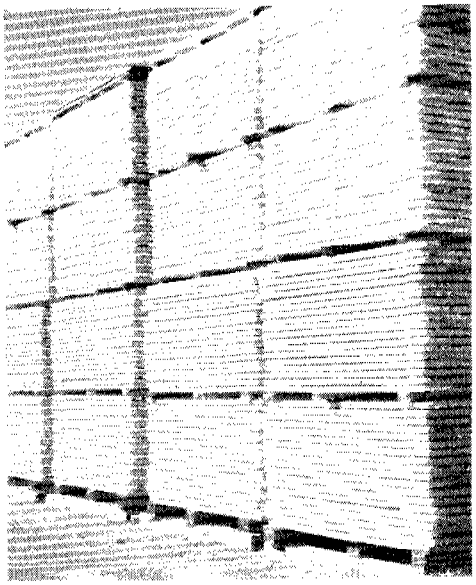
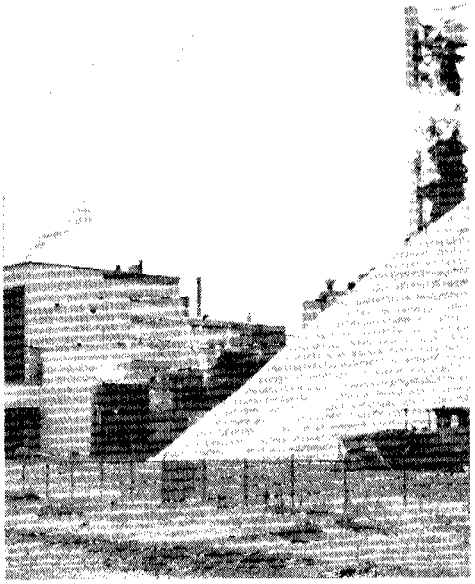
HARVESTING AND UTILIZATION OPPORTUNITIES FOR FOREST RESIDUES in the northern rocky mountains





Symposium Proceedings Nov. 28-30, 1979, Missoula, Mont.

USDA Forest Service General Technical Report INT-110
Intermountain Forest and Range Experiment Station
U.S. Department of Agriculture, Forest Service

USDA Forest Service
General Technical Report INT-110
March 1981

HARVESTING AND UTILIZATION OPPORTUNITIES FOR FOREST RESIDUES

in the northern rocky mountains

Symposium Proceedings
Nov. 28-30, 1979
Missoula, Mont.

Sponsored by:

Intermountain Forest and
Range Experiment Station,
Forest Service, USDA

Bureau of Business and
Economic Research,
University of Montana

Forest Products Research Society
Inland Empire Section

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
U.S. Department of Agriculture
Forest Service
Ogden, Utah 84401

THE FOREST RESIDUES UTILIZATION R&D PROGRAM

Roland L. Barger
USDA Forest Service, Intermountain Forest and
Range Experiment Station

ABSTRACT

Since 1974 the Intermountain Station has directed an integrated program of research toward developing methods to achieve more efficient timber utilization, consistent with responsible management of the forest ecosystem. This research combines the efforts of scientists in utilization, engineering, economics, marketing, and the biological sciences. Research in residue characterization has defined the volume, character, and product potential of residues in various timber types and harvesting situations. Research in products, processes, and markets has included work relating to solid wood and chip and fiber products. Particular emphasis has been given the processing and use of dead timber, by far the largest residue component in the Intermountain West. Other research has explored the feasibility of achieving closer utilization with conventional cable and ground skidding harvesting systems under different silvicultural and management prescriptions. Related research is developing new harvesting system concepts and practices, with emphasis upon systems that can function more efficiently in handling small timber, residue material, and small volumes per acre. More efficient utilization of the wood resource represented by forest residues can substantially extend the resource base.

KEYWORDS: forest residues, wood utilization, timber harvesting, forest practices

FOREST RESIDUES--PROBLEM AND OPPORTUNITY

A major challenge in the Intermountain area is the need to achieve more complete and efficient use of our available wood resource. Although utilization practices have improved dramatically in recent years, the aggregate volume of unused residues

and potential salvage material is still very large. There are two immediate and related needs. The first need is to improve the recovery and utilization of the total wood resource, leaving less material as residue. National projections predict substantial increases in demand for wood and wood-fiber-based products, especially softwood housing construction materials. Environmental considerations also favor extending (or at least maintaining) the use of wood, a renewable resource that can be processed with less energy and less attendant pollution than alternative materials. Harvesting practices that facilitate more complete utilization of the available wood resource in the Northern Rocky Mountain States can contribute significantly to meeting this demand.

The second and concurrent need is to reduce the adverse esthetic and environmental impacts of timber harvesting, associated road construction, and other onsite activities. Present utilization standards and logging practices leave large amounts of residue--small trees, cull and broken logs, tops, and dead timber--on the ground following harvesting operations. Road right-of-way clearing and thinning operations result in additional volumes of unused wood. These residues can contribute to the forest's nutrient reservoir, reduce erosion, protect seedlings, and provide wildlife cover. In the quantities that frequently occur, however, they create a fire hazard, inhibit regeneration, detract from area esthetic values, and represent waste of a scarce fiber resource. Harvesting and transportation practices that improve the economic feasibility of using more of this material can remedy a major source of undesirable impacts on the area.

Since 1974 the Intermountain Experiment Station has directed a coordinated program of research, the Forest Residues Utilization R&D Program, toward investigating alternative timber harvesting practices that may facilitate more intensive, environmentally compatible, timber utilization. Major objectives of this program have been:

(1) To develop resource information--present and predicted--defining the location, quantity, and physical characteristics of material considered residue, as a means of strengthening utilization opportunities;

(2) To evaluate harvesting and transportation systems that can improve the technical and economic feasibility of recovering and using more of the total wood resource;

(3) To evaluate product, process, and market alternatives that will facilitate more complete and efficient use of material commonly left as residue;

(4) To evaluate the biological and environmental effects of residue reduction, and the influence of residue reduction on postharvest forest management needs and activities.

The principal subjects of this report and of the "Harvesting and Utilization Opportunities for Forest Residues in the Northern Rocky Mountains" symposium are the first three areas of investigation--research and related industrial experience in resource evaluation, harvesting, and utilization. The fourth area, environmental and management consequences, was the subject of a separate symposium in September 1979 (USDA Forest Service 1980).

THE RESEARCH PROGRAM

To meet specified objectives, program research has necessarily involved a wide variety of subject matter and associated disciplines. The core program staff has included researchers with skills in engineering, wood technology, economics, meteorology, microbiology, entomology, and biometrics. Other Station research work units in such subject areas as silviculture, fire management, economics, hydrology, and wildlife habitat have participated extensively in studies of biological and management impacts. Other major participants in the research have included researchers at other Forest Service units, researchers at several universities, and industrial timber harvesting and processing firms in the region. The Bureau of Business and Economic Research, University of Montana, and the forest products industry are especially worthy of note because of their extensive involvement.

Early program planning was developed around three basic concepts: recognition that wood utilization objectives and practices must extend from, and be compatible with, broad forest management objectives; belief that the best approach to residue utilization is through more efficient initial harvesting practices, rather than salvage operations; and recognition that residue reduction has significant and direct effects upon the forest ecosystem and subsequent management activities. The typical procedure followed in planning and implementing program research is illustrated in figure 1. First consideration was given to defining the total forest resource management objectives for a particular timber stand and site situation. Harvesting specifications were then developed for tree removal and other stand or site character modifications (usually an array of possible alternatives) to meet management objectives. Harvesting systems, utilization levels, and postharvest treatments that could achieve the selected treatment effects were applied. Finally, technical and economic feasibility were evaluated, and the environmental and management consequences of tested alternatives were determined. A central concern, of course, was to apply and test harvesting alternatives that have the capability of recovering much of the wood material commonly left onsite as residue.

Assessing the Resource

The term "forest residues" is commonly applied to all woody material that for one reason or another remains in the forest. Major components of this residue resource in the Northern Rocky Mountain area are: (1) logging slash and cull material from harvested trees; (2) standing and down dead timber; and (3) submerchantable trees cut in the process of thinning, postharvest site treatment, or right-of-way clearing. For most primary raw materials, the term "residues" implies an unusable waste byproduct. By contrast, wood residues have the same basic physical and chemical characteristics as the primary resource and are differentiated only by size, shape, or condition. They can be used (within the limits imposed by size, shape, or condition) by the same sawmill, pulpmill, or particleboard plant that uses the so-called "merchantable" part of the resource. Residue is simply that part of the total wood resource that cannot be used at a given time, because of constraints imposed by technology or economics--largely economics.

A first step in evaluating the utilization potential of the residue resource is to develop some estimate of quantity and physical characteristics. Although an accurate assessment would be extremely difficult, expensive, and probably not warranted, reasonable estimates are needed and have been obtained through various inventories and studies. A brief review of some of these inventory figures will serve to illustrate the scope of the residue resource.

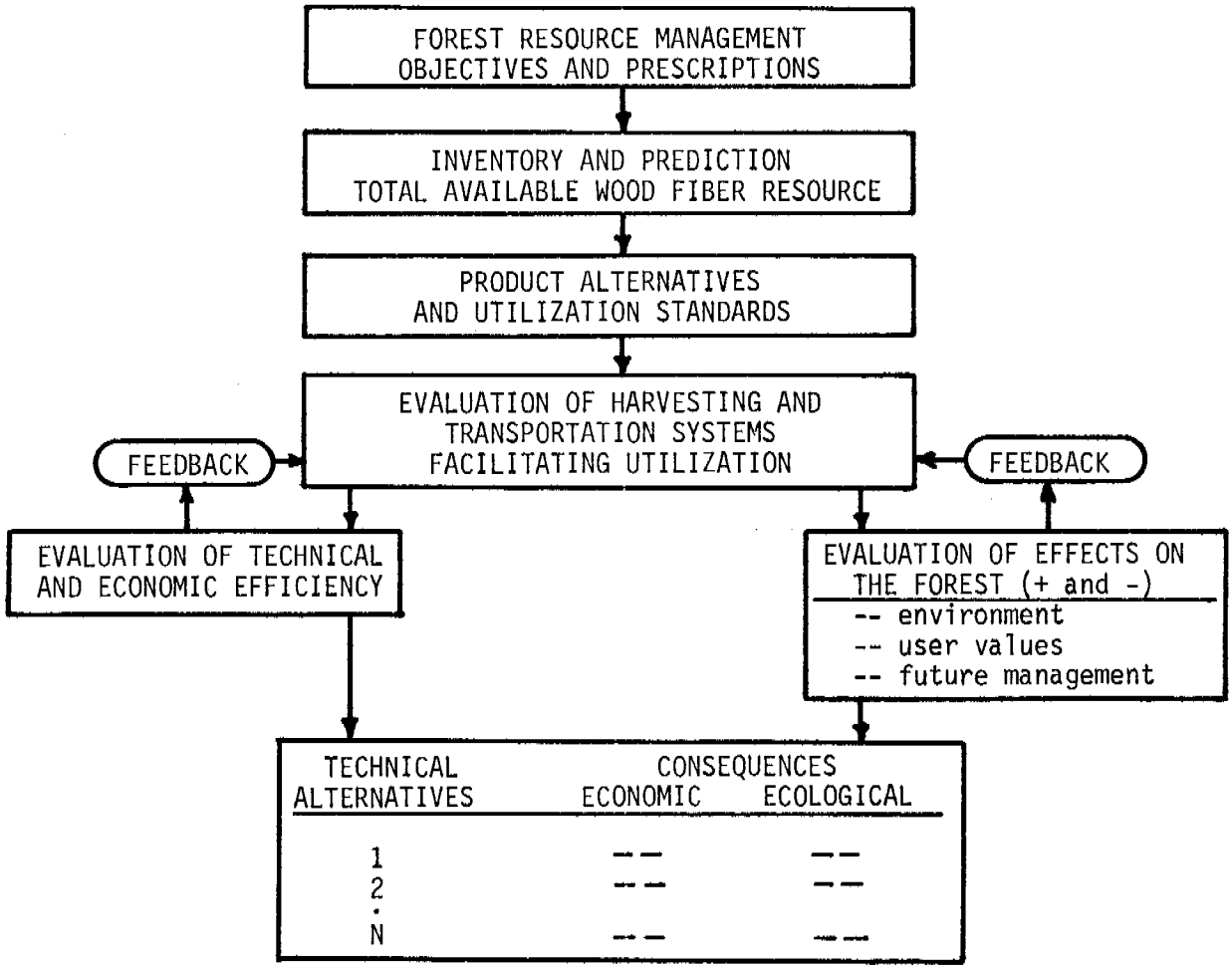


Figure 1.--Research program schematic depicting sequence of key phases. The program emphasized developing and testing harvesting and utilization alternatives that are compatible with, and facilitate, total forest resource management on the site.

The largest and most conspicuous residue component in Northern Rocky Mountain forests is dead timber (fig. 2). Dead timber, resulting largely from a long and continuing history of insect and disease damage, can remain sound for many years on the relatively cold, dry sites common in this area. Forest Survey information indicates that approximately 6.7 billion ft^3 (190 million m^3) of salvable, dead sawtimber exists within the nine Rocky Mountain States (table 1). Montana alone contains an estimated 3 billion ft^3 (85 million m^3), roughly equivalent to 12 years' allowable cut at present harvesting levels. In addition, the annual sawtimber mortality for the same States is estimated to be 2.5 billion bd. ft. (71 million m^3), of which about two-thirds occurs in Montana and Idaho.

Figure 2.--Old-growth lodgepole pine stands contain a large proportion of dead material, both standing and down.

Table 1.--Net volume of salvable dead timber on commercial forest land in the Rocky Mountain States (source: Green and Setzer 1974).

State	Salvable dead timber		Percent of total
	Million ft^3	(Million m^3)	
Idaho	940.0	(26.6)	14
Montana	3,000.7	(85.0)	45
Wyoming	577.1	(16.3)	9
South Dakota	47.0	(1.3)	<1
Arizona	133.4	(3.8)	2
Colorado	1,340.7	(38.0)	20
Nevada	10.4	(0.3)	<1
New Mexico	346.5	(9.8)	5
Utah	303.9	(8.6)	5
Total	6,699.7	(189.7)	100

Residues remaining after a conventional saw log harvesting operation include dead timber rejected as unmerchantable, slash and cull material, and small stems either accidentally or purposely downed (fig. 3). Recent research studies, discussed in some detail by researchers participating in this symposium, indicate volumes of residue ranging from 2,000 to over 4,000 ft^3 per acre (140-280 m^3/ha) (Benson and Johnston 1976; Foulger and Harris 1973). Residues remaining following conventional clearcut logging in old-growth lodgepole pine, for example, averaged 4,333 ft^3 per acre (303 m^3/ha) (Foulger and Harris 1973). Material 3 inches (7.6 cm) and larger in diameter accounted for 82 percent of the residue (table 2).

Figure 3.--Residues remaining following conventional saw log harvesting operations in old-growth stands frequently exceed 100 tons per acre (224 tons/ha).

Table 2.--Wood and bark residues remaining following clearcut logging to conventional saw log utilization standards in mature lodgepole pine--Teton National Forest (source: Foulger and Harris 1973).

Diameter size class		Residue volume					
		Wood		Bark		Total	
in.	(cm)	- - - - - Ft^3 per acre (m^3 per hectare) - - - - - -					
<0.3	(<0.8)	2.4	(0.2)	5.7	(0.4)	8.1	(0.6)
0.3-0.6	(0.8-1.5)	69.3	(4.8)	41.2	(2.9)	110.5	(7.7)
0.6-3.0	(1.5-7.6)	562.7	(39.4)	84.8	(5.9)	647.5	(45.3)
>3.0	(>7.6)	3,274.5	(229.1)	292.5	(20.5)	3,567.0	(249.6)
Total		3,908.9	(273.5)	424.2	(29.7)	4,333.1	(303.2)

Gross inventory figures do not imply that the entire residue resource is economically or physically available. Harvesting costs, access problems, and the randomly scattered nature of much of the resource are likely to limit economic availability indefinitely. Nevertheless, the figures indicate that with even slightly improved harvesting and utilization practices, the currently unused wood could provide a substantial basis for industry expansion and added product manufacture with no added drain on the timber supply.

Harvesting Research

Much of the research investigating the feasibility of intensive levels of wood fiber recovery was conducted on three primary sites. These include:

(1) The Coram site--typical of old-growth western larch/Douglas-fir stands on steep slopes.

(2) The Lubrecht site--dry site Douglas-fir, with intermixtures of ponderosa pine and larch, on gentle terrain; broadly representative of a major segment of the more productive commercial forest land in the region.

(3) The Teton site--typical of higher elevation old-growth lodgepole pine in the Central and Northern Rocky Mountains.

These study sites are described in detail, including harvesting systems and utilization standards tested, in this publication under "Intensive Utilization with Conventional Harvesting Systems" (Barger 1980). On these major sites, harvesting systems research was closely integrated with pre- and postharvest studies evaluating the biological and environmental consequences of intensive utilization. On a number of other sites, researchers cooperated with industrial logging firms to study the physical and economic feasibility of specific harvesting systems and practices (fig. 4).

Figure 4.--An experimental salvage operation recovers pole-size timber, establishing a measure of the costs and productivity of the practice.

Program research in harvesting systems has taken two directions--evaluation of the efficiency of existing systems and practices when used to achieve close utilization standards, and development of new harvesting practices and equipment better suited to handling smaller, low-value material. Field studies have included the use of in-woods chipping systems; use of conventional tracked and wheeled skidding equipment in relatively gentle terrain; and use of cable systems in steeper terrain. Low capital investment systems evaluated in small timber have included horse skidding as well as use of farm tractors (Host and Schlieter 1978). In each study, utilization prescriptions have generally extended from standard saw log utilization down to total utilization of available fiber.

The development of new systems has concentrated on systems for steep slopes, primarily smaller, more versatile cable systems. Of particular interest are systems that can reduce the density of roads; reduce sensitivity to road location; and gather or bunch smaller material to make larger yarding payloads. A number of these concepts are discussed at length in this publication under "Outlook for New Harvesting Technology" (Gonsior 1980).

Related research has been directed toward developing improved methods of evaluating proposed harvesting operations, laying out sale areas and units for cable logging, and evaluating economic operability. Determination of economic feasibility becomes more critical for high investment systems such as cable systems and whole tree processing systems, where substantial hourly amortization costs must be covered. The increased use of cable systems also requires greater care and precision in laying out sale areas, particularly in areas that are borderline in terms of topography and operability.

Products and Process Research

Program research in products and processes has been oriented toward defining product and process opportunities that can achieve economically viable utilization of forest residue material. The utilization of dead timber and small stems has received the greatest attention, because these components make up a large share of the residue resource. Forest residues include material that can be used for virtually every product manufactured from the merchantable timber resource. Given favorable economic conditions, material normally considered residue has been used for lumber, commercial poles, house logs, and a full array of products with less demanding specifications. Near-future opportunities for utilizing significant volumes of residue seem to be brightest in four basic areas: (1) extended utilization for conventional roundwood and sawn products; (2) use for pulpwood; (3) use for particleboard and fiberboard manufacture; and (4) use as an industrial fuel.

Practices that achieve extended utilization of residue for conventional sawn and roundwood products include revising sawtimber merchantability standards to accept smaller tree and log diameters, manufacturing lumber or treated products from older dead timber, and relaxing quality standards used to identify cull material. Smaller chipping headrigs and more efficient small-log processing plants have succeeded in reducing the size of the minimum merchantable log in many situations. Finger-jointing and end-and-edge gluing have become relatively common practices, facilitating use of small pieces and nonstandard widths. Still in a development and trial stage are mills specifically designed to utilize cull logs. Roundwood product manufacturers are less reluctant than they have been in the past to make use of dead timber. Some have discovered distinct advantages in dead material for their particular application.

Extended utilization is especially sensitive to market conditions. During depressed market periods, products and processes nearest the manufacturing margin are the first to be discontinued. Given the long-term upward trend in demand for all wood products, however, it seems inevitable that more intensive utilization for conventional products will increase. Much of the material currently considered residue will become an economically available resource for these products.

Forest residues also include a large volume of material suitable primarily for chip, particle, or fiber-based products. Major foreseeable uses for such material are likely to be for pulp, particleboard or fiberboard, or fuel.

In the Northern Rocky Mountain area, there appears to be a relatively close balance between chippable mill wastes and pulpwood demand, with little room for expansion. As demand for pulp chips increases, and competing uses appear, the price of mill-waste chips can be expected to increase. In addition, as greater conversion efficiencies are achieved in plywood and lumber manufacture, available chip supplies may actually decline. When the cost of mill-waste chips approaches the cost of handling and chipping forest residues, the forest residues will become an economically viable source of pulpwood (fig. 5).

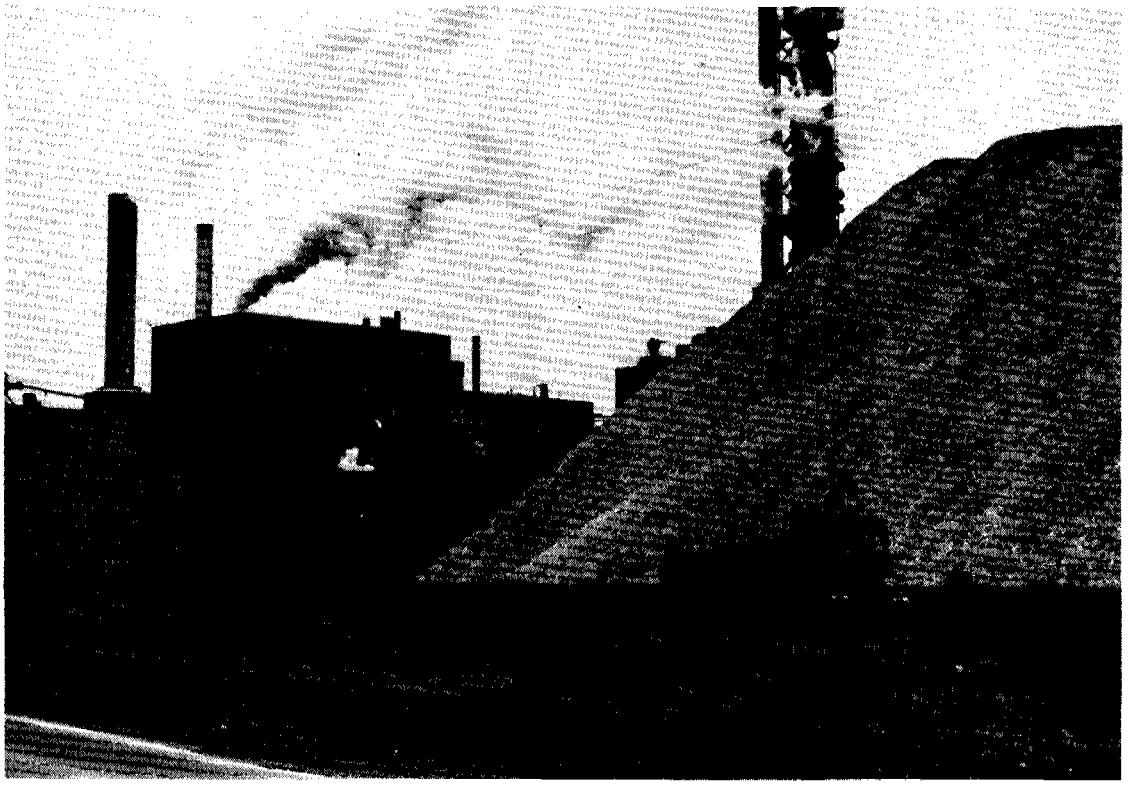


Figure 5.--Forest residues include large volumes of material suitable primarily for chip or fiber products, such as paper.

The development of a new class of particleboard products, referred to as structural particleboards, may offer more immediate promise for utilizing forest residues. Structural particleboards are designed to provide the strength and weather resistance necessary for exterior and structural applications such as wall and roof sheathing. To obtain the added strength, the boards are manufactured from relatively long, thin flakes of uniform size and shape. The flakes or particles may be alined in one direction, cross-banded, or combined with veneer face plies. With the exception of large residues such as veneer cores, mill residues are not suitable for the production of acceptable particles. Roundwood or forest residues will be required.

Structural particleboards are in the developmental stage, but their success and rate of market growth are difficult to predict. Historically, the construction industry has been slow to adopt new concepts and projects. If it can compete with plywood, structural particleboard could utilize significant volumes of forest residues within a few years. Assuming that pricing will be comparable to that for exterior plywood, the particleboard industry should find forest residues within economic reach.

Recent concerns about soaring energy costs and shortages of fossil fuels have directed renewed interest toward wood as an industrial fuel. Many industrial firms are facing potential restrictions on the availability of fuels and electrical energy, and at best are operating with interruptible energy sources. One obvious solution is to reconsider the role of wood residues as fuel.

Wood wastes have long been used as fuel by the wood products industry, however, and recent trends within the industry are toward expanding capability to use wood fuel. Residues burned in manufacturing plants can produce both process steam and electricity, with much of the energy used in the form of steam and heated air. Recent developments in wood combustion technology have dramatically improved the efficiency of wood-fired furnaces. Increasing alternative energy costs, physical unavailability of other fuels, and the need to develop self-sufficiency will all contribute toward making forest residues an economically available industrial fuel.

Program studies have included the investigation of product potential represented by residues; processing characteristics affecting drying, treating, chipping, gluing, and other manufacturing treatments; the physical characteristics of products produced from residues; and the economic availability and probable cost of residues delivered to processing facilities. Specific research results are discussed in detail in subsequent sections of this publication. Representatives from wood products firms also discuss the practical considerations that influence the utilization of low-quality wood.

REPORTING THE RESULTS

The purpose of this publication is threefold:

--To report the results of research conducted by the Residues R&D Program in harvesting and utilization opportunities for forest residues;

--To provide a record of proceedings of the 3-day symposium exploring both research and industrial experience in residues utilization;

--To provide a compendium of information useful to those involved or interested in improving the recovery and utilization of forest residues.

Improved resource utilization depends upon better resource information, improved harvesting alternatives, identified product and market opportunities, and knowledge of the economic and management consequences. The information presented in the remainder of this publication covers all of these subjects to some degree. The material is organized in four sections entitled "The Resource," "Harvesting Opportunities," "Utilization Opportunities," and "Economic and Management Considerations." The results and information presented in any particular paper, however, may include aspects ranging all the way from resource considerations to economic implications.

More efficient utilization of our wood resource can substantially extend the available wood fiber resource, providing a base for industrial expansion and economic growth. It is the most effective way to add to timber supply in the short run. Improved utilization practices can also contribute to resolving some of the more difficult environmental and management problems associated with timber harvesting. It is toward these goals that the research program and the symposium have been directed.

LITERATURE CITED

Barger, Roland L.
1980. Intensive utilization with conventional harvesting systems. In Harvesting and utilization opportunities for forest residues in the Northern Rocky Mountains, Symp. Proc., USDA For. Serv. Gen. Tech. Rep. INT-___ (In process).

Benson, Robert E., and Cameron M. Johnston.
1976. Logging residues under different stand and harvesting conditions, Rocky Mountains. USDA For. Serv. Res. Pap. INT-181, 15 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Foulger, A. N., and Johnny Harris.
1973. Volume of wood, bark, and needles after clearcutting a lodgepole pine stand. J. For. 71(2):93-95.

Gonsior, Michael J.
1980. Outlook for new harvesting technology. In Harvesting and utilization opportunities for forest residues in the Northern Rocky Mountains, Symp. Proc., USDA For. Serv. Gen. Tech. Rep. INT-___ (In process).

Green, Alan W., and Theodore S. Setzer.
1974. The Rocky Mountain timber situation, 1970. USDA For. Serv. Resour. Bull. INT-10, 78 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Host, John, and Joyce Schlieter.
1978. Low-cost harvesting systems for intensive utilization in small-stem lodgepole pine stands. USDA For. Ser. Res. Pap. INT-201, 20 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

USDA Forest Service.
1980. Environmental consequences of timber harvesting in Rocky Mountain coniferous forests. Symp. Proc., USDA For. Serv. Gen. Tech. Rep. INT-90, 526 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.