HARVESTING IMPACTS AS A FUNCTION OF REMOVAL INTENSITY[1]

by

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ABSTRACT: Single-tree selection, group selection, shelterwood, seed-tree, and clearcut harvesting methods were evaluated for residual site impacts. The stands were harvested during the summer of 1993 on the Ouachita National Forest in Arkansas. Manual felling and rubber tired skidders were used to harvest all 23 stands.

Percentage of area in primary skid trails was 8.2, 9.6, 13.2, 12.5, and 13.7 for the single-tree selection, group selection, shelterwood, seed-tree, and clearcut treatments, respectively. The single-tree selection treatment had the most undisturbed soil area (39.4 percent) after harvesting as compared to 25.6 percent for the group selection, 13.1 for the shelterwood, 9.1 for the seed-tree, and 6.0 for the clearcut. Residual pine damage was greatest for the group selection treatment.

KEY WORDS: Silvicultural treatment, soil disturbance, tree damage, skid trails.

INTRODUCTION

In 1993, the USDA Forest Service initiated a research study during Phase II of the Ecosystem Management Research Program on the Ouachita National Forest to assess stand disturbance after harvesting (Baker 1994). The study areas consisted of mixed shortleaf pine *(Pinus echinata* Mill.), loblolly pine *(Pinus tseda.)*, and various southern hardwood species. The stands were harvested using five silvicultural treatments: singletree selection, group selection, shelterwood, seed-tree, and clearcut. In addition to the silvicultural methods, the removal of just pine or pine and hardwood both was also evaluated as subtreatments.

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The mean number of treated hectares was 18.4[2], 20.0, 13.6, 15.6, and 16.0 for the single-tree selection, group selection, shelterwood, seed-tree, and clearcut, respectively. These stands were on sites scattered across the several physical divisions of the forest. Mean preharvest pine stand densities for the single-tree selection, group selection, shelterwood, seed-tree, and clearcut stands were 405, 415, 388, 480, and 350 trees per hectare, respectively. Mean preharvest hardwood stand densities for the single-tree selection, group selection, shelterwood, seed-tree, and clearcut stands were 445, 455, 405, 120, and 395 trees per hectare, respectively.

The objective of this study was to assess the site impacts associated with the silvicultural treatments. Soil surface area disturbance and residual tree damage were measured and evaluated. Other studies, as part of this program, have resulted in previous assessments (Stokes and others 1993; Kluender and others 1993; Kluender and Stokes 1994). An assessment of productivities and costs associated with such treatments are also reported by Kluender and others 1995.

‘TREATMENTS

The following partial cutting methods, listed in increasing order of harvesting intensity and/or site disturbance, were imposed to develop and maintain uneven-aged pine/hardwood stands (Baker 1994):

(1) Low-impact, pine/hardwood single-tree selection - Pines and hardwoods were reduced to residual basal areas of 13.9 to 18.6 m^2/ha, with up to 11.6 n? /ha being in hardwoods. Individual trees were selected; a lo-year cutting cycle is intended.

(2) Pine/hardwood single-tree selection - Pines and hardwoods were reduced to residual basal areas of 10.5 to 15.1 m^2/ha, with 1.2 to 4.6 m^2/ha being in hardwoods. Individual trees were selected; a lo-year cutting cycle is intended.

(3) Pine single-tree selection - Pines were reduced to residual basal areas of 10.5 to 15.1 m^2/ha. All merchantable hardwoods were harvested or removed except those needed to meet den-tree and mast-production standards for wildlife (0.5 to 1.2 m^2/ha).

(4) Pine/hardwood group selection - All pines and some hardwoods were harvested or removed in group openings ranging from about 0.04 to 0.4 hectares (representing from one to three times the height of adjacent trees). Residual basal areas of hardwoods within group

[2]Area and stand information in this paper was provided by Dr. Jim Baker, Team Leader, USDA Forest Service, Southern Research Station, Monticello, AR 71656. and Dr. Jim Guldin, Research Ecologist. USDA Forest Service, Southern Research Station, Hot Springs, AR 71902.

openings are 1.2 to 2.3 m^2/ha. Pines outside group openings were thinned to a basal area of 16.3 to 18.6 m^2/ha. No hardwoods were harvested or removed outside group openings.

(5) Pine group selection - The same as (4) except that no merchantable hardwoods were left within group openings.

The following partial cutting methods, listed in increasing order of harvesting intensity and/or site disturbance, were imposed to establish and maintain even-aged pine/hardwood stands (Baker 1994):

(1) Pine/hardwood shelterwood - A total of 50 to 100 of the largest pines and hardwoods per hectare (7.0 to 9.3 m^2/ha of basal area of which 1.2 to 3.5 m^2 /ha are in hardwoods) were retained; all other merchantable pines and hardwoods were harvested or removed.

(2) Pine shelterwood - A total of 50 to 100 of the largest pines per hectare (7.0 to 9.3 m^2/ha of basal area) were retained; all other merchantable pines and hardwoods were harvested or removed except those needed to meet den-tree and mast-production requirements (0.5 to 1.2 m^2/ha of hardwoods).

(3) Pine/hardwood seed-tree - A total of 25 to 38 of the largest pines and hardwoods per hectare (2.3 to 4.6 m^2/ha of basal area of which 1.2 to 3.5 m^2 /ha are in hardwoods) were retained; all other merchantable pines and hardwoods were harvested or removed.

(4) Pine seed-tree - A total of 25 to 38 of the largest pines per hectare (2.3 to 4.6 m^2/ha of basal area) were retained; all other merchantable pines and hardwoods were harvested or removed except those needed to meet den-tree and mast-production requirements (0.5 to 1.2 m^2/ha of hardwoods).

Stand information summarized by treatments and subtreatments are shown in Table 1.

METHODS

Area in Skid Trails

Lengths of primary and secondary skid trails were measured with'a road wheel, and widths were sampled to determine the percentage of total area in skid trails in each stand. Primary trails were defined as those having branching trails, whereas secondary trails did not have branches (Stokes and others 1993).

Soil Disturbance

Grid points at approximately **20 m were** used for assessing soil disturbance. A compass and pacing were used to traverse the harvested areas. Along each line, points were located approximately **20 m apart and the soil disturbance at each point was** classified. The disturbance classes included: (1) undisturbed; (2) disturbed with litter in place; (3) disturbed with mineral soil exposed; (4) disturbed depression with mineral soil exposed; (5) slash; (6) nonsoil (rocks, stumps).

Residual Tree Damage

Residual tree damage was assessed concurrently with the soil disturbance. At every fifth point along the traverse, a fixed radius plot was installed and all pines in the 5.1 cm DBH class (4.1 to 6.4) and above and all hardwoods in the 15.2 cm DBH class (14.2 to 16.5) and above were tallied and all tree damage recorded. Residual tree damage was classified as either cambium exposed or wood damage. Length and width of each damaged spot were measured, *along* with distance from ground to damaged area. For the clearcut, seed-tree, and shelter-wood sites, a 0.04-hectare fixed radius plot was used. A 0.02 hectare fixed radius plot was used for the single-tree and group selection sites.

RESULTS

Area in Skid Trails

For percentage of total area in primary and secondary skid trails, no significant differences were found between pine and pine/hardwood subtreatments within treatments, so they were also combined during the analysis. Primary and secondary skid trails accounted for 14.3 and 14.6 percent of total area for the single-tree selection and group selection treatments, respectively (Table 2). The shelterwood treatment left an average of 22.6 percent of area harvested in skid trails. The seed-tree and clearcut treatments resulted in 19.8 and 22.4 percent, respectively.

Soil Disturbance

Percent soil disturbance by class for the five treatments is summarized in Table 2. As harvesting levels increased, so did the proportion of the total tract that was trafficked.

Differences between percent disturbed area by disturbance class were tested using Tukey's Studentized Range Test to detect differences among treatments and between subtreatments. No differences were found between pine and pine/hardwood subtreatments within the treatments, so they were combined during the analysis.

There was significantly more undisturbed area for the single-tree selection treatment than the shelterwood, seed-tree, and clearcut treatments_ There was no significant difference between the single-tree selection and the group selection treatments for percentage of undisturbed area An average of 39.4 percent of area harvested using the single-tree selection treatment was left undisturbed as compared to 25.6 percent for the group selection, 13.1 percent for the shelter-wood, 9.1 percent for the seed-tree, and 6.0 for the clearcut treatments.

The percentage of area with mineral soil exposed (total of exposed and exposed-with-depression classes) increased as harvesting levels increased. An average of 18.4 percent of area harvested using the single-tree selection treatment had mineral soil exposed, as compared to 22.0 percent for the group selection treatment, 22.4 percent for the shelterwood treatment, 23.8 percent for the seed-tree treatment, and 29.9 percent for the clearcut treatment. The percentage of area with slash also increased as harvesting levels increased. There was no significant difference among the single-tree selection, group selection, and shelterwood treatments for percentage of slash.

Residual Tree Damage

Residuai pine and hardwood damage was classified as either cambium exposed or wood damage. Damaged trees per hectare within treatments were tested using Tukey's Studentized Range Test to detect differences between pine and pine/hardwood subtreatments. For residual pines with cambium exposed, there were significant differences. No differences were found between pine and pine/hardwood subtreatments within the treatments, so they were combined during the analysis (Table 2). The group selection treatment resulted in the highest number of damaged pines, with 37.5 pine trees per hectare with cambium exposed, followed by the single-tree selection, shelterwood, and seed-tree treatments with 29.8, 14.1, and 7.5 damaged pine trees per hectare, respectively. The damaged trees of the group selection treatment were in the residual stand that had selected trees removed. There were no damaged pine trees observed for the cleat-cut treatment. Residual hardwood damage with cambium exposed was highest for the group selection treatment, which averaged 24.3 trees per hectare, while the single-tree selection treatment resulted in 10.3 hardwood trees per hectare with cambium exposed. The shelterwood and clearcut treatments both averaged 7.8 hardwood trees per hectare with cambium exposed, while the seed-tree treatment resulted in 5.5 hardwood trees per hectare with cambium exposed .

DISCUSSION

Percentage of total area in skid trails was similar for the single-tree selection and group selection treatments. Due to lower volume removals, skidders were more restricted in their travel, using the same trails more frequently and not creating others.

There were some significant differences in all impact assessments over the range of silvicultural treatments. The soil disturbance assessment revealed that as harvesting intensity increased, the amount of area left undisturbed decreased. Since the single-tree selection treatment required less travel into the stand by the skidder, it left a higher percentage of the stand undisturbed, followed by the group selection treatment. As tree removal intensity increased, so did the percentage of area that was disturbed. Figure 1 shows that, generally, as harvesting intensity increases, the percentage of exposed mineral soil (total of exposed and exposed-with-depression classes) also increases. Also, as removal intensity increased, the percentage of area covered with slash increased due to limbs and tops.

There was a general trend of an increasing number of damaged residual pine trees per hectare with a decreasing number of trees removed per hectare. Figure 2 illustrates the general reduction in residual pine and hardwood damage as harvesting intensity increases. The trend was somewhat stronger for the pine subtreatments as compared to the pine/hardwood subtreatments, which results from fewer residual trees remaining after harvest. Additional research is needed to more fully understand the effect of removing or leaving hardwood understory. Due to the lower volume removal levels for the single-tree and group selection methods, the skidders were required to operate in more dense areas, which resulted in more trees being damaged from contact with skidder tires and logs in transport to the deck. There were no significant differences in the number of damaged hardwood trees per hectare between subtreatments or among treatments, except for the group selection treatment. This is due to thinning between the group openings, which resulted in more hardwood damage and to damaged hardwoods left in the group openings.

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Table 1. Pre-harvest and post-harvest stand summary for Phase II residual damage assessment study sites, Ouachita National Forest, 1993 (Guldin and Baker, 1995).

Stand	Harvesting Selection Method	Residual Stand	Ha.	Density (trees/ha) Pre-harvest Pine[1]	Pre-harvest Hwd[2]	Post-harvest Pine	Post-harvest Hwd
628	SGT (LI)[3]	Pine/Hwd[4]	17	468	490	375	315
3541	SW[5]	Pine[6]	14	475	440	88	135
3542	GS[7]	Pine/Hwd	21	390	455	263	345
45810	ST[8]	Pine	16	430	290	78	98
45816	CC[9]	NA	16	415	350	NA	10
6099	SGT	Pine/Hwd	16	408	188	308	50
895 1	SW	Pine	13	308	480	93	148
107719	SGT (LI)	Pine/Hwd	21	358	483	243	185
10847	ST	Pine	13	668	490	70	120
10944	SW	Pine/Hwd	12	340	238	123	105
10976	SW	Pine	14	473	460	133	90
11069	GS	Pine	21	323	578	123	453
111921	SW	Pine/Hwd	14	348	403	95	35
111922	ST	Pine/Hwd	16	415	463	20	108
112411	GS	Pine/H wd	21	555	318	353	213
11255	SGT	Pine	17	475	370	338	140
16468	ST	Pine	16	385	423	58	113
165416	SGT	Pine/Hwd	22	365	553	278	148
165816	SGT	Pine	19	380	425	283	135
16585	c c	NA	16	285	438	NA	13
16481	GS	Pine	16	395	465	200	205
16516	ST	Pine/Hwd	16	498	440	55	65
164913	SGT	Pine/Hwd	19	375	613	153	145

[1] All pines => 9.1 cm DBH

[2] All hardwoods => 9.1 cm DBH

[3] Low impact single-tree selection

[4] Low hardwood removal

[5] Shelterwood

[6] High hardwood removal

[7] Group selection

[8] Seed-tree

[9] Clearcut

Table 2. Post-harvest residual damage assessment for five harvesting methods for Phase II, Ouachita Nationa Forest, 1993.

	Harvest method				
	Single-tree selection	Group selection	Shelterwood	Seed-tree	Clearcut
No. of stands	7	4	5	5	2
Area in skid trails (percent)					
Primary	8.2b	9.6ab	13.2ab	12.5ab	13.7a
Secondary	6.1a	5.0a	9.4a	7.3a	8.7a
Total	14.3a	14.6a	22.6a	19.8a	22.4a
Ground disturbance (percent)					
Undisturbed					
Untrafficked	39.4a[1]	25.6ab	13.1bc	9.1c	6.0c
Disturbed					
Litter in place	26.9ab	30.3ab	34.5a	30.2ab	22.7b
Exposed	11.8a	13.4a	13.3a	12.7a	19.1a
Exposed - with depression	6.6a	8.6a	9.1a	11.1a	10.8a
Slash	14. lc	19.7c	25.4bc	33.7ab	38.4a
Non-soil	1.1a	2.2a	4.6a	3.0a	3.0a
Residual pine tree damage (trees/hectare)					
Cambium exposed	29.8a	37.5a	14.1b	7.5b	NA
Wood damage	1.5a	0.8a	0.3a	1.0a	NA
Residual hardwood tree damage (trees/hectare)					
Cambium exposed	10.3ab	24.3a	7.8b	5.5b	7.8b
Wood damage	0.3a	0.3a	0.3a	0.0a	0.3a

[1] Letters indicate groups that were similar at the 0.05 level in a means separation test using Tukey's Studentized Range Test.

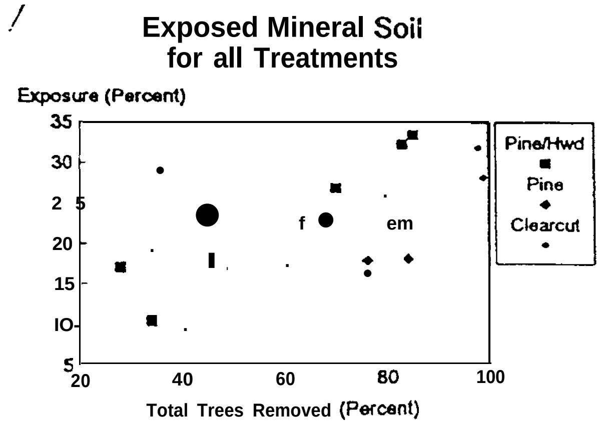

Figure 1. Percentage of exposed mineral soil for all treatments as harvesting intensity increases by subtreatments.

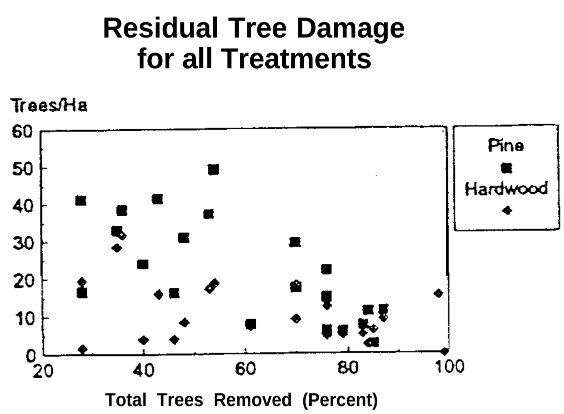

Figure 2. Residual pine and hardwood tree damage for all treatments as harvesting intensity increases by subtreatments.