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# Review of the Logging Residue Problem and Its Reduction Through Marketing Practices

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ABSTRACT

This study notes the increasing concern over logging residue in forest land management and describes the various administrative and technological means for accomplishing reductions of logging residue.

Alternative sales arrangements can include s'uch things as reduction of stumpage charges for low quality logs or required yarding of unutilized material to the landing or to some stockpiling or disposal point.

Improvements in materials handling can include use of logging systems that create less breakage or that can handle small pieces more efficiently.

Specialized chip mills and increased chip markets, including chip exports, can give added incentive for removal of formerly unutilized material. Other potentials for utilization are also indicated.

Keywords: Logging economics, clearing operations (post-logging), forest residues.

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*Figure 1.--Accumulation of debris can be large after stands of old-growth Douglas-fir are clearcut, Willamette National Forest.*

These amounts of logging residue do not include limbwood or so-called fine residue--pieces less than 4 inches (10.2 cm) in diameter outside bark and 4 feet (1.2 m) in length. Although they may be a physical barrier to reforestation and represent a short-term fire hazard, they are excluded from discussion in the remainder of this report, primarily because of their low potential value for products.

## LOGGING RESIDUE AND THE DEMAND FOR WOOD

The overall demand for wood products in the United States has increased 65 percent in the last three decades, and a continuing increase is expected. With only modest increases in available timber harvests, the result will be a continuing pressure toward increasing prices of timber and timber products (USDA Forest Service 1973).

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Forest managers see a growing desire on the part of top levels of management, environmental agencies, and the general public to reduce the amount of logging residues, These residues are created in logging, and it is only natural to expect the logging process itself to pay for them or to carry out measures to reduce them. Thus, the sales arrangements contained in any timber sale contract are a critical element in how much of the total wood material is removed and paid for, and in how any remaining residues are to be treated.

Most logging residues in the Pacific Northwest were formerly burned. Now, however, public awareness of air pollution has focused attention on the unfavorable results of burning of logging slash--the tops, limbs, defective pieces, and broken chunks left after harvest, The smoke is plainly visible, and its source is obvious. Since timber cutting began, untreated logging residue from old-growth forests has been a fire threat and an obstruction to resource management. Many public viewers are now sensitive to the visual impact of smoke from slash burning, especially on otherwise clear days, and critical of the disorderly appearance of logging slash.

As part of the growing concern for the environment everywhere, a general attitude is emerging that environmental objectives must be given greater weight in all aspects of forest land management. These objectives include maintaining clean air, an uncluttered landscape, and a prompt return of harvested areas to a productive forest condition.

Greater utilization is an obvious solution to the problem of reducing the amount of logging residue on harvest areas; and greater utilization can come from stronger incentives in the timber selling process, more efficient materials handling and development, and new products or processes that utilize low-quality wood.

Another motive for reducing logging residue comes from the land manager himself. This is to clean up the land and make it more accessible for men and equipment for more intensive management of the next crop, a task becoming more real and more urgent as the general threat of natural resource shortages receives attention.

Our purpose in this report is to review potential for and problems of reducing logging residue, through improvements in timber selling procedures, materials handling, and product utilization. We will also examine the economic framework of residue reduction, current practices in residue management, recent studies and developments, and suggest possible improvements, primarily in sales arrangements.

Although this report focuses on reduction of logging residue, we recognize that on delicate or unfertile soils some of the smaller residue should be left as protective cover, for soil building, and for nutrient recycling (Cramer 1974).

## QUANTITIES OF LOGGING RESIDUE

Howard (1973) estimated that on clearcut areas in 1969 in western Washington and western Oregon the average net volume of chippable residue ranged from 1,328 cubic feet per acre (93.0 $m^3$/ha) on private lands to 3,127 cubic feet per acre (218.9 $m^3$/ha) on National Forest lands (fig. 1). On the east side of Washington and Oregon, the averages were 352 cubic feet per acre (24.6 $m^3$/ha) for private lands and 291 cubic feet per acre (20.4 $m^3$/ha) for the National Forests. For both States, the total net residue generated during 1969 was 547 million cubic feet (15.5 million $m^3$).

Part of the projected growth in demand for wood could be met, and price pressures eased, by increased utilization of both mill and logging residue, use of trees presently classed as culls, and increased efficiency in construction and manufacturing. Greater efficiency in the utilization of residues could also contribute to wood needs, and improve public acceptance of timber harvesting.

By way of perspective, coarse wood residues from manufacturing have been increasingly utilized over the past two decades. The estimated volume of chips received at pulpmills, mostly produced from slabs, edgings, veneer cores, and other similar coarse material, has grown from 0.1 billion cubic feet (2.8 million $m^3$) (solid-wood basis) in 1950 to 2.1 billion cubic feet (59.4 million m3) in 1973 (developed from Phelps and Hair 1974). Some of this mill residue, of course, comes from increased utilization of logging residue, or of what would otherwise be left as logging residue.

In Washington and Oregon, consumption by pulp and board mills increased strongly for both utility grade logs and chips from roundwood chipping mills (Bergvall and Gedney 1970, Bergvall and Ormrod 1974, Manock et al. 1970, Schuldt and Howard 1974):

| | Consumption of Utility grade logs | Consumption of chips from roundwood chipping mills |
|---|---|---|
| | (Million board feet Scribner scale) | (Thousand tons, dry weight) |
| 1968 | 177.8 | 75.6 |
| 1972 | 481.4 | 2,041.4 |

Chip exports from the two States, from both roundwood and mill residue, increased threefold between 1968 and 1974 (Ruderman 1975):

| | Chip exports |
|---|---|
| | (Million short tons, dry weight) |
| 1968 | 1.2 |
| 1972 | 2.2 |
| 1974 | 3.6 |

## THE ECONOMIC FRAMEWORK OF RESIDUE REDUCTION

Practical-minded men familiar with logging operations are often quick to point out that logging residues are left because they have no value, or even a negative value. They point' to the gradual improvement in logging utilization over the years in response to higher prices and claim that it is useless to try to force more complete utilization of logging residue because this might only displace some other more suitable raw material.

This reasoning is partially valid, but it does not lead to a fully satisfactory conclusion. For one thing, it reflects only a short-term viewpoint and does not recognize that in the long run the total size of the market can be increased so that residue can be utilized without displacing other raw material. Moreover, innovative processes, products, and equipment can make efficient utilization possible. In this sense, channeling residues into more integrated manufacturing complexes will probably lead to expansion of the total market.

Also, this view does not recognize that socially desirable ends are not always achieved by market forces. Under favorable conditions, market forces can be changed by (1) shifting from average

cost pricing of timber stumpage to some form of dual pricing where low value material goes at a cheaper rate, (2) reallocating fixed logging and manufacturing charges, and *(3)* channeling residues into more integrated manufacturing complexes where they can be put to a wider variety of uses.

In a sense, residue reduction is largely a physical accomplishment objective. It provides a symbolic demonstration of good land stewardship, professional management, and avoidance of physical waste. Advocates of cleaner logging assert that residue reduction should not have to yield a dollar return; it is regarded more as just another part of the harvest job, required by a commitment to quality land management.

Such reasoning may be used to justify more residue reduction in the form of disposal, but most people prefer greater utilization to a disposal treatment. Here, however, utilization at a cost greater than the value of the product would generally be considered a misallocation of resources. Clearly, the challenge is to develop new sales arrangements, materials handling, and utilization processes that lower costs or increase the demand for and value of potential products.

Management of logging residue is becoming a vital part of the forester's job. This involves chiefly a reduction of total amounts of residue where that residue is excessive. It also involves a planned effort to recognize the benefits of leaving some residue on the ground for soil building, soil stabilization, and nutrient recycling,

## CURRENT PRACTICES IN RESIDUE MANAGEMENT

A variety of logging practices concerning utilization are in effect on lands of different ownership classes. These illustrate both the variety of conditions and the trial-and-error nature of efforts by different agencies and owners toward making residue reduction a part of the forest and land management job.

### FOREST SERVICE

Management of the National Forests has always had implicit goals of protection and stewardship of the environment, but in practice these have not always been easy to achieve.

Normally, timber sales are made on a competitive bid basis, after appraisal, with either (1) a bid price per thousand board feet for each species, with quantity based on scale recovery of the logs as they are removed, or (2) on a tree measurement basis, where bidding is on the basis of a total dollar amount for the sale as a whole. These two methods are called the scale recovery method and the lump-sum method.

#### Scale Recovery Method

In the scale recovery method, the bid price for each species or class of material applies uniformly to all the volume of each removed. This means that some logs are lower in value and some are higher. However, logs lower in value than the bid price may cost the purchaser more than they are worth, and he may be tempted to fell and buck the timber so as to produce a minimum of such logs. In addition, he might have little interest in removing marginally unsound logs, permitted without charge, because of the danger that, in scaling, these might be judged sufficiently sound (usually one-third or more) to require payment at the full bid price the same as the higher quality logs.

Historically, nearly all Forest Service timber sales in Region 6, the Pacific Northwest Region (Washington and Oregon), have been by the scale recovery method, rather than the lump-sum method. This is due chiefly to the purchaser's risk that any given sale will produce less than its estimated volume, and to the desire of both seller and purchaser for scaling records for inventory control and for other purposes.

In the last few years most Forest Service sales on the west side of the Cascade Range have had mixed pricing, with logs of 80 board feet and larger net scale subject to pricing on a scale recovery basis, and smaller logs or logs less than one-third sound priced at a low fixed dollar amount per acre.

Although opportunities are limited, a purchaser could alter his bucking practices so as to throw some of the standard scale-recovery material into the substandard per-acre material and escape payment for it, even though he removes it. As far as can be determined, this has not occurred to any great extent.

## Tree Measurement or Lump-sum Sales

In the tree measurement or lump-sum method, the total price is fixed, and there is no charge for additional material taken out, large or small, cull or sound. In theory this should encourage greater utilization because the extra stumpage cost for any extra piece is zero. An advantage of this method over the combined scale recovery and per-acre pricing arrangement is that in the complete tree measurement sale there would be no incentive to alter the bucking practice to divert more logs into the cull or per-acre pricing category. A disadvantage is the more intensive cruising required for acceptable accuracy in measurement of timber volume.

Up to now, Region 6 of the Forest Service has made relatively few tree measurement sales.

## Yarding of Unutilized Material

Required yarding of unutilized material, called "YUM yarding," has been used since 1969 on portions of designated Forest Service timber sales. Most sales using this arrangement specify that all substandard logs of a given diameter or larger (usually 8- or 12-inches (20.3- or 30.5-cm) diameter inside bark at the large end) and 10 feet (3.0 m) or more in length must be yarded to landings or to specified locations on the sale area (fig. 2).

From the standpoint of the land manager, there are four major purposes for YUM yarding. First, the smoke from broadcast slash burning can be reduced or eliminated, particularly in the smoke sensitive period of early fall. The YUM piles will burn hotter and can therefore be burned later in the season, on overcast days when not visually objectionable, and on days when air movement is away from population centers. Piles burn with less smoke than a broadcast ground fire, and the higher temperatures from combustion will carry the smoke to higher atmospheric levels for dispersion.

Second, this serves the land manager's objective for greater utilization because the cost of YUM yarding enters the appraisal as a fixed cost and the operator's only extra costs are those of loading and hauling. Third, YUM yarding makes the area more accessible to men and machines for reforestation, thinning, and other management activities, Finally, the cleaner, well-groomed look is more esthetically acceptable to the public (fig. 3). Other purposes have been discussed by Combs (1975).

*Figure 2.--Unmerchantable material yarded to landing, Willamette National Forest.*

Potential advantages of YUM yarding to the purchaser are that it provides more total work and appraisal cost allowance for his men and equipment, and potentially provides more raw material for industry. An additional advantage of YUM yarding would accrue if an efficient operator should find he can do the extra yarding work for less than estimated in the appraisal. Finally, a strategic advantage can be recognized where the purchaser, after developing a chip mill or a specialized small log sawmill able to utilize this extra material, could have an edge over competitors not having such an integrated outlet.

The purposes of YUM yarding are understood by timber purchasers and operators, but these persons often dislike doing the job, especially when other more productive logging jobs are available. Some suggest that YUM yarding might be better handled by the Forest Service or as an entirely separate contract. Others contend that actual costs have sometimes exceeded estimated costs.

*Figure 3.--Clearcut area after unutilized material has been yarded, Willamette National Forest.*

Other criticisms of YUM yarding are that (1) it does not really eliminate the need for broadcast burning of fine material and competing low vegetation which are deterrents to reforestation, (2) the remains of burned YUM piles are unsightly and these often burn so hot that soil damage may occur, and **(3)** costs of up to $500 per acre are questioned as being greater than benefits (Dowdle 1973).

YUM yarding is probably not a universal land management prescription, but it has been at least partially successful in achieving its objectives. Although the cost appears high compared with other treatments, it is justified by land management benefits and by the incentive it gives for additional utilization of the resource.

## BUREAU OF LAND MANAGEMENT

Timber on BLM, U.S. Department of the Interior, lands is nearly always sold on a lump-sum basis. No standards for cutting and removal of pieces to a stated minimum size need be included in the sale contract. After he has paid for the entire timber volume, the purchaser has an incentive to remove all material whose revenue exceeds the costs of removal.

The BLM requires slash disposal on nearly all timber sales. Burning is the primary means of slash disposal. Gross yarding, a term analogous to the Forest Service's YUM yarding, is authorized for use in locations where it is desirable as a means of preparing the area for reforestation or where there is a smoke-management problem.

## STATE OF WASHINGTON

The Washington Department of Natural Resources has a vigorous program of timber sales on State forest lands. Mast of their old-growth timber in western Washington is sold on a scale recovery basis.

In May 1971, the Department of Natural Resources publicized a proposal to develop an assured, stable market in northwest Washington for large Utility grade logs[1/] and for small sound logs or chunks to a minimum size of 4 inches by 8 feet (10.2 cm by 2.44 m). Through competitive bidding, a processing firm would be guaranteed a 10-year supply of such material, up to 40 million board feet (188,800 $m^3$) annually, at a guaranteed uniform delivered price, subject to price adjustment every 2 years. The firm would operate a pulp-chip mill and presumably other facilities to rebuck Utility grade logs so as to salvage sound segments that would have higher value for lumber and veneer,

Some established purchasers of timber opposed the plan because they felt they already had developed a good market for fiber logs and did not want to give up this advantage. Others claimed that the mechanism for sorting and grading logs was uncertain and the mechanism for price adjustment too cumbersome. The proposal has not yet been activated.

## STATE OF OREGON

The State of Oregon has almost no old-growth forests under its management and therefore does not experience the large amount of defect or heavy breakage that contributes to the major slash and residue problems on other ownerships. State-owned timber in Oregon is sold under both the scale recovery and the lump-sum methods, the latter used mainly in the more uniform young-growth stands.

Slash disposal on State of Oregon forest lands is done by the timber operator. Where necessary, slash concentrations are treated by piling and burning, spot burning, or by broadcast burning.

## INDUSTRY LANDS

The comments which follow are based largely on discussions with representatives of three large industrial landowners. This type of landowner exerts more control over utilization of wood, from tree stump through all stages of processing, than do smaller landowners or the public agencies. This is a decided advantage in land management for residue reduction.

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**1/ A Utility grade log is one that does not meet the requirements of Peeler or Sawmill grade logs but has a usable chip content of at least 50 percent of its gross volume, a minimum diameter of 6 inches (15.2 cm), and generally a minimum length of 12 feet (3.7 m) (Columbia River Log Scaling and Grading Bureau et al. 1972).**

On private lands with controlled access, the results of logging are viewed less by the public; and in remote locations esthetics understandably may receive less consideration. Industrial landowners, in contrast to stumpage purchasers, are in a position to obtain the benefits of reduced hazard, easier reforestation, and better access for subsequent land management, and they have an economic interest in recovering maximum timber volume from each acre.

### Utilization

Industry lands are often closer to log markets than are public forest lands. This lowers transportation costs and tends to make closer utilization more feasible.

A key to logging residue reduction lies in marketing, in finding ways to utilize the less valuable pieces rather than spending money to dispose of them. For a large integrated manufacturing firm, every addition to the supply of wood raw material adds opportunity for profit in the manufacturing and marketing process. Also, large firms with their own logging crew often pay wages on an hourly basis, thus eliminating the logger's incentive to leave small and defective logs of low value for larger and more valuable timber elsewhere.

### More Efficient Log Handling

Large industrial firms have achieved closer logging utilization by: (1) sorting logs in central log yards under close supervision to assign each log to its highest value use, depending on mill needs or orders; (2) bucking logs at a central yard to raise grade: and (3) increasing logging efficiency, with each step more under the landowner's control than occurs under public timber sales.

## REVIEW OF RECENT STUDIES

Several studies in the last few years have dealt with the problem of logging residue. The following review of these studies traces the growing recognition of logging residue as a problem in resource management and helps to establish why reduction of logging residue is becoming a working objective of forest management.

### Feasibility Study in Western Washington

In 1964 the Gram Development Corporation reported on the economic feasibility of utilizing logging residue in selected Washington counties (Gram Development Corporation 1964). This study examined several locations for a chipping plant or a combination chipping plant and sawmill. The conclusion was that a specialized operation could be feasible, but logs would have to be obtained on favorable terms; a close working relationship would be necessary between timber buyer and seller and a location near an integrated forest products industry complex would be desirable.

### Forest Residues Problem Analysis and Research Program

Fahnestock[2/] prepared a research problem analysis on impacts of forest residues and their disposal. His conclusion was that management systems should be devised to encourage more utilization, charging part of the added costs against the direct and indirect benefits to land management. This analysis stimulated formation of the Forest Residues Program at the Pacific Northwest Forest and Range Experiment Station.

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2/ Fahnestock, George R. 1968. Impacts of forest residues and their disposal on forest land management and environment in the Pacific Northwest. In-Service report, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 28 p.

### Forest Management in Wyoming

An interdisciplinary Forest Service study team investigated the management of four National Forests in Wyoming, in response to public concern of current practices (USDA Forest Service 1971). Principal findings were that people are concerned about the full range of forest values, about unfavorable effects of timber harvesting, and about the quality of forest stewardship. They found that much of the criticism could be attributed to inadequate, improper, or poorly timed treatment of logging residue.

They recommended research on possibilities for greater utilization or treatment, studies on effects of logging residue management on water quality, and more coordination of burning with meteorological information so as to reduce objectionable effects on air quality.

### Study of Prospective Residue Utilization

In 1971, a consulting firm, H. C. Mason and Associates, prepared a report for the Pacific Northwest Forest and Range Experiment Station on prospective utilization of substandard log material.?/

Factors identified as contributing to successful operations included: stronger chip markets, flexible management policies, close working relationships with timber sellers and logging operators, a stable market, and an outlet for accumulations of higher grade logs or log segments. Part of the success of an operation in logging residue would rest on the opportunity to buck out higher value segments from otherwise Utility grade logs.

3/ Mason, H. C., E. M. Matter, G. O. Tolman, and R. C. Smith. 1971, Study of prospective utilization of substandard log material. 35 p., illus. H. C. Mason and Assoc., Inc., Gladstone, Oreg.

In one sense, removal of logging residue was viewed as a service function, It was suggested that the desirability of cleaning up the woods may be worth some form of purchaser credit on stumpage.

The required yarding of unusable cull logs was considered discouraging to operators, and charred log remains at the landing or other location are apt to be more detrimental to appearance of the site than if left in place throughout the unit.

### Close Timber Utilization Committee Report

In 1971 a Forest Service committee on close timber utilization prepared a procedure for making close timber utilization a stronger part of Forest Service management direction. Their report noted that even though the Forest Service has had a long-standing policy to obtain the closest utilization economically practical, the present national concern for environmental quality indicates that greater efforts are now required (USDA Forest Service 1972c).

Their main recommendations were to:

1. Prepare interim standards that specify target levels of residue reduction according to different conditions of fire hazard, public exposure, and other factors,
2. Defer timber harvesting where these standards cannot be met.
3. Extend application of already available practices which encourage better utilization, including lump-sum sales, YUM yarding, multistage logging, and service contracts with salvage rights.
4. Study alternative timber sale arrangements including sale of logs at the roadside or at a concentration point, use of an extended land management contract, and alternative pricing procedures to avoid average cost pricing of low-value material.

5. Require residue removal under a "prudent land manager" concept, which gives greater recognition to the total management needs of the landowner.

6. Give greater priority to research and development of methods for reducing logging residue.

7, Encourage improved utilization on State and private forest lands, establish regional teams to promote better utilization on all lands, and implement a 5-year effort to reduce logging residue substantially on all forest lands.

### National Forests in a Quality Environment

A nationwide review of environmental aspects of National Forest timber management was made by a multidiscipline team of Forest Service staff specialists (USDA Forest Service 1972b).

Recommendations involving logging residue were: (1) to increase Forest Service sensitivity to esthetic values in planning and executing timber harvests and related activities, (2) to design and apply silvicultural treatments to selected road foregrounds in a manner that would perpetuate appropriate species and provide an attractive roadside, (3) to recognize areas where the final harvest cut must be deferred until markets and sale procedures assure a reasonable level of utilization of the timber, and (4) to accelerate research in key program areas, one of which includes research in practices to enhance the environment and reduce unfavorable impacts on it.

### Forest Service Response to Recommendations of Forestry Deans

The Forest Service responded in June 1972 to the recommendations of five forestry school deans who had evaluated clearcutting on the National Forests in a report to the Council on Environmental Quality (USDA Forest Service 1972a). The deans recommended improvement in Forest Service timber sale administration and supervision, greater contract flexibility, and more effort toward increased logging utilization. They also recommended research for improved logging systems and for better ways of slash disposal and removal of logging debris.

The Forest Service response recognized public concern over the "harsh visual aspect" of a patch-cut area and outlined steps being taken to give more attention to environmental quality and to study alternative mixes of various uses that National Forests can provide. Reduction of logging residue, either by utilization or by some form of disposal, is being given greater emphasis as an important policy objective.

### Report of the President's Advisory Panel on Timber and the Environment

In an appendix to a report by a special advisory panel on timber and the environment, Newport (1973) outlined possible changes in timber sale policies to improve logging utilization and reduce waste. These included more thinning and salvage sales, more sales on a lump-sum or tree measurement basis, and pricing policies to provide for sufficient profit and volume to encourage investment in new equipment and processes especially designed for small logs and defective logs.

A staff paper for the advisory panel's report also explored a service-type contract for Federal timber sales, with a logging contract separate from the log sale contract and a reduced stumpage charge for low value logs, compensated by higher charges on high value logs, or by purchaser credit for noneconomic removal of small or defective material.

The purpose of both these reports was to suggest methods for reducing logging residue through new forms of sales arrangements.

### Status of Timber Utilization Report

Grantham (1974) reviewed the status of timber utilization on the Pacific coast and pointed to technological advances in yarding systems, log sorting centers, new pulping systems, new structural products, and more accurate sawing as means to reduce wood residues.

He discussed recent advances in wood combustion technology including predrying, reduction to uniform-sized fuel, improved combustion control through furnace or boiler design, and improved exhaust emission control. Suggested uses were for direct heat exhaust to veneer dryers and dry kilns, or to boilers for electric power generation by some of the larger forest industry plants, especially pulp mills and papermills. Application of these technological advances can contribute to greater logging utilization.

### Studies of Lump-sum and Per-acre Pricing

In western Oregon, a 1970 study compared six each of scale-recovery and lump-sum sales and found no significant difference between the two groups with respect to volume of logging residue, costs of sale preparation and administration, and bid prices (Beuter and Arney 1972). Observed differences, however, suggested the possibility that other factors such as type of equipment, market situation of the logger, and time of logging may have had a strong influence on logging utilization.

Another study of 1971 logging on National Forests in western Washington and western Oregon compared 19 scale recovery sales with 19 sales where logs of 80 board feet in volume and over were sold on a scale recovery basis but all smaller, cull, and Utility grade logs were included on a lump-sum per-acre basis (Hamilton et al. 1975). Results showed an adjusted average of 16.8 percent less residue on the lump-sum per-acre sales, statistically significant at the 10-percent probability level but not significant at the 5-percent level. The authors concluded that this was weak statistical evidence of a real difference between the two methods and that other factors surrounding the harvest operation may be more important.

## IMPROVED SALES ARRANGEMENTS

Several variations in timber selling procedures have been described earlier in this report. These include scale recovery sales, lump-sum or tree measurement sales, sales to specified utilization standards, combination per-acre and scale recovery sales, and sales with required yarding of unutilized material. Several marketing aspects inherent in the timber selling process are:

1. The sales contract is a legal agreement between independent parties to do what is specified in the contract. It is difficult to specify every detail precisely in a contract and yet retain the flexibility needed for common sense decisions and efficient operation.
2. Timber purchasers have a primary interest in obtaining logs for their manufacturing business or for resale. Logging operators, to continue in business, must produce adequate and sustained income; this directly depends on high-volume log production. For the purchaser or logging operator, logging costs rise sharply for small or low-quality material. Most logging residue has little or no value to these parties.

3. One of the principles of marketing is that to accomplish something through another party you must find a way to make him significantly better off. Reduction or removal of logging residue is not easy under this principle.

4. If logging residues on public lands are to be significantly reduced, the public somehow will have to stand the cost, either in reduced stumpage receipts or in higher product prices.

The above marketing aspects raise the question of what actions might be taken to modify the sale procedure to help achieve greater logging utilization. Alternatives have been considered, and additional research or pilot testing is needed. Some promising ideas are:

## TUNE *UP* PRESENT SYSTEM

Some actions can be taken to improve logging utilization under current authority and regulations. Any effort to intensify or modify management prescriptions will take time for refining and testing. This, however, requires direction and support from top levels of management of both sellers and buyers.

Rapid closeout of cutting units for resale may also encourage residue removal. Resale may be either for relogging of parts of the unit, or more probably, for sale of YUM piles.

## INCREASED SLASH DISPOSAL DEPOSITS

Increased purchaser deposits under the Brush Disposal Act (16 U. S. C. 490) could provide for additional residue reduction work. At present, these deposits are collected primarily for fire protection work, where objectives are not as broad as the residue management objectives which relate to the total impact of residues on other uses and the environment.

## REQUIRED REMOVAL

Before introduction of per-acre pricing for logs under 80 board feet in size, the utilization standard specified in Region 6 Forest Service sales was generally to a 50-board-foot net log size in old-growth stands and to 20 or 30 board feet in young-growth or intermediate-age forests. Operators were expected to remove all logs down to the minimum size standard. Larger pieces not removed would be scaled and paid for at a penalty rate.

Initial experience under the per-acre pricing for material under a given minimum size has not been uniform. Some operators were encouraged to remove more of the small material, since it bears no direct stumpage charge, but other operators left such material, preferring to move to more valuable material in another sale. When per-acre pricing was first introduced, there was no strong requirement to remove the per-acre material. However, in July 1974, the Forest Service in Region 6 adopted an arrangement under which pieces down to 30, 20, or 10 board feet in individual sales were required to be removed. With Utility, Special Cull grade,[4/] and hardwood logs, an exception was made for gross economic impracticability at the time of removal of other timber. Much residue material, however, does not meet these specifications and is not affected by required removal of the specified material.

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**4/ The Douglas-fir Special Cull grade includes logs that do not meet the requirements of Peeler and Sawmill grade rules but are suitable for rotary cutting and have surface characteristics of a good No. 2 Sawmill log. In addition, they must have an adjusted gross diameter of at least 16 inches (40.6 cm) and adjusted gross length of 8 feet 8 inches (2.6 m); they must contain at least 60 percent usable material of firm white speck or better (Columbia River Log Scaling and Grading Bureau et al. 1972).**

The Washington State Department of Natural Resources has similar removal requirements in most of its current contracts.

Where insufficient space is available on regular landings, nearby storage areas might be provided to hold YUM material, particularly Utility grade and Special Cull logs during a poor market period. Although the idea of storage areas has much appeal, possible problems include size of storage area, length of storage period, conflict with other potential uses of the storage site, accountability of logs if more than one purchaser uses the same storage area, susceptibility to insect, disease, and fire hazard, and what to do with logs still in decks at the contract expiration date.

### SERVICE CONTRACT

Under a service contract, the public land management agency would in effect hire the operator to do the logging job as directed and deliver logs to a sorting yard or to a third party. This would give the public agency more control over logging, which could then be more flexible than under the present system of stumpage sales. Any degree of residue removal could be required because the operator would be paid to do the work. The payment to the operator could be from a revolving fund or purchaser credit toward other timber, or some form of third party payment to the operator.

### LAND MANAGEMENT CONTRACT

The land management contract would focus attention on the land management job rather than on the logging job. The contracting firm would be given a high degree of responsibility and control and would need capability in a broad range of land management skills in addition to logging skills. Residue management would be considered a part of this land management job. For example, a current timber sale on the Wind River Experimental Forest specifies a desired residue level to be left on three clearcutting units, rather than giving specifications for minimum size pieces to be removed. It is up to the purchaser to reach this desired level with the yarding process.

An advantage claimed for the land management contract concept is that the contractor's success would be related to how well he does the land management job, rather than how fast and how cheaply he gets out the logs.

Rather than specifying the details of operation, the contract could require that operations be carried out in accordance with an approved annual logging plan which would contain the details and be subject to negotiation and change each year without modification of the basic contract.

Potential disadvantages of this concept include inflexibility because of the probable long-term nature of commitment, possible loss of control over detailed operations by the agency, and difficulty of defining precisely the responsibilities of the contracting parties, particularly those which might differ from the present timber sale contract. Lack of capability to perform technical work might exclude some operators or firms from qualifying for such a contract.

## MATERIALS HANDLING

Some logging residues constitute a materials handling problem in yarding, where heavy, expensive logging equipment is not suited to handling small or defective pieces. Logs and chunks are also left as residues when the operator doesn't have a market for the total range of available raw material. Improvements in materials handling can therefore increase utilization and thus reduce logging residue.

Conventional logging equipment is not always suitable for protection of land values on steep slopes nor for use under partial cutting prescriptions, Improved logging systems are therefore needed to reduce the physical impact of the logging process and to create less residue.

## TWO-STAGE LOGGING

Two-stage cutting or yarding may prove feasible, in which heavy equipment is used for large logs, and smaller more flexible equipment and crews for smaller pieces. However, stage cutting has tendency to cause breakage in felling the second stage because of numerous stumps left from the earlier stage.

Part of the advantage of two-stage logging, similar to adding a small sawmill alongside a large sawmill, is that the large log handling system can be relieved of handling smaller logs, which are more costly with the large equipment. This allows the large-log system to operate closer to its full capacity and avoids wasting time with smaller logs,

The second stage logging can remove not only the small logs impractical to handle with the larger system but also some of the logs that either system could remove. Therefore, the second stage logging can also operate more efficiently by having a larger volume over which to spread fixed costs (Adams 1965).

## MORE EFFICIENT LOGGING SYSTEMS

Ordinary timber sales are seldom geared to a rational integration of the logging and manufacturing process in an efficient total system. Availability of an increasing diversity of logging methods now calls for more skill in sales layout and more coordination with types of equipment used. Efficient logging also bucks logs and sorts species, sizes, and grades to meet the various requirements of the manufacturing plants involved. Logging residues tend to be reduced when logging is integrated more closely with the diversity of utilization outlets available.

The conventional high-lead system has an inherent tendency to create residue by breaking logs when pulling them out of a jammed situation and when they hang up against stumps and other logs or roll down a sidehill in yarding. On the other hand, skyline systems create less residue because they can suspend logs or lift one end higher during the in-haul to the landing. Thus, there is less interference from intervening stumps and slash. Balloon and helicopter systems have this capability, but their high cost of operation increases the size of the log that is economically submarginal and might be left as residue.

Grapple systems are faster than choker systems and can permit more rapid and thus cheaper handling of low-value material that might otherwise be left as residue. However, grapple systems are mostly limited to clearcutting.

Skidding or yarding is just part of the materials handling process. More efficient loading can sometimes be accomplished by cold-decking small-diameter or short pieces for later handling by a smaller loader than used for the larger logs. Hauling of small-diameter or short pieces can be inefficient or even impossible with standard long-log trucks unless there are sufficient bunk logs to support the load. Short truck and trailer combinations have been developed, with stakes set to accommodate short logs. An extra trailer and a loading crib can be used to accumulate the next load while the main truck and trailer is on its way to the mill (Adams 1965). However, except for strictly salvage or large integrated operations, keeping such equipment fully occupied on a daily basis is difficult,

### COMBINED LUMBER AND CHIP MILLS

Special sawmills have been designed to operate on a high proportion of Utility-grade logs. Such mills aim to increase value recovery of the logs by rebucking long logs into better grade segments suitable for lumber or veneer production. Value recovery is increased from what would otherwise be largely pulp logs or culls.

Such mills must be designed to handle a large volume of chips, preferably with a whole-log chipper available. They also require a market outlet for the large accumulations of sawdust, rot, and bark usable only as hogged fuel.

Keys to successful operation are low capital investment, a limited product line, small crew, a dependable log supply, and a firm outlet for chips and hogged fuel.

A conventional sawmill cannot afford to operate in this fashion, because the investment in equipment and high labor cost requires use of largely sound material from which volume and value output is greater.

### MOBILE CHIPPERS AND SATELLITE PLANTS

Large mobile chippers have been used successfully for conversion of small logs to chips at the logging site but have been made largely obsolete by introduction of chip-and-saw mills, or by other small-log mills that are able to make a higher value product for small sound logs. Smaller mobile chippers are now available, but these find difficulty in producing chips that can compete with mill residues in the chip market.

Independent chipping plants have also been tried but generally have not been successful because of a fluctuating chip market. These mills seem to be the first affected in a poor market because of their inability to make other higher value products in combination with the chipping operation. Other chip mills, integrated with larger forest industry firms, have been more successful and probably will increase in number.

The chief advantage of mobile chippers and satellite chipping plants is that they reduce raw material to chip form early in the marketing process, thus avoiding costly handling and rehandling of many individual small irregular-shaped-pieces.

Mobile chippers and satellite chipping plants also have the disadvantages of geographic separation from the utilization plant and lack of business and marketing efficiency when the chipping facility is in separate ownership from the utilization plant. Further disadvantages of mobile chippers, in particular, are their need for an independent power source, costly transportation of workers to remote sites, delays caused by weather, and the difficulty of servicing breakdowns away from parts and servicing sources.

## EXPANDED MARKETS

Reduction of logging residue through greater utilization ultimately depends on enlarging the market for end products that can use such material. In the short run, logging residue is left *on* the logging site because it cannot compete with higher value raw materials already in use. Only a technical breakthrough, higher log prices, or a larger total market can bring more of this low-value material into use.

Small, sound logs down to a 5-inch (12.7-cm) top diameter may be utilized in chip-and-saw or other specialized small log sawmills. For material not

suited to lumber or plywood use, the chief markets are chips for domestic pulp or particleboard or for export. Other potential outlets might be as raw material for electric power generation or mulch and soil conditioner.

## CHIPS FOR DOMESTIC PULP OR PARTICLEBOARD

It is true that much logging residue contains a large amount of sound fiber. However, in normal times pulpmills have been well supplied by mill residue and Utility grade logs. Also, much of the sound fiber in existing logging residue is mixed with partially or totally decayed fiber or is in irregularly shaped pieces not suitable for handling and debarking, and costs of collecting and handling are excessive for this less suitable material.

The 1973-74 slump in the lumber industry sharply reduced available mill residues, and the pulp industry turned strongly to logging residue as a supplemental source of chips. Several large chip mills were built, and these will probably continue operating even when availability of chips from mill residue resumes. However, sharp fluctuations in the chip market can disrupt any general program for increased residue utilization.

The particleboard industry is growing rather strongly, but from only a modest base relative to volume of all wood used by industry. Its principal markets are in the East and Central States, and raw materials closer to these markets have a transportation advantage, plus a labor cost advantage in many cases. If the public were to share a part of the cost of delivering raw materials to the particleboard industry as a residue disposal measure, expansion of the particleboard industry might be more feasible.

Structural flakeboard is a new type of board in the developmental stage. Its main features are longer flakes (1-1/2 to 3 inches (3.8 to 7.6 cm) long) and controlled orientation of the flakes to give the product greater strength. Douglas-fir flakes are especially well suited because of their improved strength properties. If development is successful, this product could greatly enlarge the market for wood residues. Its principal use would be for wall and roof sheathing in the housing and construction markets.

## CHIPS FOR EXPORT

The chip export industry, exporting chiefly to Japan, is well established on the west coast and is expected to continue strong except for minor fluctuations. Long-term contracts (about 7 years) are presently in force, and in the long term some expansion of this market is possible. So far foreign purchasers have been interested mainly in dealing with large well-established firms that can assure a long-term dependable supply.

## ELECTRIC POWER GENERATION

Use of logging residue for electric power generation has been investigated by the Pacific Northwest Forest and Range Experiment Station (Grantham et al. 1974). The study found that this potential use is severely limited by the high cost of collecting and transporting large volumes of residue to a generator site. Use could be either in power stations in the 25- to 50-megawatt size class, or in industrial power plants such as those at pulpmills where there is a demand for process steam as well as electric power. Larger sawmills and plywood plants also have need for substantial amounts of electric power as well as for heat energy for kilns or veneer drying, At present, these

latter uses show much promise for increased use of residues. However, none of these can realize the full economy of large scale powerplants, which with other fuels will occur more in the 500- to 1,000-megawatt size class.

Electric power generation from logging residue in the Pacific Northwest was found potentially feasible only if the public were to absorb a portion of the costs of collecting and transporting the residue material. Electric power generation is a low-value use for logging residue. Generally it cannot compete with higher value uses for sound fiber for pulp or particleboard. This situation may change if demand and price for electric power continue to increase. Other objectives, such as environmental cleanup and the building of diversity or reserve capacity into our total power system, could overcome a costwise disadvantage.

Burning of wood residue in combination with municipal refuse to generate power might be feasible once a decision was made to handle municipal refuse in this manner, but the technology for this use has not yet been well perfected. A 115-megawatt plant of this nature has been proposed for Lane County, Oregon (CH2M Hill 1973).

## OTHER ENERGY USE

The 1973 worldwide oil crisis created much interest in developing other sources and types of fuel, such as methanol for automobiles (Reed and Lerner 1973) and methane gas from municipal organic wastes or animal manure. Wood residues also could be converted to these products, yet many technical and logistic problems would have to be solved before suitable processes could be economically feasible on any large scale (Grantham and Ellis 1974). At present, all evidence points to other sources of energy being much cheaper and accessible in larger quantities, such as coal or natural gas as a primary methanol source.

## MULCH AND SOIL CONDITIONER

Bark mulch is used extensively for landscaping purposes, but whether chipped logging residue could ever be competitive in this use is questionable, mainly because bark is already available at a very low cost at mills and because the color and texture of bark mulch is more esthetically pleasing.

### Highway Use

Chipped logging residue may be suitable for highway roadside mulching, where appearance factors are not as critical as in other landscaping use. The purpose would be to conserve soil moisture for landscape planting, to control growth of weeds, and to prevent erosion. On the negative side, highway mulch could be somewhat of a fire hazard during dry periods, but selective use may be feasible where potential benefits are high and the fire hazard low.

Chipped logging residue would have to be delivered to highway departments at a cost competitive with bark mulch now already available at low cost from mill residues (Mater 1971). Some portable chippers are already in use by highway departments for disposal of roadside brush and small trees.

### Agricultural Use

Physical and chemical properties of bark make this material suitable for agricultural use (Bollen 1969). Trials have been made of bark and other wood residues used as an orchard mulch

(Cruikshank 1971). Benefits to the crops would have to be determined. Besides the obvious high cost, there would usually be a nitrogen deficiency that would have to be monitored and corrected, With logging residue, some undesirable as well as desirable fungi or other microbiota might be introduced.

The use of chipped logging residue worked into the soil as a conditioner, in contrast to a mulch placed on the surface, is another possibility. Here the nitrogen deficiency would be more serious. Any decision on this use will depend on the benefits to farming, not the benefits of residue reduction. Agricultural scientists have given only brief consideration to this use of wood residues. So far, it appears impractical, particularly from the cost standpoint (McGauhey 1971).

Chipped logging residue could be explored for long-term soil building in excessively sandy or clay-type soils lacking organic matter, not as a commercial practice but as part of a public effort to reclaim land not now suited to agricultural use. This could apply to situations where irrigation development of desert land needs supplemental application of organic matter to the soil. On the other hand, a simpler plowed-under cover crop could probably do as well at much less cost.

### Forest Use

Scattering chipped logging residue back on the logging areas would help recycle nutrients and prevent soil erosion, could cause nitrogen deficiency, and on steep ground would be extremely costly, if not physically impossible. If the spreading were restricted to what could be reached along existing roads or spurs it might be physically or silviculturally feasible, but still very costly in collecting and handling. Roadside chipping of slash from partial cutting or right-of-way cutting has been tried, but this method was found to be approximately 12 times more costly than slash burning (National Industrial Pollution Control Council 1971). In addition, scattering chipped logging residue on the logging site and along roads would usually increase the fire hazard.

Where roadside hazard is high, a protective strip adjacent to the road might be excluded with chips placed only beyond this strip. On little-used spur roads or secondary roads, a protective strip might not be necessary.

## CONCLUSIONS

Our conclusions are intended to highlight the current situation and to bring the various aspects of the residue problem into focus:

1. Increasing public travel in the forest and increasing public concern for the environment make former levels of logging residue and smoke from slash burning more and more objectionable. Realistically, logging residue and slash burning can be reduced but not eliminated. Perhaps the public would accept these things more readily if given a better understanding of what was being done and why. From a conservation standpoint, utilization of logging residue is preferred over treatment or disposal methods.

2. Logging residue is lower in value and much more costly to handle than sound material with which it competes. However, in the long run, as market forces gradually increase the total size of the market and as the stumpage cost of sound logs increases, there will be a gradual increase in utilization of the type of material that is now logging residue. Any incentives that can be provided through improved sales arrangements, materials handling, and

utilization processes can speed adjustment to a changing market.

3, From the user's point of view, logging residue is often the highest cost source of raw material and tends to bear the greatest impact resulting from fluctuations in demand. In some instances, however, its low stumpage cost may offset higher logging costs.

4. Some changes in timber sale arrangements such as lump-sum pricing, required removal, and elimination of road maintenance charges for residue-type material can encourage increased logging utilization, but there is no universal solution, and a broad range of alternatives is desirable.

5. Despite its high cost, YUM yarding may sometimes be the only residue reduction measure available to the land manager. It has been an effective land management measure, especially in reducing residue and slash burning. However, it may not be desirable on steep, fragile soils or where landing space is limited.

6. Increasing demand for wood and the need to reduce residues has brought development of specialized log handling equipment, sorting yards, and chip mills to handle the lower grade material. As these become more common, the utilization of residues will work its way more and more into the permanent industrial and marketing structure and create a continuing demand for what is now residue.

7. The electric power industry is oriented toward large-scale hydro, nuclear, or fossil-fuel plants for economies of scale in preference to smaller, higher cost generating plants that might be based on use of wood residues. However, as the cost of purchased energy increases, forest-oriented industrial users such as pulpmills are finding it advantageous to generate more of their own electric power, heat, and processing steam from wood residues. Use of available wood fuel reduces dependence on purchased fossil fuels or purchased power, both of which may be cut off in times of low supply,

8. At present, sound wood fiber has a higher market value for pulpwood chips, particleboard, or chip exports than as hogged fuel for electric power generation. However, when logging residue is used for these products a sizable proportion of bark, rot, and other material suitable for hogged fuel will also be produced.

9. Integrated firms that find a way to utilize logging residue will have a competitive edge over those that don't, even though the return from residue utilization itself is not attractive.

10. Public benefits from reduction of logging residue and reduction of slash burning can justify public sharing of the costs of such reduction. In addition to onsite benefits, these benefits include the addition to the raw material base and the additional employment generated.

11. Not all logging residue should be removed, nor are all residues necessarily objectionable. Some level of residue is generally beneficial, depending on soil and site characteristics.

12. Continuing studies are needed of specific localized situations where a combination of favorable factors can make more residue utilization feasible.

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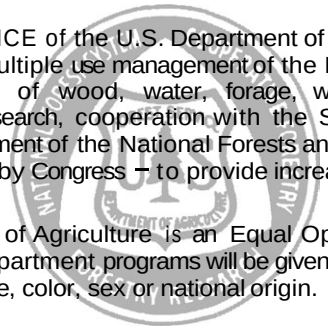

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