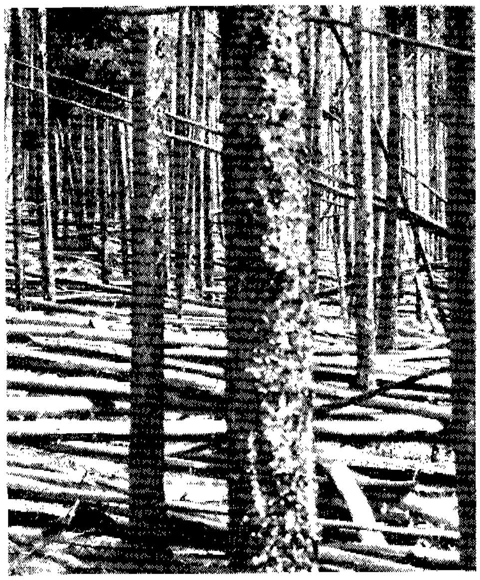
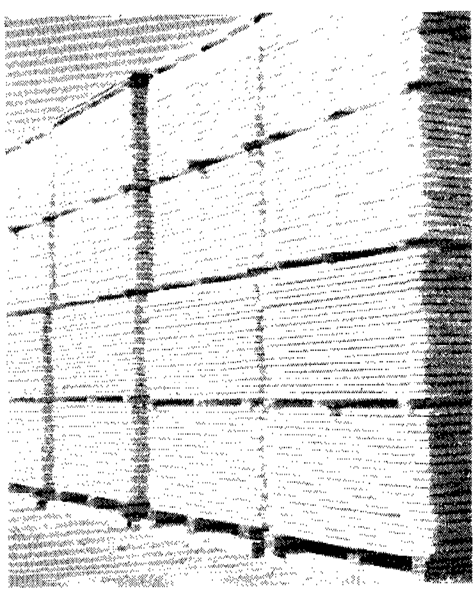
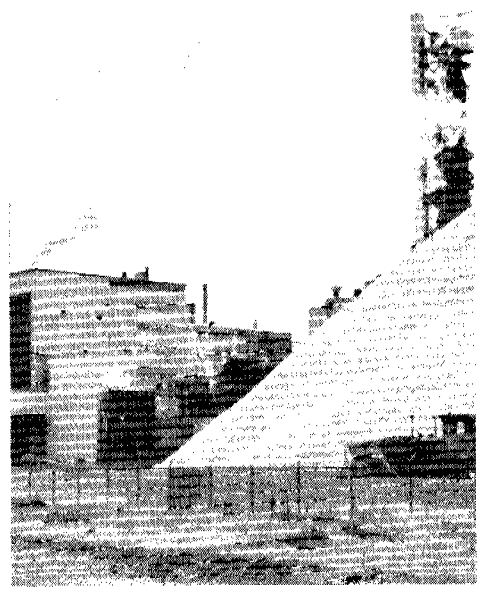
HARVESTING AND UTILIZATION OPPORTUNITIES FOR FOREST RESIDUES in the northern rocky mountains



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INTENSIVE UTILIZATION WITH CONVENTIONAL HARVESTING SYSTEMS

Roland L. Barger
Program Manager
and
Robert E. Benson
Research Forester

USDA Forest Service
Intermountain Forest and Range Experiment Station

ABSTRACT

Forest residues utilization research has included case studies of the efficiency of existing harvesting systems in achieving close fiber utilization. Field evaluations included the use of in-woods chipping systems in gentle terrain; crawler skidder systems in gentle terrain; and skyline systems in steep terrain. In each situation, utilization standards ranged from conventional saw log utilization to near-total utilization of available fiber.

Intensive utilization has been achieved concurrent with saw log harvesting, rather than through postharvest salvage. The total costs of harvesting merchantable material and residue together are partitioned to derive costs of residue recovery. Costs of recovery vary significantly among the case situations studied, and also vary with the method by which costs are allocated. Residue recovery costs commonly run $30-$60 per dry ton ($33-$67 per tonne).

KEYWORDS: forest residues, timber harvesting, wood residues utilization, logging systems, timber harvesting productivity.

THE HARVESTING TASK

Although timber harvesting practices have improved dramatically in recent years, large volumes of wood residues and salvable material remain unused in the Rocky Mountain area. More complete and efficient utilization of this resource poses a major challenge. National projections predict substantial continued increases in demand for wood and wood fiber-based products. Environmental considerations also favor extending the use of wood, a renewable natural resource that can be processed with less energy and less attendant pollution than alternate materials. Increasing interest in biomass fuels for supplementary power generation further emphasizes the undeveloped potential of the wood residue resource.

Excessive volumes of forest residues result in significant management problems: fire hazards, reduced wildlife use, degraded esthetic quality, difficult regeneration, and costly disposal. Harvesting and utilization practices that facilitate more complete use of these residues can help meet national needs for wood products and solve critical forest resource management problems.

Forest residues remaining on logged sites include small trees, cull and broken logs, tops, and dead timber. The most immediate opportunity to increase utilization of this material is to remove it in conjunction with conventional harvesting operations. A primary barrier to improving utilization, however, is the added cost of recovering residue material. Typically, the value of residues will not cover the costs of harvesting them. Harvesting systems and practices are needed that can more effectively and efficiently recover residue.

The residue utilization research program has included both the evaluation of existing harvesting systems and the development of new harvesting concepts for achieving close fiber utilization. This report covers the field testing and evaluation of harvesting systems in common use under various stand and terrain conditions and silvicultural systems encountered in the Northern Rockies.

EVALUATING EXISTING SYSTEMS

Recovering residue material with conventional harvesting systems, in conjunction with the harvest of merchantable material, offers potential advantages. Conventional logging systems are available, are in place, and involve no radical changes in technology. Further, they require no new or added capital investments, and no significant changes in job skills or training requirements. The costs of practicing intensive utilization with existing systems are largely unknown, however, as are the technical problems that may be encountered.

Research efforts reported here were directed toward defining costs of residue recovery with three conventional systems: skyline logging on steep terrain; tractor logging on gentle terrain; and in-woods chipping teamed with a ground skidding operation on gentle terrain. Because the silvicultural prescription has a significant effect on most harvesting costs, a range of silvicultural practices were included on two sites. Utilization standards for cutting units on each site included conventional saw log utilization and one or more intensive fiber utilization standards. Intensive utilization prescriptions specified the removal of material down to a defined size and quality class, and allowed the contractor to accomplish this jointly with removal of the "merchantable" portion of the timber. The three harvesting operations, and associated utilization standards, recovery, and costs, are described in following sections.

Skyline Harvesting--The Coram Site

The Coram study site is located on Coram Experimental Forest, on the Hungry Horse District of the Flathead National Forest. The site typifies old-growth western larch/Douglas-fir stands on steep slopes. Elevations range from 3,900 to 5,300 feet (1 188 to 1 615 m), and annual precipitation is in the 25- to 35-inch (64 to 89 cm) range. Western larch and Douglas-fir are the predominant tree species, although subalpine fir, Engelmann spruce, western hemlock, and birch also occurred in intermixture on the harvested units.

Steep slopes and operating constraints dictated the use of either aerial or cable yarding systems capable of relatively long reach (1,000 to 1,200 feet) (305 to 365 m) and at least partial suspension of logs being yarded. Skyline yarding systems were used--a running skyline system where both up- and downhill yarding were required (fig. 1), and a live skyline where uphill yarding alone was adequate. Silvicultural prescriptions included in the field tests, and the utilization standards practiced, are described in table 1.

Figure 1.--A running skyline system was employed on the Coram site to provide both up- and downhill yarding capability.

Table 1.--Harvesting treatment specifications for cutting units, Coram site

Silvicultural system	Cutting specifications	Utilization standards
SHELTERWOOD	All trees designated by utilization standard cut; approximately half the volume in 7"+ (17.8 cm) d.b.h. trees left, aiming for good height and species diversity.	(1) Conventional: logs to 8'x5½" (2.4 m x 14 cm) top, one-third sound, removed from all 7"+ (17.8 cm) d.b.h. trees cut, green and recently dead.
		(2) Intermediate: logs to 8'x3" (2.4 m x 7.6 cm) top, one-third sound, removed from all cut trees 5" (12.7 cm) d.b.h. and larger, and all standing and down dead timber.
		(3) Intensive: all cut green and recently dead trees 5" (12.7 cm) d.b.h. and larger removed tree-length; all green trees 1"-5" (2.5-12.7 cm) d.b.h. removed tree-length in bundles (FS crews cut & bundle); all standing and down dead timber 8'x3" (2.4 m x 7.6 cm) and larger removed if sound enough to yard.
GROUP SELECTION	All trees designated by utilization standard cut, in selected groups of 0.5 to 1.5 acres (0.2 to 0.6 ha) in size.	Same as (1), (2), and (3) above.
CLEARCUT	All trees designed by utilization standard cut.	Same as (1), (2), (3) above.

Six sale area blocks were logged, two under each basic silvicultural system. Each block was subdivided into treatment areas upon which the alternate levels of utilization were applied. Blocks were laid out to take advantage of existing and new system roads, and purposely included both up- and downhill yarding. Back-to-back yarding with the running skyline system allowed laying out the larger units up to 2,000 feet (609 m) in slope length. Utilization treatment areas designed for post-harvest broadcast burning were burned the season following logging.

Volumes of merchantable timber available for harvesting (table 2) ranged from 1,767 ft^3/acre (124 m^3/ha) in the conventionally logged shelterwood unit, to over 7,000 ft^3/acre (490 m^3/ha) in the group selection units. Volumes of nonmerchantable material included on intensively harvested units varied from 1,700 ft^3/acre (119 m^3/ha) to over 3,000 ft^3/acre (210 m^3/ha). Actual recovery of residue material, however, was generally no more than 25-50 percent of the gross volume potentially available. The remainder either did not meet the minimum size and condition specifications for removal, or was overlooked and left onsite.

Table 2.--Volumes of merchantable and nonmerchantable material available for harvest, and volumes of nonmerchantable material removed, under alternative treatment specifications, Coram site

Harvesting treatment	Volumes available for harvest: Merchantable	Nonmerchantable 6"+ (15.2 cm)	Nonmerchantable 3"-6" (7.6-15.2 cm)	Nonmerchantable <3" (7.6 cm)	Nonmerch. volume removed
	- - - - - -	- - - - - -	*Ft*^{3}*/acre (m*^{3}*/ha)*	- - - - - -	- - - - - -
Shelterwood:					
(1) Conventional	1,767 (124)	--	--	--	--
(2) Intermediate	2,299 (161)	734 (51)	966 (68)	--	425 (30)
(3) Intensive	2,057 (144)	813 (57)	918 (64)	48 (3)	906 (63)
Group Selection:					
(1) Conventional	7,083 (496)	--	--	--	--
(2) Intermediate	6,620 (463)	1,900 (133)	804 (56)	--	785 (55)
(3) Intensive	5,100 (357)	1,872 (131)	940 (66)	113 (8)	1,962 (137)
Clearcut:					
(1) Conventional	4,994 (349)	--	--	--	--
(2) Intermediate	5,520 (386)	2,408 (168)	631 (44)	--	860 (60)
(3) Intensive	3,515 (246)	1,702 (119)	530 (37)	23 (2)	783 (55)

Harvesting productivity and calculated costs of harvesting are described in table 3. The costs shown were developed on the basis of recorded production per hour and calculated system costs per hour. All turns yarded were scaled to determine the volumes of merchantable and nonmerchantable material produced per hour. Cost estimation was based on average industry costs (1974 dollars) for the equipment and crews being used.

Harvesting costs, such as the cost of a yarder and operating crew, can most conveniently be expressed per hour of operation. Other costs, such as the cost of felling and bucking timber, are commonly expressed per unit of volume produced. To develop a common base for combining costs, a "system cost per hour" was adopted. System cost per hour is comprised of the yarder and crew cost per hour, plus the costs of all other logging functions (fell, buck, bunch) required to produce the volume of material yarded in an hour. These costs can then be allocated against volume produced per hour in any desired fashion.

Table 3.--Harvesting productivity and calculated costs of harvesting, Coram site

Harvesting treatment	Yarder production/hour: Merchantable		Yarder production/hour: Nonmerch.	Cost of hourly production: Fell-buck-bunch: Merchantable	Cost of hourly production: Fell-buck-bunch: Nonmerch.	Cost of hourly production: Yarding	Total hourly cost	Cost per M bd. ft. merch.[1]	Cost per m^3, all volume
	Bd. ft.	*Ft^3 (m^3)*	*Ft^3 (m^3)*	*Dollars (1974)*					
Shelterwood:									
(1) Conventional	2,968	474 (13)	0 --	53	--	187	240	81	18
(2) Intermediate	2,355	379 (11)	114 (3)	56	17	187	260	110	19
(3) Intensive	1,267	204 (6)	488 (14)	31	91	187	309	237	15
Group Selection:									
(1) Conventional	3,276	524 (15)	0 --	59	--	187	246	75	16
(2) Intermediate	3,026	484 (14)	189 (5)	73	28	187	288	95	15
(3) Intensive	2,130	340 (10)	324 (9)	51	60	187	298	140	16
Clearcut:									
(1) Conventional	5,398	862 (24)	0 --	65	--	187	252	47	11
(2) Intermediate	4,654	745 (21)	134 (4)	74	13	187	274	59	11
(3) Intensive	3,138	506 (14)	100 (3)	50	15	187	252	80	15

[1]Total costs allocated to merchantable volume recovered.

Costs attributable to residue recovery (tables 4 and 5) can be calculated in either of two ways, depending upon the philosophy adopted. The first approach, illustrated in table 4, initially assigns all costs of harvesting to the merchantable saw log volume recovered (table 3). The differences in cost per M bd. ft. of merchantable volume between the conventional saw log units and the more intensively utilized units are ascribed to residue recovery (table 4). Example: Intermediate utilization under the shelterwood prescription results in a difference in cost per M bd. ft. of \$110-\$81 = \$29 (from table 3). This cost is assigned to residue recovery of 48 ft^3 per M bd. ft., resulting in a calculated residue recovery cost of \$29 ÷ 48 = \$0.60/ft^3 (table 4). The assumption is that costs of recovering merchantable material should not vary among the treatments; consequently, any change in cost must be attributable to recovering nonmerchantable material. Where residue recovery is required by contract, and in the absence of viable markets for residue material, this is likely to be the cost approximation method adopted.

Table 4.--Cost of residue recovery, allocating to residues all costs in excess of saw log harvesting costs experienced in conventionally logged units

Harvesting treatment	Residue volume recovered per M bd. ft. logged	Added cost of logging per M bd. ft.	Imputed cost of residue recovery		Cost per dry ton
			Per ft^3	Per m^3	
	Ft^3 (m^3)	*Dollars (1974)*			
Shelterwood:					
(1) Intermediate	48 (1.4)	29	0.60	21	48
(2) Intensive	385 (10.9)	156	.41	14	33
Group Selection:					
(1) Intermediate	62 (1.8)	20	.32	11	26
(2) Intensive	152 (4.3)	65	.43	15	34
Clearcut:					
(1) Intermediate	29 (0.8)	12	.41	15	33
(2) Intensive	32 (0.9)	33	1.03	37	82

A second approach to estimating costs of recovering residue material, illustrated in table 5, allocates total harvesting costs to merchantable and nonmerchantable material. Felling, bucking, and bunching costs are identified separately for nonmerchantable material, and total yarding costs are prorated on the basis of cubic volume of each yarded. This would seem to be a preferred approach to calculating costs in situations where merchantable and residue material are being jointly harvested for identified end uses.

Table 5.--Cost of residue recovery, allocating costs to merchantable and nonmerchantable volumes recovered

Harvesting treatment	Residue volume recovered per production hour	Cost of felling, bunching[1]	Proportional cost of yarding[2]	Cost of residue recovery Per ft^3	Cost of residue recovery Per m^3	Cost per dry ton
	Ft^3 (m^3)	*Dollars (1974)*				
<u>Shelterwood</u>:						
(1) Intermediate	114 (3.2)	17	43	0.53	19	42
(2) Intensive	488 (13.8)	91	132	.46	16	37
<u>Group Selection</u>:						
(1) Intermediate	189 (5.3)	28	53	.43	15	34
(2) Intensive	324 (9.2)	60	91	.47	16	38
<u>Clearcut</u>:						
(1) Intermediate	134 (3.8)	13	29	.31	11	25
(2) Intensive	100 (2.8)	15	31	.46	16	37

[1]Based on two-thirds of residue volume in trees requiring felling; one-third of residue volume in trees requiring felling and bunching.

[2]Yarding cost/hour prorated between merchantable and nonmerchantable material based on cubic volume of each yarded.

Tractor Skidding--The Lubrecht Site

The Lubrecht study site is located on Lubrecht Experimental Forest, a State-owned and administered area belonging to the University of Montana. The area is essentially dry site Douglas-fir, with a significant intermixture of ponderosa pine and western larch, on gentle terrain. The area has a cutting history of selective removal of older, larger timber in the late 1800's-early 1900's. The remaining mixed species and mixed age class stand is broadly representative of a major segment of the commercial forest land in the region. In addition, the stand occurs on one of the more productive Douglas-fir habitat types (*Pseudotsuga menziesii/Vaccinium caespitosum*), and represents an operating situation and management opportunity in which intensive utilization is likely to occur first. The mixed size and age classes provide an opportunity for a range of silvicultural and utilization options.

Harvesting treatments tested were developed to include combinations of silvicultural practices, utilization standards, and postharvest site treatments considered viable management options. Silvicultural prescriptions and utilization standards specified for the cutting units are described in table 6.

Table 6.--Harvesting treatment specifications for cutting, Lubrecht site

Silvicultural system	Cutting specifications	Utilization standards
CLEARCUT	Harvest all trees merchantable under the specified utilization standard.	Conventional utilization--removal of green and sound dead logs from sawtimber trees 9" (23 cm) and larger d.b.h.; utilization to 5" (13 cm) top, and one-third or more sound.
		Intensive utilization--removal of all green and dead saw log material if sound enough to skid; removal of all submerchantable trees 1" (2.5 cm) and larger in d.b.h., tree length (smaller stems hand bunched prior to skidding).
SELECTION	Harvest about half of the merchantable volume, leaving designated overstory of small sawtimber and pole stems. Dense sapling and pole stands selectively thinned.	Conventional utilization
UNDERSTORY REMOVAL	Harvest about half of merchantable volume (and up to two-thirds of total cubic volume), leaving designated overstory of better sawtimber and large poles.	Conventional utilization Intensive utilization
OVERSTORY REMOVAL	Harvest all sawtimber trees; thin pole stands, leaving seedling-sapling-small pole stems as residual stand.	Conventional utilization Intensive utilization

Four cutting units totaling approximately 60 acres (24 ha) were harvested, one under each of the described silvicultural prescriptions (fig. 2). The three units designated for clearcut, overstory removal, and understory removal were further subdivided into treatment areas for application of the two utilization standards. The remainder of this discussion will cover only the three harvesting treatments that included intensive utilization.

Figure 2.--Harvested units on the Lubrecht site included clearcut (left), and understory removal (right) treatments. Intensive utilization subunits are illustrated.

Gentle slopes and easy access to cutting units made possible the use of a ground skidding harvesting system. On all units logs were skidded with crawler tractors. On areas designed for intensive utilization, smaller trees (1" to 6" [2.5 to 15 cm] in diameter) were bunched by hand prior to skidding, and were skidded tree length.

Volumes of merchantable timber harvested from the units ranged from approximately 4 M bd. ft. (understory removal) to over 11 M bd. ft. (clearcut) (table 7). Volumes of nonmerchantable material recovered varied from 630 to 880 ft^3 per acre (44 to 62 m^3 per ha). Harvesting costs per acre and per unit of material recovered are shown in table 7.

The summary and analysis of harvesting productivity on this site is based upon documenting the volume and number of stems removed under each treatment specification, determining the crew and equipment time involved in each harvesting function, and relating time (and cost) to volume. Time and productivity data for the skidding operation were obtained by direct measurement of turn times and volumes or pieces moved. Sawyer time for felling and bucking was estimated from the contractor's records. Production rates for felling and bundling smaller stems under the intensive utilization option were derived from measured production per crew hour.

Typical industry costs (1977 dollars) for crew and equipment time were applied to derive cost per unit of volume produced. In the conventional utilization blocks, all costs were ascribed to the removal of merchantable logs. This base cost was also applied to the merchantable volume removed under intensive utilization, and the balance of harvesting costs incurred in these blocks was attributed to removing the nonmerchantable material.

Intensive utilization removes residue material that would otherwise typically require some residue reduction treatment (fig. 3). Slashing, or slashing followed by burning, are common treatments. Costs of residue recovery can be calculated either ignoring or recognizing the reduction in postharvest treatment costs, depending upon the rationale favored. Tables 8 and 9 demonstrate costs of residue recovery under both conditions. Gross costs of residue recovery, ignoring reductions in subsequent treatment costs, range from \$0.63 to \$0.80 per cubic foot (\$22-\$29/m^3) (table 8). Allowing credit for reduction in residue treatment costs (table 9) reduces the net costs of residue recovery to \$0.42 to \$0.75 per cubic foot (\$15-\$27/m^3).

Figure 3.--Residue reduction treatments following conventional saw log harvesting typically include slashing and burning.

Table 7.--Volume recovery and calculated costs of harvesting, Lubrecht site

Harvesting treatment	Volume recovery: Merchantable		Volume recovery: Nonmerch.		Cost/acre, stump to deck: Fell, buck	Cost/acre, stump to deck: Bunch	Cost/acre, stump to deck: Skid	Total cost per acre	Cost per M bd. ft. merch.[1]	Cost per m^3, all volume
	M bd. ft./a	*(m^3/ha)*	*Ft^3/a*	*(m^3/ha)*	- - - - - - - - - - -	- - - - *Dollars (1977)*	- - - -	- - - -	- - - -	- - - -
<u>Understory removal</u>:										
(1) Conventional	4.46	(51.9)	--		96	--	183	279	63	13
(2) Intensive	5.77	(67.2)	879	(61)	219	256	435	910	158	18
<u>Overstory removal</u>:										
(1) Conventional	8.80	(102.5)	--		196	--	367	563	64	14
(2) Intensive	8.85	(103.1)	632	(44)	253	200	513	966	109	16
<u>Clearcut</u>:										
(1) Conventional	11.59	(135.0)	--		195	--	380	575	50	11
(2) Intensive	10.66	(124.2)	732	(51)	310	176	633	1,119	105	16

[1]Total costs allocated to merchantable volume recovered.

Table 8.--Cost of residue recovery, assuming no credit for reduction in postharvest treatment costs, Lubrecht site

Harvesting treatment	Residue volume recovered per M bd. ft. logged	Added cost of logging per M bd. ft.	Imputed cost of residue recovery		Cost per dry ton
			Per ft^3	Per m^3	
	Ft^3 (m^3)	*Dollars (1977)*			
Understory removal:					
Intensive	152 (4.3)	95	0.63	22	50
Overstory removal:					
Intensive	71 (2.0)	45	.63	23	50
Clearcut:					
Intensive	69 (1.9)	55	.80	29	64

Table 9.--Cost of residue recovery, allowing credit for reduction in postharvest treatment costs, Lubrecht site

Harvesting treatment	Residue volume recovered per M bd. ft. logged	Added cost of logging per M bd. ft.	Less savings in slashing costs	Less savings in slashing and burning costs	Net cost per ft^3 (m^3) when treatment is		Net cost/dry ton	
					Slash only	Slash/burn	Slash only	Slash/burn
	Ft^3 (m^3)	*Dollars (1977)*						
Understory removal:								
Intensive	152 (4.3)	95	77	64	0.51 (18)	0.42 (15)	41	34
Overstory removal:								
Intensive	71 (2.0)	45	40	34	.56 (20)	.48 (17)	45	38
Clearcut:								
Intensive	69 (1.9)	55	52	47	.75 (27)	.68 (25)	60	54

In-woods Chipping--The Teton Site

The Teton study site is located on the Gros Ventre District, Bridger-Teton National Forest, southwest of Dubois, Wyo. The site is typical of higher elevation old-growth lodgepole pine in the central and northern Rocky Mountains. The area is a gently rolling plateau at about 9,000 feet (2 743 m) elevation, in the *Abies lasiocarpa/Vaccinium scoparium* habitat type. The stands are essentially pure, overmature lodgepole pine, interspersed with natural, open meadows. Stand volumes are heavy for lodgepole pine, averaging in excess of 9,000 ft^3 per acre (254 m^3/ha) in stems 3 inches (7.6 cm) d.b.h. and larger. Standing and down dead material makes up approximately one-third of this volume.

Harvesting activity in old-growth lodgepole pine often results in large volumes of residue because of the decadent nature of the stands. Consequently, harvesting alternatives that can achieve more intensive recovery and utilization of the total fiber resource are particularly important to successful management of the site. Intensive utilization can solve a difficult residue disposal problem, reduce adverse public reaction to harvesting, and facilitate planting and other site-management activities.

Old-growth lodgepole pine is usually clearcut in some fashion because a manageable residual stand does not exist. Treatments applied to the study site specified clearcutting, and included two levels of utilization, described in table 10.

Table 10.--Harvesting treatment specifications for cutting units, Teton site

Silvicultural system	Cutting specifications	Utilization standards
CLEARCUT	All trees designated by utilization standard cut. On conventional utilization units, all green and recently dead merchantable sawtimber trees cut and bucked. On intensive utilization units, all trees (green and dead) 3" (7.6 cm) d.b.h. and larger cut with feller-buncher.	(1) Conventional: logs to 8'x6" (2.4 m x 15.2 cm) top, one-third or more sound, taken from all green and recently dead trees 9" (22.9 cm) d.b.h. and larger. (2) Intensive: in addition to saw log recovery, all nonmerchantable trees 3"+ (7.6 cm) d.b.h., all sound down material 6'+ (1.8 m), and all residues from sawtimber trees chipped in field with whole-tree chipper.

Four cutting units, each approximately 20 acres (8.1 ha), were harvested. Two were logged to conventional utilization standards, using common chain saw felling and bucking, and log-length saw log skidding. Residue volumes following harvesting on these units amounted to over 4,300 ft^3 per acre (121 m^3/ha). The two remaining units were logged to a near-complete utilization standard using a feller-buncher (fig. 4), tree-length skidding with rubber-tired grapple skidders, and segregating merchantable logs at the deck. All material not meeting minimum specifications for saw logs was chipped using a portable whole-tree chipper at the site (fig. 5).

Figure 4.--A feller-buncher was employed on the Teton site to fell and bunch whole trees on the intensive utilization units.

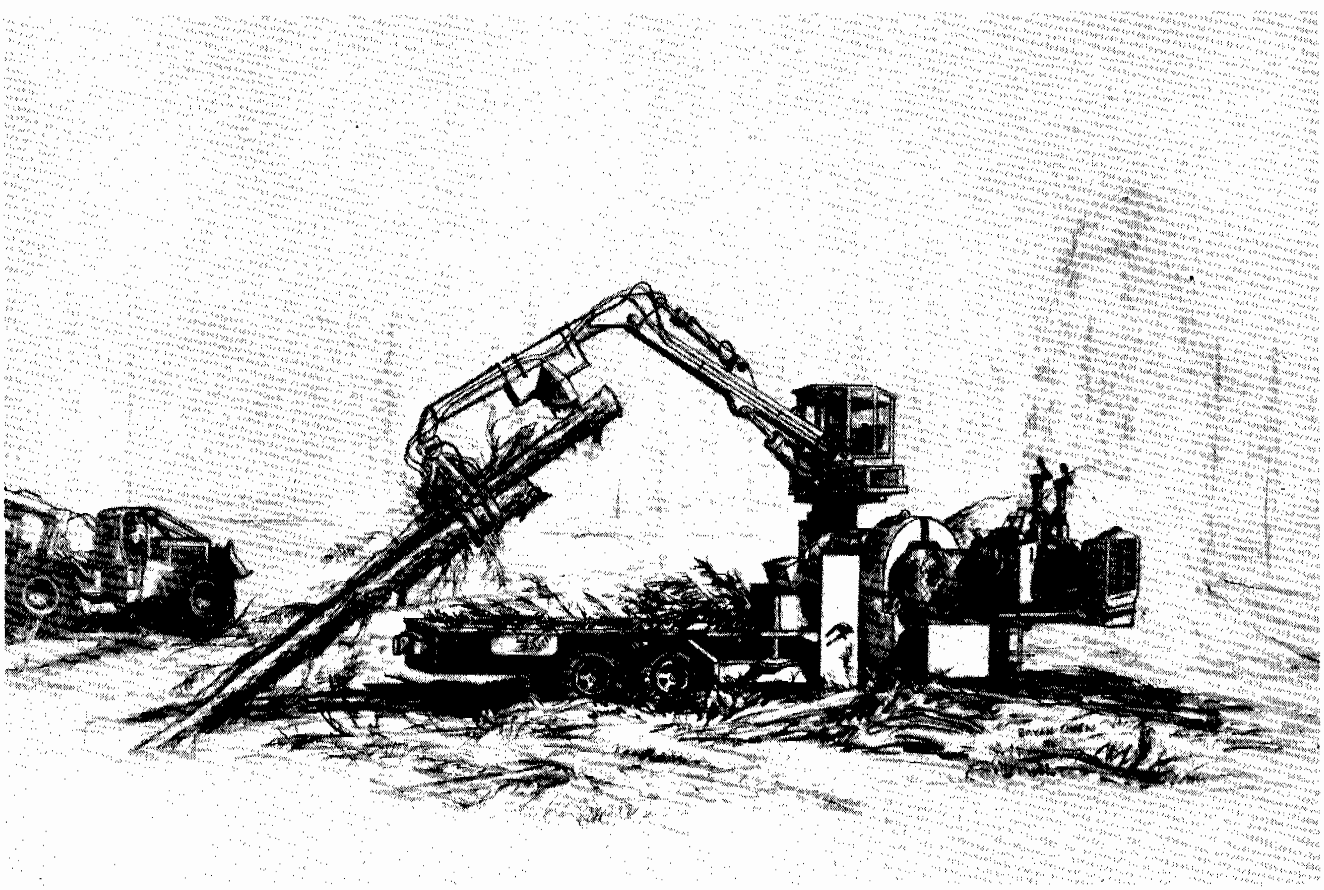

Figure 5.--All material not meeting minimum specifications for saw logs was chipped using a portable whole-tree chipper located on the logging site.

Gross volumes recovered from the cutting units included over 6,500 ft^3/acre (455 m^3/ha) of merchantable sawtimber, plus 4,580 ft^3/acre (320 m^3/ha) of nonmerchantable material from the intensive utilization units (table 11). Chip recovery was influenced by the utilization practices common at the time (1971). Only recently dead timber was considered merchantable for saw logs, and substantial volumes of standing sound dead timber were chipped. Under current utilization standards, much of this sound dead timber would be judged acceptable for sawn products.

Harvesting cost analyses for this site are based on documented crew and equipment time per unit of material harvested. Reported industry costs (1971) for crews and equipment were applied to derive costs per unit produced. Calculated costs, shown in table 11, indicate an average recovery cost of \$0.14/ft^3 for harvesting nonmerchantable and residue material.

Table 11.--Volume recovery and calculated costs of harvesting, Teton site

Harvesting treatment	Volume recovery		Cost/unit, stump to deck				Cost per dry ton
	Merchantable	Nonmerch.	Merchantable		Nonmerch.[1]		
			Per M bd. ft.	Per m^3	Per ft^3	Per m^3	
	Ft^3/a (m^3/ha)	*Ft^3/a (m^3/ha)*	*Dollars (1971)*				
Clearcut:							
(1) Conventional	7,698 (538)	--	16	2	--	--	--
(2) Intensive	6,522 (456)	4,580 (320)	17	2	0.14	5	11

[1]Cost through chipper.

SUMMARY

The case studies reported here were conducted over a span of several years, as indicated. Consequently, the costs experienced in each case reflect the price level prevailing at the time, and cannot be directly compared. Table 12 summarizes costs of residue recovery for the three study operations, and adjusts costs to a common 1980 price base.

Caution must be exercised in drawing any conclusion from differences in costs between the case studies. Each study operation is unique in many respects--timber character, operating mode, crew skill and aggressiveness, and other factors. Costs cannot be assumed to represent more than the specific set of circumstances under which the case study was conducted.

Costs of residue recovery were generally sensitive to the volume of material recovered, with higher volumes per acre resulting in lower unit costs of recovery. The relatively low cost of residue recovery on the Teton site probably resulted from an extremely high volume of recoverable material per acre and the use of a harvesting system specifically designed for efficient residue recovery.

Present research efforts continue to be directed toward developing harvesting systems that can more efficiently recover material currently considered unmerchantable. A principal deterrent to improved recovery of residue material during logging operations is the cost of harvesting large numbers of small pieces, and subsequent handling and transportation problems. Systems that facilitate prebunching, whole-tree processing, and in-woods conversion to a form more easily handled and transported can improve the potential for utilization. Systems that can more efficiently operate in small-stem stands also afford the opportunity to recover such material before it is left as logging or thinning residue.

Better systems are also needed to accommodate the wide mix of material size and quality that may come from older, mixed stands. Most harvesting systems are best adapted to handling one or a few types of material, and additional classes of material are difficult to accommodate. Yet, an essential element in more complete and efficient utilization is the allocation of material to optimum end uses. Efficient harvesting systems for mixed material may require close coordination with merchandising or concentration yard processing and allocation operations, intermediate between the woods and the final processing plant.

Table 12.--Summary of costs of harvesting nonmerchantable material, and cost adjustment to 1980 price level

Study site	Harvesting treatment		Cost/unit, stump to deck: Study year price level, per ft[3]	1980 price level[4]: Per ft[3]	Per m[3]	Per dry ton
			- - - - - - - - - - Dollars - - - - - - - - - -			
Coram	Shelterwood					
	Intermediate	1	0.60	0.92	32	74
		2	.53	.82	29	66
	Intensive	1	.41	.63	22	50
		2	.46	.71	25	57
	Group Selection					
	Intermediate	1	.32	.49	17	39
		2	.43	.66	23	53
	Intensive	1	.43	.66	23	53
		2	.47	.72	25	58
	Clearcut					
	Intermediate	1	.41	.63	22	50
		2	.31	.48	17	38
	Intensive	1	1.03	1.59	56	127
		2	.46	.71	25	57
Lubrecht	Understory removal					
	Intensive	1	.63	.79	28	62
		3	.42	.53	19	42
	Overstory removal					
	Intensive	1	.63	.79	28	63
		3	.48	.60	21	48
	Clearcut					
	Intensive	1	.80	1.01	36	81
		3	.68	.86	30	69
Teton	Clearcut					
	Intensive		.14	.26	9	22

[1]Allocating to residue recovery all costs in excess of saw log harvesting costs experienced in conventionally logged units.

[2]Allocating costs between residue and merchantable volumes recovered, proportional to volume of material handled.

[3]Net cost of residue recovery, allowing credit for reduction in postharvest slashing and burning costs.

[4]Based on Gross National Product implicit price deflator (1972=base 100). Source: Dept. of Commerce, Bureau of Economic Analysis.