress to the framework by citing examples of management problems, and of opportunities for solutions, grouped in four problem areas. Although the examples were drawn mainly from the coniferous forests of the Western United States, they are intended to illustrate the universal need for a framework. With it, forest managers anywhere should be better able to make decisions, and at the same time, bring better perspective to the concerns of the forest-using public for esthetics, water quality, wildlife, and related values. The problem areas are: unused wood fiber, conflagrations, impairment of other forest resources, and opposition to treatment of forest residues.

The problem of unused wood fiber warrants detailed discussion because it is within the timber harvesting activity that both the general public and foresters have concentrated efforts to solve residue problems. Further, forest management frequently is initiated through timber harvesting. This emphasis does not imply, however, that this category ranks higher than the other three.

UNUSED WOOD FIBER

When wood fiber remains unused following logging in the Western United States, a conservation issue develops. Special interest groups concerned with preservation of forest areas for parks and wilderness question the need to devote vast public forest areas to timber production.

Harvesting of old-growth timber in much of Western United States yields large volumes of residues which, though heavily defective and rotten, do contain sound, unused wood fiber. Surveys indicate that 50 to 90 percent of the total residue volume on some clearcut units in the Douglas-fir type is potentially usable under existing technology, but various size and quality classes of residues are difficult to separate for efficient processing. With the many economic factors that influence timber processing costs and returns, generalized statements seldom really identify which forest residues are truly waste.

One significant factor that influences residue utilization is the demand for wood products. According to Hair and Fleischer (1970), available data on timber demand and supply indicate that, in the next few years, sizable price increases will be necessary to bring the United States' timber demand into balance with supply. Price increases are likely to be especially large for softwood lumber and plywood. Fisher (1971) concluded that stumpage prices will rise steeply during the next 5 years and stressed that increases will substantially exceed those projected for other sectors of the Nation's economy.

Part of the predicted increase in demand for wood could be met and price pressures eased by increased utilization; that is, reducing the volume of wood residues, reusing paper and wood products, and extending supplies through increased efficiency in construction and manufacturing. It is noteworthy that during the past two decades, coarse wood manufacturing residues have been increasingly utilized throughout the United States, and there has been some increase in the use of sawdust and other fine manufacturing residues as well as logging residues.

There is a growing public concern over pollution and depletion costs associated with competing nonwood materials. Restrictions on processing of petrochemicals and metals that would raise costs and force prices up would substantially increase the demand for wood. Yet another possibility is in the use of forest residues to replace fossil fuels and hydroelectric installations for power generation.

In contrast to optimistic projections of demand for wood products, the industry must offset a general rise in materials-handling labor costs for all primary forest products, and by this, may improve on means to handle residues. Materials-handling, as used here, refers to logging activities concerned with moving logs and smaller wood sections from stump to processing plant or place of sale. It includes sorting and bucking logs to upgrade value or to increase usable quantity, as well as including some preliminary processing. As smaller and more defective pieces are taken, higher per-unit handling costs result. To offset higher costs, greater efficiency is needed.

Efficiency in logging is achieved in part through an ever-changing technology involving both equipment manufacturers and users who desire to perform an operation in less time, or with reduced costs. Advances usually result in fewer men being required for a given task, or less time being required per unit of output. In either case, unit labor cost is reduced but is generally in part replaced by investment in equipment.

For steep terrain, high-lead yarding and other systems with standing skylines are costly to set up because of elaborate guying required. Mobile "jammers" and "skidders," on the other hand, have generally required a more closely spaced road system than high-lead yarders. Both are being replaced with a new generation of even more mobile yarders that require few back-guys and use a cable system consisting of a three-line running skyline automatically interlocked to maintain uniform tension. When used on clearcut areas, a grapple that can be opened and closed by the yarder operator holds the logs, rather than wire-rope chokers which must be set by additional crewmembers. Characteristics of this new generation of yarders are lighter weight, mobility and line speed, and capacity to reach distances of 2,000 to 2,700 feet (600 to 825 meters). Prototypes are being tested. Even with greater mobility and more rapid in-haul capability, loggers will still be faced with the need to amortize substantial equipment investments through high productivity.

These and other developments will tend to lower the direct per-unit costs of materials-handling. With more efficient logging systems, the opportunity to use residues can be improved. However, public pressure to reduce the visual impact of logging is expected to, in part, counteract gains made in logging efficiency. Pressure to reduce "visual pollution" caused by road cuts and fills will likely require longer yarding distances calling for at least some helicopter or balloon yarding systems. Pressure to forgo clearcutting may tend to favor additional shelterwood cutting or other partial timber removal.

With such a variety of interacting forces, it is a temptation to anticipate the invention of miraculous wood products which will create vast markets for low-quality wood. Although development of new products continues, radical changes seldom occur. Manufacturers of products that utilize low-quality wood do so because of cost, not from preference. Substantial progress in the utilization of mill residues for specialty products has been made, and literature on the subject is voluminous; but industrial research and development organizations probably will continue to concentrate on mill and plant residues, deferring attention to residues in the forest. To wood manufacturing firms, this approach is logical; costs have already been incurred in delivery of material to a plant and in partially processing it.

Some apparent guidelines for the land manager seeking residue reduction through increased use of wood fiber are:

1. Progress in utilization resulting from increased timber demand, improved materials-handling, and new product development is likely to be incremental and most influenced by shrinking timber supplies relative to demand for wood products and by prices of wood products relative to those of competing materials.

2. A dramatic change in timber demand requiring residue utilization might, in time, come from public reaction to environmental pollution resulting from processing of such competing materials as aluminum, steel, and plastics; but changes in public policy to conserve exhaustible materials and favor the use of renewable wood fiber are highly uncertain.

3. For residues to be removed and utilized at an accelerated rate in a given locality, incentives must be provided for the logger and processor.

These conclusions suggest that implementation of materials-handling and new product opportunities will be determined by industry innovation, and possibly by governmental demonstrations, on an area-by-area basis.

Sellers of timber must balance the profits on stumpage with those on subsequent investments required to establish a new stand of trees. Particularly for large public ownerships, the efficiency of wood-fiber utilization, in contrast to disposal of logging debris by burning, should be promoted. Both utilization of residues and disposal are intended to accomplish the same results--site preparation for planting and a more acceptable appearance--but utilization frequently can be done with smaller direct and social costs.

At present on public lands, timber selling and subsequent residue disposal are usually administered as two separate activities. There is resistance on the part of timber managers to subsidize purchasers through offering low-quality wood at less than appraised value. The forest protection activity then has a larger task of slash disposal or extra fire protection requiring greater expenditures than if a portion of the residues had been removed.

Any sale of timber stumpage with residue reduction required by the purchaser affects revenues and costs of both parties (fig. 1). As disposal requirements are made more stringent, the buyer will offer less for all the stumpage. The seller may reduce his disposal costs but in doing so forgoes maximum obtainable revenue from timber. In either case, then, generally the seller must expect to bear the cost of residue disposal.

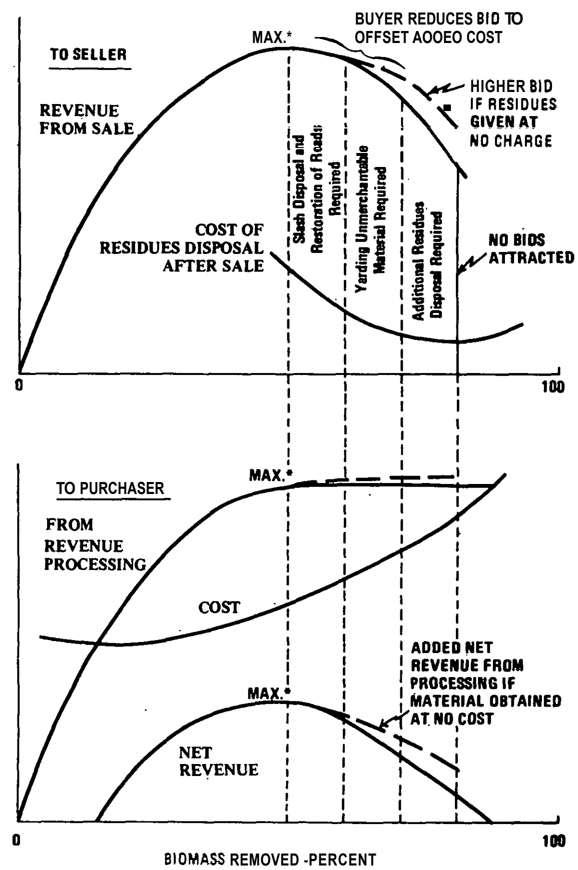

Figure 1.—Revenue and cost to timber seller and purchaser when residue reduction is required in the sale contract.

OTHER PROBLEM AREAS

Other problem areas, although of equal importance, are reviewed only briefly because they are more straightforward than the economic variables that influence timber revenues. Although research and development are definitely needed, opportunities for solutions are generally more apparent in these areas.

DANGER OF CONFLAGRATIONS

Almost every year a critical fire situation occurs somewhere in the western United States forests. The magnitude of damage and suppression costs is staggering. Within a few days in 1970, wildfires in central Washington State burned over 125,000 acres (50,000 hectares) of public and private forest lands. Suppression costs alone exceeded $20 million.

Under dry, windy, and warm conditions, "natural" forest fuels permit spread of fires. When slash accumulations are superimposed on these natural fuels, fire intensity and difficulty of control are severely aggravated. Therefore, aside from esthetics, slash disposal is necessary whenever heavy concentrations of slash retain twigs and needles for several years (Fahnestock 1960). In timber types and stand sizes that can accommodate prescribed underburning, the practice may prove to be the most efficient residue management measure.

IMPAIRMENT OF FOREST RESOURCES

Other forest resources to be considered include water, esthetics, livestock forage, and recreation. The presence or arrangement of forest residues can detract from the enjoyment or satisfaction of users of any of these resources. Typical situations resulting from forest residues are described below.

The Northwestern Region of the U. S. Federal Water Pollution Control Administration (1970) cited logging wastes in Douglas-fir forests as a serious threat to the quality of water yield from cutover timberland. Water quality is adversely affected by chemical pollution caused by leaching of ashes from burned slash, by changes in stream channels clogged with debris, and by increases in biochemical oxygen demand resulting from logging residues submerged in streams.

The forest-using public resents esthetic degradation following timber cutting. Increasingly, forest managers are confronted by groups which oppose all timber harvesting operations, at least in part, because of the logging slash. Vivid, often emotional, descriptions of harvested areas reflect the attitude of these forest users, who are not oriented to timber production. These people, whether informed or not, will have a political impact on the creation and treatment of logging residues.

Livestock ranchers who secure public lands for forage under permit have complained that large logs and other debris in timber stands interfere with the use of the area by domestic livestock. Hunters find it difficult to travel on foot.

Accumulations of residues on Douglas-fir clearcuts, weighing as much as 200 tons per acre (454,000 kilograms per hectare), impede timber management activities such as restocking with young trees. Lesser amounts of residues created by selective cutting or overstory removal can interfere with future silvicultural operations. Dense brushy vegetation frequently encroaches on cutover sites and requires treatment in order to return land to timber production.

When the forest manager is faced with decisions involving two or more resources, maximum output of one product or service may be sacrificed to enhance another. Short-term degradation of appearance resulting from timber cutting may be necessary to develop vigorous new trees which will provide long-term improvement in esthetic quality. Although often obvious to forest managers, these trade-offs are not widely understood. Each situation can vary widely in cause and effect. For this reason, benefits and undesirable consequences have seldom been well quantified. Even when documented, their usefulness for residue management decisions is limited, unless the interaction of residues with all resources present on an area is known.

OPPOSITION TO TREATMENT OF FOREST RESIDUES

To meet the needs of the decision-maker, the effects of forest residue treatments must be quantified. Treatment methods can have environmental consequences far removed from the forest, and the full impacts of these consequences are not always well known.

The most commonly used disposal method for residues is burning. On clearcut areas, slash may be piled or windrowed and burned, but the usual practice is to broadcast burn the entire area. If not performed under favorable conditions of wind, temperature, and moisture content of fuel, large amounts of smoke are carried into the air. If the smoke plume meets a stable layer of air, smoke may accumulate and remain trapped until a change in weather occurs. This is a particularly troublesome phenomenon when smoke fills a heavily populated valley. Public opposition to burning forest residues has mounted because of these air quality considerations. Fortunately, foresters in cooperation with meteorologists are learning how much burning can be done under given atmospheric conditions for the airsheds in which they are working. Global implications and the actual health hazards associated with burning forest debris are less well known. One might conclude from Hall's (1972) review of literature and application of knowledge of the chemistry of combustion, that emotion plays a large role in the expressed concern over wood smoke in the atmosphere. Even so, foresters are asking that wood smoke from various species and species combinations be analyzed to document actual emission products and to relate this knowledge to known health hazards.

Other aspects of the use of fire for the reduction of residues draw opposition. Some silviculturists concerned about the characteristically low levels of available nitrogen in forests suggest that burning contributes to nitrogen deficiency to a degree that is not offset by the benefits of fire hazard reduction and the additional amounts of nutrients rapidly made available for plant use. At least one tree disease may be a result of burning residues. *Rhizina* root-rot was identified as the cause of mortality in Douglas-fir plantations on burned forest sites in British Columbia (Ginns 1968). Surveys in western Washington State have detected the presence of this pathogen, but its distribution and importance remain to be established.

Questions have been raised as to the long-term impact of wood utilization on site productivity. Objections to mechanically chipping or crushing logging residues and mixing them with soil may be based upon an assumed additional nitrogen demand. Both burning and crushing call for examination in terms of the natural recycling of plant nutrients and of trade-off values.

In sales of public timber, the logging industry objects to extensive cleanup requirements in the sale contract. One practice gaining increasing use requires the purchaser to yard unmerchantable material above a stated size to "landings" and other locations on the sale area. Resulting piles are burned after conclusion of the sale, when smoke dispersal is favorable. Although a cost allowance for such yarding is included in the appraisal of timber to be sold, loggers believe it is often inadequate for the effort demanded. Further, it decreases their production. The degree of cleanup required in remote areas has also been questioned.

FRAMEWORK FOR OPTIMAL RESIDUE TREATMENT

A model of the framework proposed for structuring decisionmaking is basically straightforward (fig. 2). It essentially portrays the thought processes employed by a manager in reaching a decision. The model can be extended to accommodate complex subroutines to evaluate residue reduction alternatives.

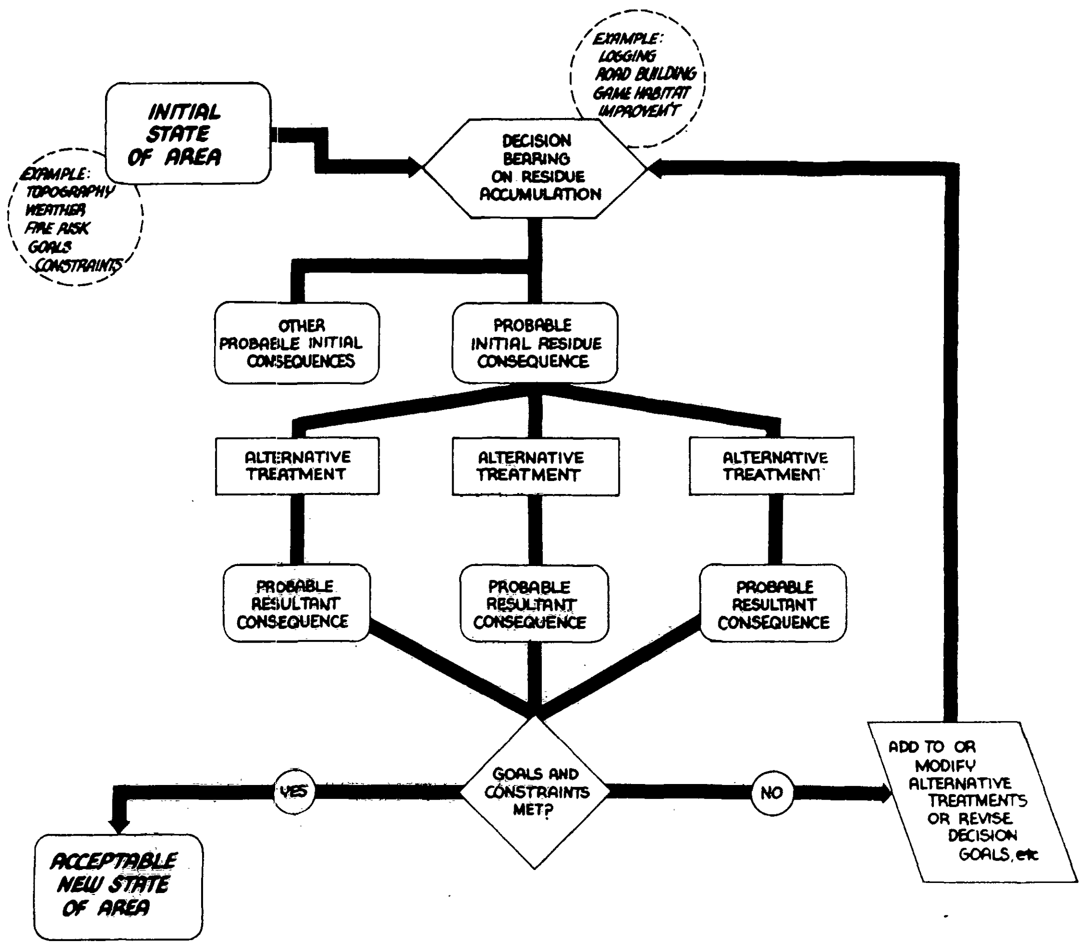

Figure 2.—Model of basic framework for evaluating alternatives and making residue treatment choices.

This framework permits a research and development team to analyze alternatives on relative scales based on subjective data, as is frequently necessary. Updating and refinement will be possible when more reliable research results become available.

Initially, it was believed that a set of quantified management goals for a given forest area, along with constraints, would be required in order to compare consequences of alternative actions. We now realize that the consequence blocks of the model can be portrayed, if necessary, even in descriptive terms for the critical elements. The results cap be used directly by land managers to determine how well the consequences meet already established policy.

For example, the Multiple Use Management Guide (USDA Forest Service 1967) contains the statement: "Recognize natural beauty as a resource and to the fullest extent possible, manage all activities to retain or enhance its qualities." A general coordinating requirement of this nature may appear too broad for actual application in a system for evaluating alternatives. However, when each of the consequence blocks in the framework carries a statement of the effect of an alternative treatment on natural beauty, they can be compared with one another and with the coordinating requirement to be followed by the land manager, regardless of the values used.

The model can be translated into operational forms suitable either for evaluating relatively simple activities or for developing broad policy. On the one hand, a forest manager might perform a simple summing of costs and benefits; but on the other hand, large masses of data including probabilities would call for automatic data processing. An example of a segment of such an operational framework is illustrated in figure 3.

RESEARCH AND DEVELOPMENT LEADING TO INPUTS FOR THE FRAMEWORK

Several agencies, universities, and much of the forest products industry in the United States are devoting efforts toward meeting the challenge of forest residues. All of these may be regarded as inputs for use in a framework such as herein proposed. To quickly highlight some of these potential inputs, the following is a brief review of some of the work being done in the U. S. Forest Service, Pacific Northwest Forest and Range Experiment Station.

PROBLEM OF UNUSED FIBER

A simulation model is being developed to study the feasibility of more complete utilization of residues in promising localities. Detailed inventories of residues according to several classes will be assembled. The economic feasibility of utilizing various kinds of residues will be projected. Expanded market opportunities will be investigated, including modification of existing plants and introduction of "satellite" plants to sort and grade low-quality wood and to manufacture products such as chips for pulping and particleboard. The results should indicate to landowners the kinds of residues that they can hope to market, and to loggers the kinds of residues that can be profitably removed and delivered to a processor. Processing firms will know whether raw material costs and processing costs will permit a profitable operation. A first priority in developing this model is to examine the feasibility of electric power generation.

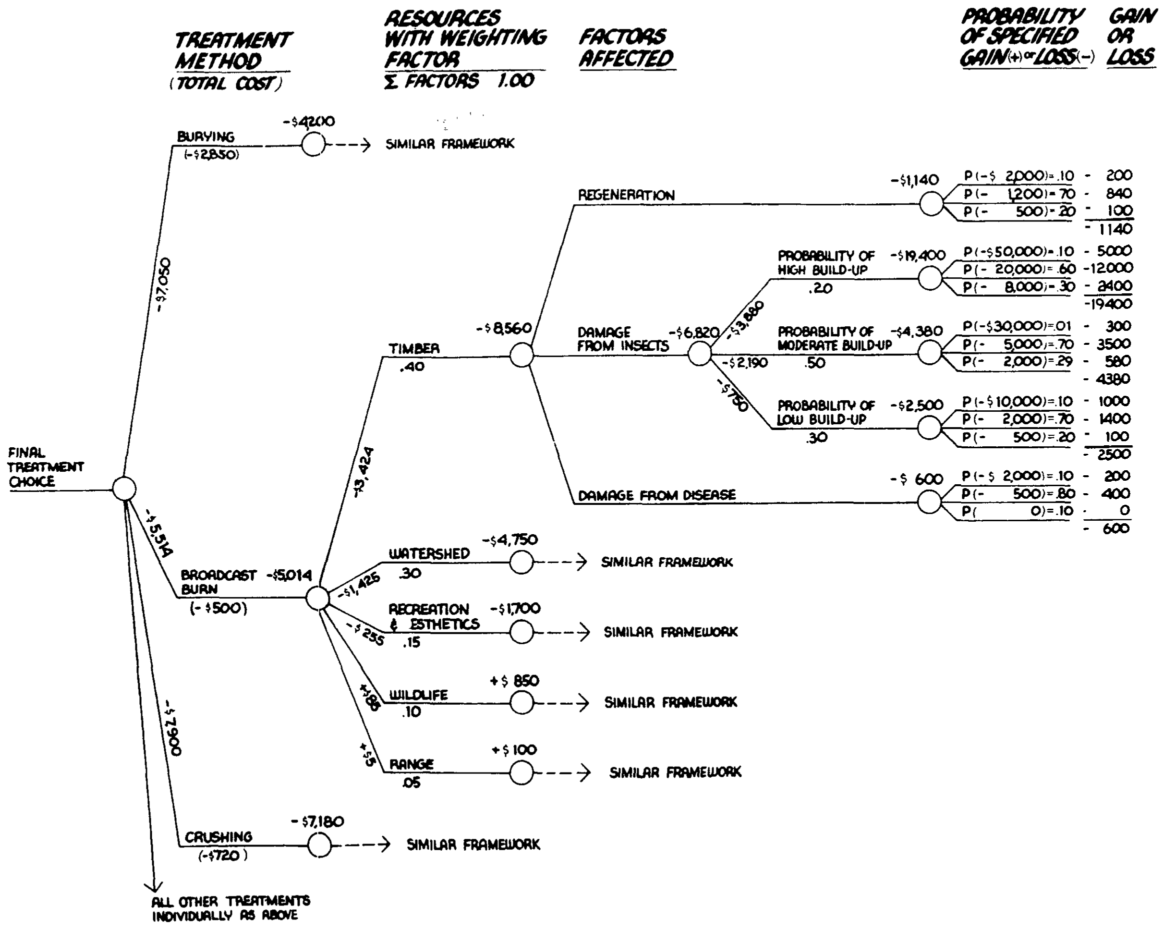

Figure 3.—Segment of expanded operational framework.

Two aspects of selling public timber will be further explored and refined. Per-acre pricing of small trees and logs on National Forest timber sales has been used with success in some cases to significantly reduce amounts formerly left as residues. Formerly, buyers purchased all designated timber stumpage on a sale area by submitting a bid per unit of volume by species or species groups. Small logs of dubious quality and market value had to be paid for, and if they were left, a penalty was assessed. Prospective buyers can now submit a bid per unit of volume for logs suitable €or lumber, plywood, or fiber. In addition, the buyer pays a stated amount of money per acre for small trees, which are not subject to bidding. Once paid for, the buyer has latitude in choosing pieces he wishes to remove, but an incentive exists for him to remove as much as possible because he has paid for all of it. Per-acre pricing is a shift toward lump-sum selling of timber based on the appraised value of tree inventory volume. Problems have resulted for the seller in deciding whether to include certain trees and logs in the per-acre priced material because buyers can increase the volume of this category by bucking trees into small-sized logs. Problems for the buyer are still related to high-volume production needs.

The second aspect of timber selling concerns changing the seller's emphasis in a conventional timber sale from obtaining maximum initial revenue to that of replacing the harvested stand of timber with a site ready for stand regeneration. A trade-off of reduced revenue to obtain a cleaner site for forest regeneration is more consistent with the concept of intensive forest management. This sale modification needs to be tested to obtain data for use in the framework in evaluating an additional timber selling alternative. As visualized, the method would combine unit volume bidding for large valuable logs, per-acre pricing of smaller material to a stated minimum size, and making all other material available to the purchaser without charge. The purchaser would be required to yard all unused material larger than a stated size to designated places on the sale area. The availability of "free" wood coupled with a fixed cost for small logs could provide an incentive to purchasers to devise efficient ways for handling small and defective logs in order to market as much as possible of the material that is required to be moved.

OTHER PROBLEM AREAS

In order to assemble inputs for the framework in terms of costs and benefits, we sought knowledge already available. For certain alternatives, such as mechanical means of treating residues and fire control, numerous references in biological disciplines and engineering technology were found.

The conflagration control guide developed by Dell (1972) for use in the Northwest Region of the Forest Service is illustrative of a first result of our searching and combining what has already been learned. It conveys to practicing forest managers the best known techniques for prefire planning. It describes criteria for selecting strategic fire control locations and the best techniques for establishing fuelbreaks in advance. Other installations to aid initial fire attack and conflagration control are included: landings for helicopters, sources of water, and methods of fuel reduction over broad areas. This state-of-knowledge publication will help identify all alternatives and make possible cost data collection for the framework. Residue management can in this way become more than only fuel disposal.

A compendium is being prepared by a team of 20 forest scientists to evaluate previous studies on biological and physical effects of forest residues and residue treatment. High-priority research needs will be identified.

New knowledge also is being added by evaluating costs and effects of promising methods of residue treatment through tests on designated land management units. Although evaluations of treatment will depend on descriptive techniques to a large degree, they should provide interim data for the decision framework and identify specific needs for more controlled investigation.

CONCLUSION

The task of managing forest residues occurring under widely diverse situations can be complex. Almost any action to modify or dispose of residues influences all forest resources, benefiting some and impairing others. People likewise are affected by treatment of forest residues.

Numerous sources of information can be used by the forest manager to reach sound decisions in attaining specified forest management goals. Choice of the best combination of alternatives, though often subjective, can be accomplished by using a relatively simple framework to systematize and evaluate courses of action. This same systematization will also make possible public involvement when environmental concerns call for more than emotionally based and abstract arguments.

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☆ U. S. GOVERNMENT PRINTING OFFICE: 1973—797-629/103 REGION 10

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2. Development and evaluation of alternative methods and levels of resource management.
3. Achievement of optimum sustained resource productivity consistent with maintaining a high quality forest environment.

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