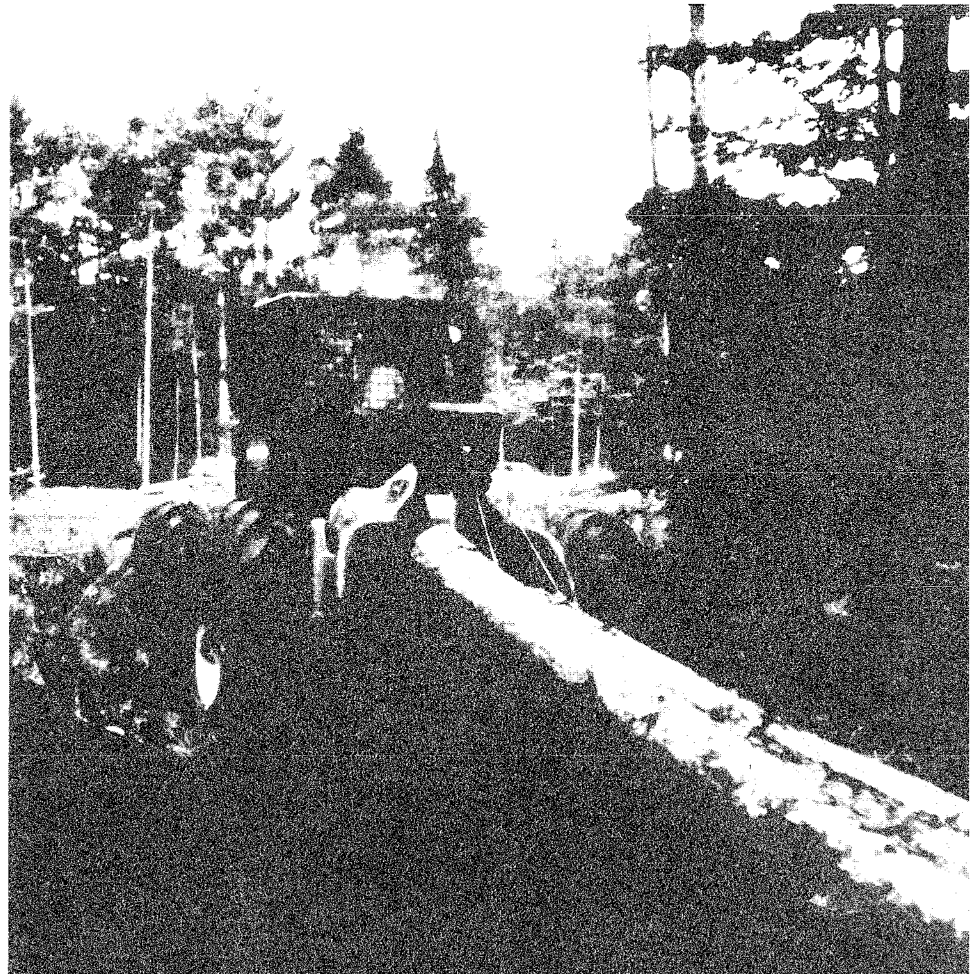

EFFECT OF MECHANIZED TREE HARVESTING ON JACK PINE REGENERATION REQUIREMENTS

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Three mechanized tree harvesting systems are being used to harvest jack pine timber crops in northern Minnesota. A study of the effect of these systems on factors influencing jack pine regeneration was made in the summer of 1969 at the University of Minnesota Forest Research Center at Cloquet. This report describes the residual site conditions existing after the final harvest of a mature jack pine stand by each harvesting method and evaluates them according to conditions required for securing pine reproduction. It is one of a series of studies to be made on the effect of mechanized harvesting on environmental factors that influence regenerating a new forest.

Figure 1. Ninety-year-old jack pine stand selected for the study.

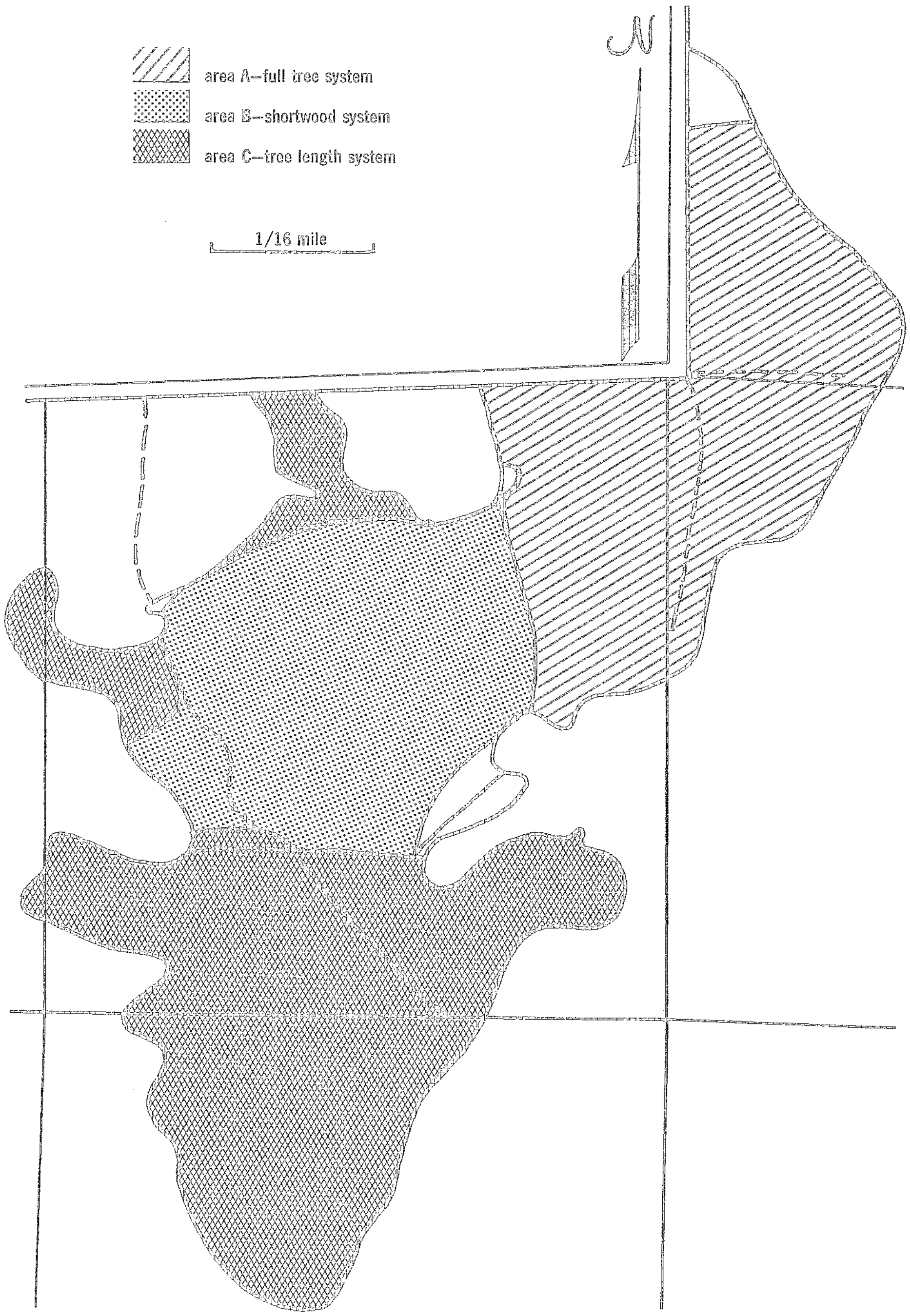


Figure 2. Study area units.

STUDY METHODS

Study Area

A 90-year-old jack pine stand at the Cloquet Forest Research Center in Carlton County, Minnesota, was selected for the study (figure 1). This 40-acre stand was divided into three units. Each unit was assigned a different harvesting system: unit A, the full tree system; unit B, the shortwood system; and unit C, the tree length system (figure 2).

Table 1 contains stand data for each unit. The soil type was Omega loamy sand, which is a medium site for jack pine. The soil organic layer was approximately 3 inches deep on all units. A well-developed stand of hazel brush with an average density of 30,000 stems and a high density of 100,000 stems per acre occurred as an understory in the stand. The advanced reproduction was primarily red maple, with a few scattered paper birch, balsam fir, and aspen. These stand conditions represent the difficult situations for securing pine regeneration in the jack pine forests of northern Minnesota.

The logging chance was good. The area is level and well-drained.

The Harvesting Operation

In this study timber harvesting was done as a commercial operation. The harvesting systems represent the highest degree of mechanization currently in use in northern Minnesota.

THE SHORTWOOD SYSTEM. In this method the processing operations of felling, limbing, bucking, and stacking are done in the immediate area of the stump. For this study the processing was performed by machine, the Omark Tree Harvester (figure 3). One man operates the machine and uses a harvesting pattern of strip cutting. Strips are approximately 50 feet wide and at right angles to the haul road. After processing, the cross section of

Table 1. Stand per acre by study areas

	Full tree unit			Shortwood unit			Tree length unit		
Species	Number of trees	Basal area, square feet	Cords	Number of trees	Basal area, square feet	Cords	Number of trees	Basal area, square feet	Cords
Jack pine	117	86	29	188	105	35	154	96	32
Red pine	12	9	3				2	1	0.5
Paper birch	41	14	4	21	8	2	22	12	3
Aspen	18	8	0.5	6	3	1			
Total	188	117	36.5	215	116	38	178	109	35.5

Figure 3. Omark Tree Harvester felling jack pine in the study area.

each strip is about as follows (figure 4):

15 feet of trees cut, no ground disturbance or slash
8 feet of machine track for operating Omark Tree Harvester
8 feet of stacked wood
15 feet of slash windrow, no ground disturbance under slash.

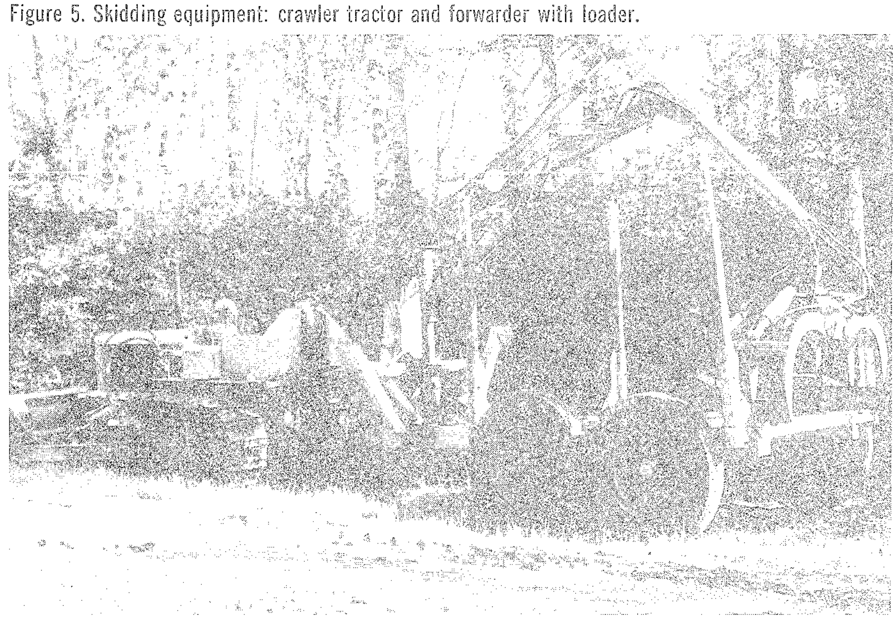
A forwarder-tractor unit (figure 5), operated by one man, was used to move the wood from the strip to a truck. Forwarding was performed on the same track used by the harvesting machine. The pulpwood was loaded directly from the forwarder onto a truck.

Tree Length System. With this method, trees are felled, topped, and limbed at the stump. The full merchantable tree length is forwarded to a landing for further processing. Use of this method is increasing in northern Minnesota.

The crew organization for this method was two men felling, one skidding, and one man bucking and hauling. Felling and limbing were done manually with a chain saw (figure 6). Cutters worked singly. The tree length logs were skidded with a four wheel drive rubber-tired skidder (figure 7). Skidding followed closely behind cutting. If skidding is not done right after cutting, logs become buried in slash and it is difficult to locate trees and set chokers. Tree length logs were skidded up to 1,000 feet and decked on landings along haul roads. Skidding trails fanned out from landings in an irregular pattern

Figure 4. Strip of pulpwood produced by the Omark Tree Harvester ready for forwarding.

Figure 5. Skidding equipment: crawler tractor and forwarder with loader.



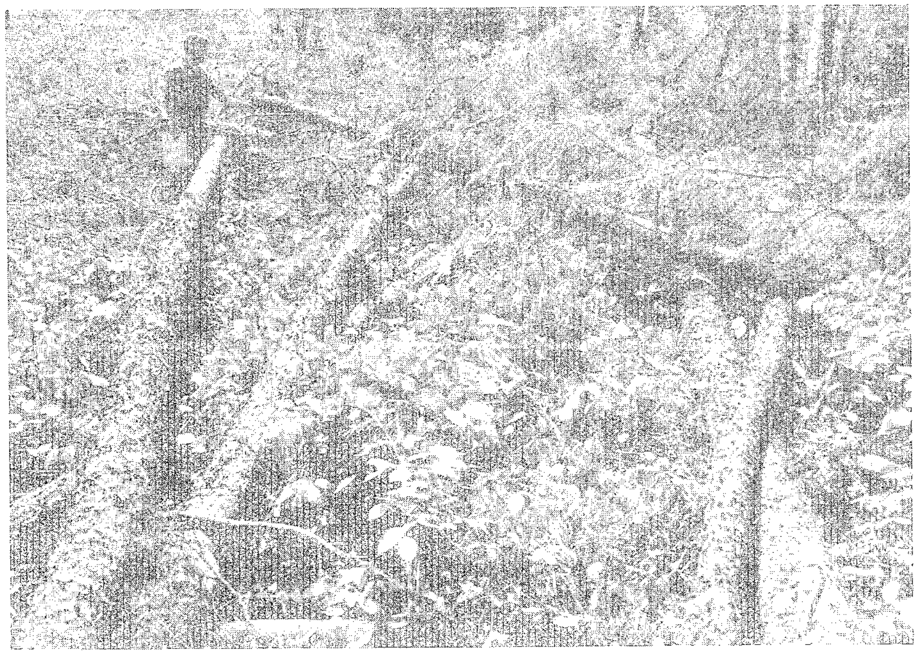


Figure 6. Tree length logs felled and limbed prior to skidding.

Figure 7. Rubber-tired skidder pulling tree length logs.

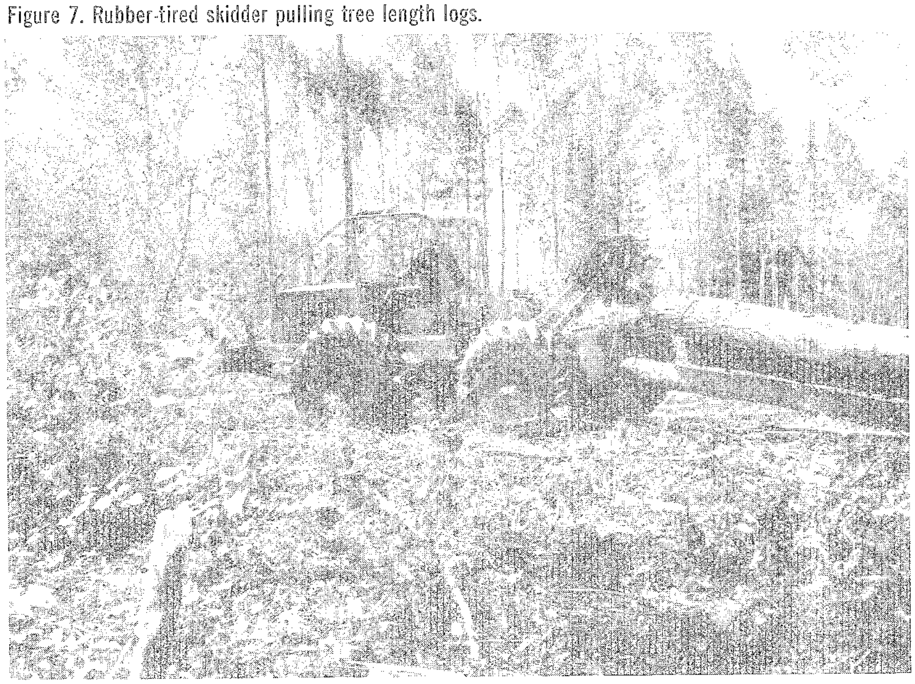


Figure 8. Processing tree length logs into pulpwood with sawbuck unit.

Figure 9. Full trees felled in one direction for ease in skidding.

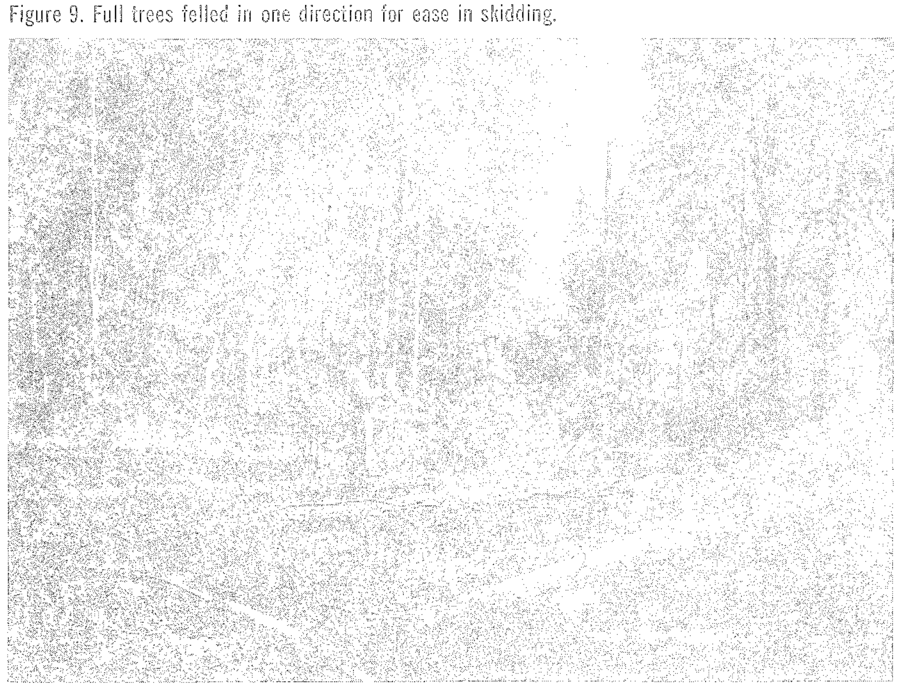


Figure 10. Skidding full trees to processor on landing.

Figure 11. Processing full trees into pulpwood on landing.

dictated by topography, residual trees, and cover. Cutting logs into 8-foot pulpwood lengths was done with a sawbuck unit equipped with a chain saw (figure 8). Three and four trees were cut into logs at one time. The bolts were loaded directly from the sawbuck unit onto a truck.

Full Tree System. In this method, the unlimbed felled trees are forwarded to a landing for processing.

Crew organization for this method was two men felling, two skidding, and one man operating the processor. Felling was done manually with a chain saw. Trees were felled directionally (figure 9). The whole stand was felled before skidding. Two skidders moved full trees to the processing area (figure 10). With directional felling, the tree butts were always exposed for setting chokers for skidding. As one group of trees was skidded away, the butts of trees they covered were exposed. Skidders followed no pattern, but used the shortest route to the landing. Maximum skidding distance was about 800 feet. A Can-Car Tree Processor (figure 11) was used to limb, cut trees into pulpwood bolts, and deck the bolts in piles. A truck equipped with a loader was used to load and haul the pulpwood.

STUDY RESULTS

The operator was given no special instructions about the application of the harvesting system in removing timber. So the results are the same as could be expected from a normal operation using these systems in similar stands in northern Minnesota.

The postharvesting site conditions were quite different for each harvesting system (table 2 and figures 12-14).

Slash Cover

About one-third of the area harvested by the shortwood and tree length systems was covered with slash resulting from limbing and topping trees. Less than one-tenth of the full tree area was slash covered. Much of this

Table 2. Ground disturbance by harvesting system

Logging system	Disturbance class*				
	None	Slash covered	Light	Medium	Heavy
	- - - - - -	- - - - - -	percentage of area	- - - - - -	- - - - - -
Shortwood	19	37	21	15	8
Tree length	6	32	16	33	13
Full tree	15	7	30	29	19

* None — No disturbance.

Slash covered — No disturbance to the soil, but covered with piles of slash resulting from topping, windfall of unmerchantable trees, or pushing slash into piles.

Light — Wheel marks of machine; no mineral soil exposed. Litter layer packed. Brush layer broken down or bent over. Machine usually travels on area only once in skidding full trees or tree length logs.

Medium — Wheels or logs breaking through litter layer; mineral soil exposed, compacted. Shrubs broken down. Machine may travel on the same trail several times. Wheels do not break into root mat.

Heavy — Same as medium, except used several times as a main trail for long skidding distances, often rutted and roots severed to depth of 4 inches or more. Can develop with only a few trips when the soil is wet.

Figure 12. Tree length system: slash cover, 32 percent of area; area disturbed, 62 percent; brush eliminated, 33 percent.

Figure 13. Shortwood system: slash cover, 37 percent of area; area disturbed, 44 percent; brush eliminated, 8 percent.

Figure 14. Full tree system: slash cover, 7 percent of area; area disturbed, 78 percent; brush eliminated, 36 percent.

slash was from debris on the ground before harvesting. Slash resulting from conventional nonmechanized shortwood operations covers one-half to two-thirds of an area, compared to about one-third for mechanized methods.

Although the area covered by slash on the shortwood and tree length units was about equal, the distribution patterns were quite different. On the shortwood area, the slash occurred in continuous windrows parallel to the cutting strip; on the tree length area, it occurred in randomly scattered piles (figures 15 and 16).

Ground Disturbance

Ground disturbance was caused primarily by the skidding or forwarding operation. The largest amount of area (78 percent) was disturbed by full tree skidding, followed next (62 percent) by tree length skidding, and then by shortwood forwarding (44 percent). However, organic layer disturbance and mineral soil exposure, which include the medium and heavy disturbed classes, were about equal for the full tree and tree length systems, 48 percent and 46 percent, respectively. The shortwood system exposed mineral soil and disturbed the organic layer on 23 percent of the area, about one-half that of the other systems. The impact that this disturbance has on soil characteristics is being examined in another study.

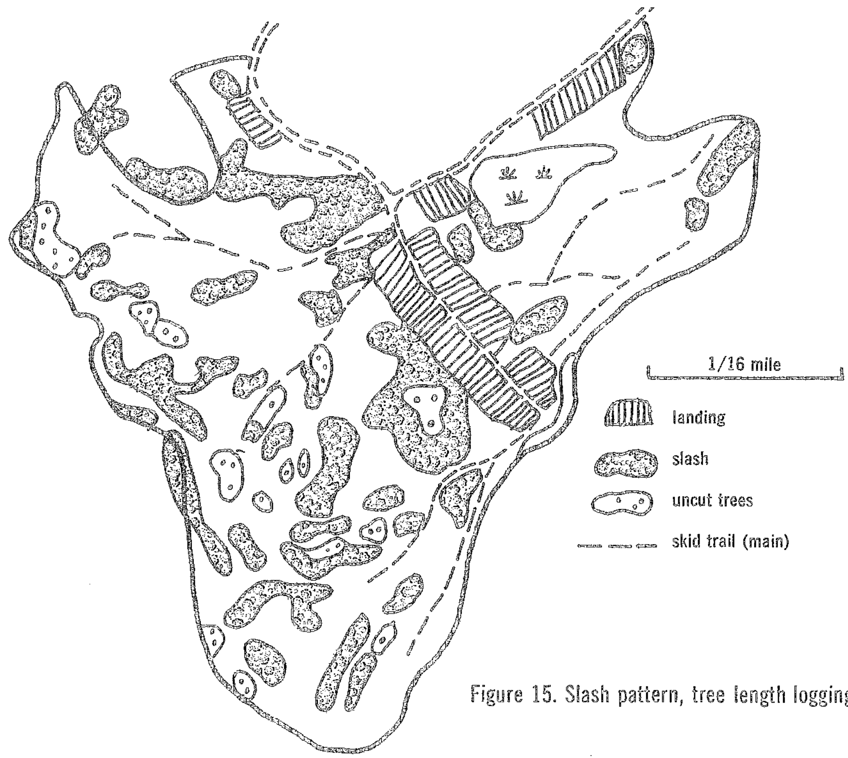


Figure 15. Slash pattern, tree length logging system.

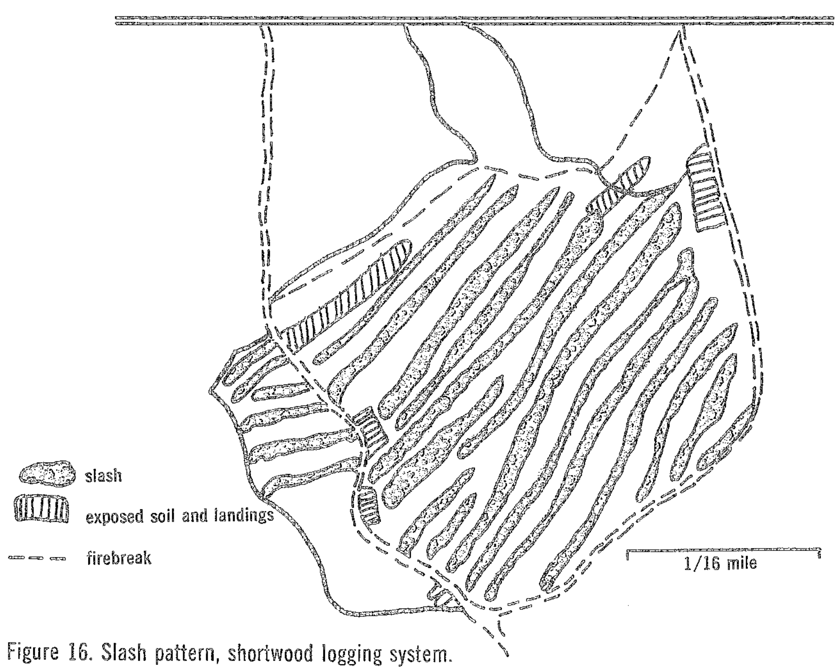


Figure 16. Slash pattern, shortwood logging system.

Disturbance of Understory Brush

Both felling and skidding operations affect brush cover. Felling causes stem breakage, whereas skidding breaks the brush stems and eliminates them by uprooting. Brush occurred on more than 95 percent of the milacre plots in all units. The full tree and tree length systems eliminated brush from 36 percent and 33 percent of the plots, respectively, compared to 8 percent for the shortwood system. Stem density was reduced 83 percent following full tree harvesting, 60 percent on the tree length unit, and 70 percent on the shortwood area.

Advanced Reproduction

Approximately 25 percent of the milacre plots on each unit were stocked with advanced growth. Harvesting under each system destroyed about half of these trees. However, desirable advanced reproduction was nonexistent on the study area. Almost all of it was red maple, which is considered undesir-

Table 3. Comparison of labor and machine use by harvesting systems

	Per cord			
Activity	Man-hours	Cost	Machine-hours	Cost
Tree length system				
Felling and limbing (manual)	0.816	3.26	....	....
Skidding (one operator with rubber-tired skidder)	0.313	1.25	0.313	1.17
Slash and load (operator with truck loader and sawbuck unit)	0.238	0.95	0.238	0.59
Total	1.367	5.46	0.551	1.76
(Cost per cord — $7.22)				
Shortwood system				
Fell-limb-buck (Omark Tree Harvester)	0.532	2.13	0.361	3.35
Skid and load (Prentice Skidder with D-2 Caterpillar)	0.314	1.26	0.314	1.17
Total	0.846	3.39	0.675	4.52
(Cost per cord — $7.91)				
Full tree system				
Fell (manual)	0.343	1.37	....	....
Skid (rubber-tired skidder)	0.353	1.41	0.353	1.32
Limb-buck-deck (Can-Car Tree Processer)	0.191	0.76	0.180	1.41
Loading on truck	0.127	0.51	0.102	0.26
Total	1.014	4.05	0.635	2.99
(Cost per cord — $7.04)				

Rates: Labor — $4.00 per hour
Skidder — $3.75 per hour
Omark — $9.30 per hour
Loader — $2.50 per hour
Can-Car — $7.88 per hour
Sawbuck — $2.50 per hour
Prentice Skidder and Caterpillar — $3.75 per hour

able on this site. From this and other studies, it is obvious that these harvesting systems greatly reduce the numbers of any advanced reproduction.

Cost of Production

Data were collected to compare production among systems. Comparisons in table 3 are based on total man-hours and machine-hours required to process wood from the stump to pulpwood loaded on trucks. Time lost to mechanical failure is not included. Time for routine machine servicing and rest periods is included. When converted to dollars, costs per cord indicate little difference among systems. The lowest man-hour and highest machine-hour use occurred with the shortwood system, which was the only fully mechanized system.

DISCUSSION OF RESULTS

Jack pine is managed in even-age stands with harvest cutting at rotation age (50-70 years, depending on site and product objectives). Following harvest, the cutover areas are restocked through some type of site preparation and a combination of planting red pine, seeding, and scattering jack pine cones. The objective is to establish an evenly distributed stand of 1,000 or more trees per acre.

Present mechanized harvesting methods are most efficient in clean cutting pure stands that are fully stocked and have a narrow range of diameter sizes. The objective in pine regeneration should be to establish stands that meet these requisites.

The current practice of establishing mixed stands of red and jack pine is not in keeping with this objective and may affect future harvesting efficiency. The planting and seeding requirements for establishing a stand of jack and red pine are similar, but silvic characteristics and management objectives for the species are quite different. For example, the rotation age for red pine is 100 years; for jack pine it is 50. Also, periodic thinnings are important for maximizing management returns with red pine, and product objectives for the species are quite different. Managers should consider these differences in establishing new stands.

Planting Possibilities

Favorable conditions for restocking the area by planting were created by the full tree system even under the difficult conditions of a heavy brush cover. Almost 80 percent of the area was free of slash and will permit hand planting a fully stocked stand. Brush competition also was greatly reduced by the full tree system. Brush was eliminated on about one-third of the area and the density was reduced by 80 percent on the remaining two-thirds. This elimination will facilitate planting and greatly reduce competition for planted trees during the next 2-3 years.

Poor conditions for planting exist on the area harvested by the shortwood system, largely due to the strip pattern of harvesting and to light disturbance by the machines. One-third of the area is not plantable because of slash windrows. On another 40 percent of the area, the brush was not disturbed or only lightly disturbed. Only 23 percent of the area with medium to heavy disturbance is now open to planting.

A better planting situation may result following harvesting with the Omark Tree Harvester on areas where no brush understory is present in the stand. Here, about two-thirds of the area will be plantable, since no brush competition exists and slash windrows are the only impediment to planting. Slash windrowing by the Omark Tree Harvester resulted in less area slash covered, when compared with conventional manual strip felling and piling operations: about 33 percent for the harvester against 40-60 percent for manual felling.

The tree length harvesting system left 60 percent of the area open to hand planting under conditions similar to the full tree area. Planting this area without some type of site preparation will sacrifice establishing a pure stand and uniform stocking. In time the slash areas will be invaded by species that are not compatible in growing characteristics or use with the planted pine.

Areas harvested by the full tree system are ready for planting immediately upon completion of the harvesting operation. This eliminates the 1-3 year lag between harvesting and regeneration that usually is required for areas harvested by other systems where site preparation or slash disposal are necessary before planting or seeding.

Seeding Possibilities

Although mineral soil is exposed or the organic layer is disturbed on half the areas harvested by the full tree and tree length systems and one-quarter of the shortwood area, none of the systems has created conditions suitable for direct seeding. The amount of area with mineral soil exposed is too little and the area is too unevenly distributed to permit desirable stocking. Also, the hazel brush stand has not been eliminated on enough area. The ability of hazel brush to resprout would produce too much competition for seedlings.

Residual Advanced Reproduction

In this study, the advanced reproduction was of undesirable species. Its elimination would be favorable from a forest management standpoint. Without some special effort for their removal during or after harvesting, these residual trees are left free to grow and occupy space in the new stand. Further study is needed to determine how best to eliminate such trees. Indications are that this work can be incorporated into a mechanized harvesting system without too much impact on production.

Slash Hazard

The full tree harvesting system, which concentrates the slash and tops, can render the cutover area almost free of hazard from fire or disease. The concentrated slash from 40 acres of coniferous forest will cover about 1½ acres. This slash can be readily and safely burned during most of the year.

High hazard conditions exist on the areas harvested by the tree length and shortwood methods. Slash covers about one-third of these areas. Disposal by prescribed burning will be easier on the shortwood area because of its even distribution. The scattered nature of the slash resulting from the tree length method might prevent the fire from carrying. Where prescribed burning is important, one of these systems might be preferable to full tree harvesting.

Harvesting Alternatives

Through mechanization, the forest manager has three alternative methods for harvesting a timber crop. In this study, there was little difference in cost among the systems, but the postharvesting conditions were quite different. The forest manager can use these differences to meet management objectives with some cost reduction.

CONCLUSIONS

This study of the effect of mechanized harvesting systems on jack pine regeneration requirements was conducted in a stand that represents difficult conditions for regenerating a new stand following harvesting. Postharvest site conditions were quite different following the mechanical harvesting systems used. Some of the conditions resulting from full tree harvesting are quite favorable for planting a new stand without further site preparation and with reduced regeneration costs. Indications are that by some adjustment in harvesting patterns, the tree length system may prove equally effective in aiding regeneration. Although the mechanized shortwood system did not develop satisfactory conditions for regeneration in this difficult situation, it might be successful under other conditions. Additional research is planned on this study area to determine the impact of machine activity on soil properties and to develop corrective measures for the regenerating residual conditions developed in these operations.

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