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Pre-Harvest Estimation of Logging Residues in Middle Georgia

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Whole-tree-harvest areas were virtually free of debris except for scattered limb piles.

In most logging operations large quantities of wood are left on the site in tops of cut trees and in unmerchantable standing trees. These residues represent a wasted resource and they hinder site preparation and the planting of a new stand. To deal with residues in a systematic way, a manager must know the quantity and type of material that will be left before an existing stand is harvested. The results reported here show that residue quantities can be predicted with reasonable accuracy prior to harvesting. If whole-tree chippers are used, the study also demonstrates the overwhelming advantage of chipping small trees before the larger, more valuable timber is harvested.

The applications described here grew out of a study sponsored by the Southeastern Regional Biomass Energy Program, which is administered by the Tennessee Valley Authority for the U. S. Department of Energy. We assumed at the outset that under certain economic conditions, recovery of the residues for fuel would be practical. In an extensive search, however, we found no operators willing to consider recovery of downed material. We therefore assume that only standing material would be recoverable.

In the energy application, predictions of residual material are necessary to assess feasibility of recovery, identify the best harvest procedure for solid products, fiber, and fuel, and to contract for the sale or subsidized removal of the fuel component. However, predictions of both standing and downed material are also important in estimating site preparation costs and determining whether more material should be removed during the harvesting operation to reduce those costs.

The study was conducted under a limited set of conditions in Middle Georgia. The general area was chosen because it has the largest array of initial stand conditions, the most varied product mixes, and the largest number of multiproduct logging operations in the State. Success here demonstrates that the same procedures can be used elsewhere.

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Procedures

The study included 10 logging areas, 7 of which were harvested with conventional equipment and 3 with a whole-tree system. The whole-tree system was included to provide a comparative demonstration of fuel recovery by what is generally considered the most efficient procedure. In the conventional logging, only solid products and fiber materials were removed. In the whole-tree chipping operations, the smaller material was removed and chipped for fuel immediately prior to removal of the more valuable material: cull hardwoods and hardwood tops were also chipped. In both types of operation, pines of pulpwood size and larger were taken in tree lengths. Pine limbs were removed by limbing gates from which the limbs were periodically pushed into piles. Area locations, types of logging, and general stand characteristics are presented in Table 1. Our procedure consisted of sampling of the areas before and after harvest. We exercised no control over or interference with the harvesting operations. Prior to harvesting each area was delineated on the basis of the apparent percentage of hardwood and the stand structure, then cruised on a systematic grid. Ten-factor prism plots were used to sample merchantable-sized trees, and the same plot centers were used for fixed-radius hundredth-acre plots to sample smaller stems. Data were collected in five species groups: pine, oak, other hard hardwoods, sweetgum, and other soft hardwoods. Identical cruises were conducted on the same sampling grids after the harvesting operations.

The cruise data were processed via the Total-Tree Multiproduct Cruise Program (Clark and others 1985) with outputs expressed as mean values per acre for each harvest area. Regressions of the quantity of standing material per acre were then run using as independent variables initial stand characteristics judged most likely to result in useful estimates of residual material.

Results and Applications

After conventional harvests the total quantity of standing residuals ranged from 5.4 to 29.3 tons per acre, whereas it ranged from 1.1 to 5.2 tons per acre after the whole-tree harvests. Several initial stand variables were tested as predictors of standing residual tonnage for conventional harvests. The most reliable was simply the total tonnage of all trees not designated for harvest as estimated by the Total-tree Multiproduct Cruise Program (Clark and others 1985). The regression equation was:

$$Y = 0.71835X-1.164,$$

where

Y = Tons per acre of standing residuals, and

X = Multiproduct Cruise Program estimate in tons per acre of all trees not designated for harvest.

It accounted for approximately 89 percent of the variation in standing tonnage.

Table 2 presents predictions of residual material for the range in tonnage of unmerchantable trees covered by our study. The predictions of standing material are based on the above equation; logging debris is derived by difference. For example, under our study conditions, 10 tons of leave trees would end up as 6 tons of standing residuals and (by difference) 4 tons of logging debris. The quantity of material on the ground would equal 66 percent of the standing material. Even the highest values of standing residuals in our study would be marginal for unsubsidized fuel chip recovery, and the debris from the same uncut stand component would impede recovery. The downed proportion increases as the tonnage of the residual stand decreases. The values in Table 2 only include material from the theoretical residual stand.

Table.--Location, size, type of harvesting, and general stand characteristics for ten logging areas in Middle Georgia.

				Tons/acre		Stems/acre	
Area	County	Acres	Type of Logging	Total	% Hardwood	Total	% Hardwood
1	Twiggs	10.1	Conventional	106.1	36.6	655.9	78.7
2	Twiggs	9.5	Conventional	101.7	44.2	927.9	75.3
3	Twiggs	24.5	Conventional	98.6	52.3	858.6	70.7
4	Twiggs	25.7	Conventional	94.5	29.2	1223.1	62.6
5	Twiggs	8.8	Conventional	77.7	8.5	704.4	43.5
6	Jones	8.8	Conventional	79.8	63.8	1094.3	89.1
7	Jones	11.2	Conventional	101.8	11.8	730.0	65.4
8	Hancock	13.3	Whole tree	80.4	49.3	774.3	77.0
9	Hancock	14.7	Whole tree	81.7	19.2	751.7	58.3
10	Hancock	12.5	Whole tree	94.6	51.8	1216.6	65.5

Table 2. Predicted residual material from unmerchantable trees on conventionally harvested mixed pine-hardwood areas.

Unmerchantable trees	Standing residuals	Logging debris	Standing residuals	Logging debris	Debris vs. residuals
----tons/acre----			----percent----		
5	2.43	2.57	49	51	106
10	6.02	3.98	60	40	66
15	9.61	5.39	64	36	56
20	13.20	6.80	66	34	52
25	16.79	8.21	67	33	49
30	20.39	9.61	68	32	47
35	23.98	11.02	69	31	46
40	27.57	12.43	69	31	45
45	31.16	13.84	69	31	44

Standing residuals ranged to over 30 tons per acre on conventionally harvested areas.

Debris consisting of hardwood sawtimber tops and pine limbs would also be left on the site. On our conventionally harvested areas, weights of sawtimber tops ranged from 1.4 to 8.3 tons per acre (average of 4.5) and made up 49 percent of the total tonnage in hardwood sawtimber trees. Approximately 4-15 tons per acre of large pine limbs would also be associated with such logging operations. Whereas the hardwood tops were scattered, the pine limbs were concentrated in a few large piles where limbing gates were located. Pine limbs, therefore, could be loaded and transported inexpensively, but this material contains dirt and other debris, and has proved difficult to chip in Commission pilot tests.[1] The foregoing presents a picture of a high proportion of debris to standing material, which translates to high recovery costs for fuel chips or high site preparation costs because of the variety of material that must be dealt with one way or the other.

Table 3 presents results of the whole-tree chipping operations and compares them to predicted results of conventional harvesting. For example, if Area 8 had been conventionally harvested, we would have predicted 15.4 tons of standing residuals: we observed 5.2 tons standing, and no debris other than the pine limb piles on the site. The total recovered material was, therefore, calculated to be 27 tons per acre. Similar to our conventionally harvested areas, pine limbs would comprise 4.5 to 9.4 tons per acre of concentrated, but unrecoverable material.

The whole-tree chipping results were consistent with previous observations (McMinn 1983) and demonstrate an overwhelming advantage over conventional harvesting if fuel chips are to be a component of the product mix. Removing smaller material first to avoid uprooting and breakage, then chipping hardwood sawtimber tops after sawtimber removal, resulted in actual recovery of 56 to 94 percent more material than would even be available for consideration after a conventional harvest. In addition, the park-like conditions created by removal of the smaller material should reduce the harvesting costs for the larger, more valuable material (Watson and others 1984).

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[1]/ Personal communication with J. Fred Allen, Chief, Forest Research, Georgia Forestry Commission.

Our residual prediction equation should be used only for the range of tonnages, percentages of hardwoods, and product mix included in our study. The predictions would not hold, for example, if hardwood saw logs were not removed. Our results indicate, however, that prediction equations can be developed for additional conditions by using the theoretical uncut trees as the independent variable.

Park-like conditions after whole-tree harvesting of all material except pine sawtimber.

Table 3.--Recovered residual material on three whole-tree-harvest areas compared to potential residual material and to the standing residuals that would be predicted for a conventional harvest.

	Standing residuals		Harvestable material	
Area	Predicted for conventional harvest[1]/	Observed after whole-tree harvest	Calculated potential[2]/	Actually recovered[3]/
	----------	tons/acre	----------	
8	15.4	5.2	32.2	27.0
9	10.1	1.1	16.9	15.8
10	22.1	1.1	43.9	42.8

[1]/Based on our prediction equation
[2]/Saplings of all species, hardwood pulpwood, and hardwood sawtimber tops
[3]/Calculated potential minus observed standing residuals

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