
Harvest Impacts in Uneven-Aged and Even-Aged Missouri Ozark Forests

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ABSTRACT: Forest managers are concerned about the potential damage to residual trees and site from cyclic harvest re-entries into the same forest stand. This study summarizes logging and felling damage resulting from the harvesting of silvicultural treatments on a large landscape experiment in southern Missouri that is designed to compare impacts of even-aged, uneven-aged and no management on a wide array of ecosystem components. Although damage levels to bole and crown of leave trees was low for all treatments, the individual tree selection (uneven-aged) treatment did show: (1) higher levels of surface area skidder impact; (2) higher percentage of leave trees with one or more bole wounds; (3) higher number of bole wounds; (4) higher percentage of wounded trees in the dominant and co-dominant crown classes; and (5) the highest percentage of leave trees impacted by logging activity. Preharvest planning that involves the layout and discussion with the skidder operator(s) will reduce the area impacted by skidding to less than 12%. Also, the probability of a bole wound to a residual tree can be reduced to less than 5% if skid trails are kept 30 ft or more from the leave tree. *North. J. Appl. For.* 21(4):187–193.

Key Words: Harvesting impacts, logging damage, bole wounds, crown damage, tree damage, even- and uneven-aged harvest impacts.

Public and private forest land agencies are increasingly interested in exploring the use of alternative silvicultural systems of management on state and federal lands. Forest managers are concerned about the potential damage to residual trees from cyclic harvest re-entries into the same forest stand. Selection harvest methods may adversely impact the quality of the residual trees and increase the potential for future disease and insect infestations.

The conduct of forest operations determines whether management objectives will be met on the ground. Poorly managed operations can cause substantial environmental degradation, a reduction in merchantable volume, and a decrease in timber quality, especially when the harvest involves partial cutting (Hesterberg 1957). In one harvest entry, one-quarter to one-half of the residual stems or stand basal area can be damaged during logging operations in stands managed by the selection method (Nyland and Gabriel 1971, Stokes 1983). With conventional logging, skid

trails and landings may cover from 10 to 40% of the ground surface after a single harvest (Turcotte et al. 1991, Stokes et al. 1995, Ficklin et al. 1997).

Even-aged systems are standard practice on public forests, and diameter limit cutting or “high grading” is common on private forest lands, although more often forest managers are prescribing selection methods because the public is interested in alternatives to clearcutting. However, there is not a long history with selection methods in Missouri, for not long ago this method was deemed inappropriate for oak forests in the Central Hardwood Region (Sander 1977). However, the Pioneer Forest, a 160,000-ac private forest ownership located in South central Missouri has used selection harvest methods for over 50 years. Recent research findings on this forest (Larsen et al. 1999, Loewenstein et al. 2000) show that the individual-tree selection harvest method can be used to sustainably manage xeric oak-hickory Ozark forests.

The purpose of this study was to summarize postharvest logging impact data following the 1996 harvest of MOFEP (Missouri Ozark Forest Ecosystem Project) sites.

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Study Site

The Missouri Ozark Forest Ecosystem Project (MOFEP), initiated in 1989 in southeastern Missouri, is a 9,200-ac landscape experiment designed to compare the impacts of even-aged, uneven-aged, and no management on a wide array of ecosystem components. Each of the three treatment regimes were replicated on three sites, and each site had to be a minimum of 600 ac in size, contiguous with minimal edge, largely free from manipulation for the past 40 years and longer, if possible, owned by The Missouri Department of Conservation, located in the southeastern Ozarks, and relatively close to each other (Brookshire et al. 1997).

MOFEP is located within the Current River Hills Subsection of the Ozark Highlands Section. The Ozark Highlands is an assemblage of nearly level to deeply dissected plateaus comprised primarily of Ordovician dolomites or

sandstones. Soils are formed primarily in loess, hillslope sediments, and/or residuum. Natural vegetation in addition to the oak-hickory and oak-pine forests include woodlands, oak savanna, bluestem prairie, and glades. MOFEP occurs in the Current-Black River Breaks and Current-Eleven Point Hills Landtype Associations (LTA) (Meinert et al. 1997).

The nine sites are located in Shannon, Reynolds, and Carter counties, the total of which are about 84% forested (Figure 1). Agricultural activities are limited to bottomland corridors along primary streams. The research area consists of upland oak-hickory and oak-pine forest communities. Dominant tree species include white oak (*Quercus alba* L.), black oak (*Q. velutina* L.), post oak (*Q. stellata* Wang.), scarlet oak (*Q. coccinea* Muenchh.), blackjack oak (*Q. marilandica* Muenchh.), chinkapin oak (*Q. muehlenbergii* Engelm.), shortleaf pine (*Pinus echinata* Mill.) and hickory

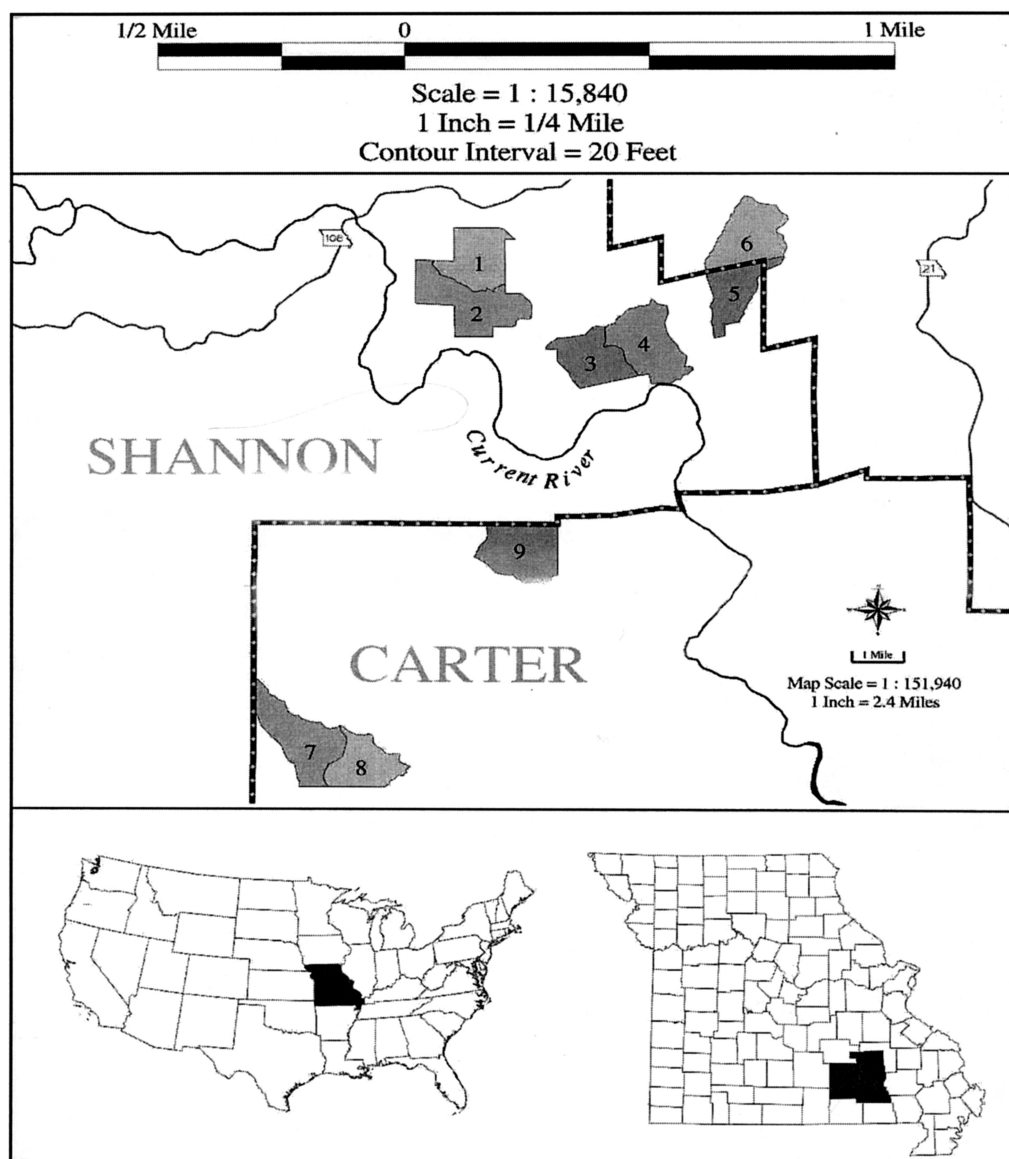


Figure 1. Map of Shannon, Reynolds, and Carter counties showing MOFEP research sites. Sites 1, 6, and 8 received the no harvest treatment. Sites 3, 5, and 9 received the even-aged treatment, and sites 2, 4, and 7 received the uneven-aged treatment.

(*Carya spp.*). Understory species include dogwood (*Cornus spp.*) and blackgum (*Nyssa sylvatica Marsh*) (Xu et al. 1997).

The MOFEP experiment is designed as a randomized complete block design using nine sites divided into three blocks. Each site is approximately 1,000 ac in size. Treatments of individual-tree selection (uneven-aged), clearcut and intermediate thin (even-aged), and no-harvest management were randomly assigned to sites within each block (Sheriff and He 1997). A system of 648 permanent cluster plots was distributed across the nine MOFEP sites. Plots were allocated among forest stands based on stand size with the constraint that each include at least one plot. The forest stand was the basic unit of management. Plots were established in each forest stand so that no treatment plot was located on the boundary between two adjacent stands. Each 0.5-ac plot contains a cluster of 4 subplots that are 0.01-ac in size. Plot center for a subplot is located 56.5 ft from the center of the 0.5-ac plot and is situated in one of the four cardinal directions.

Treatment

Each site was subdivided into cutting blocks based on LTA. Each cutting block was comprised of multiple forest stands. Timber harvesting began in May and concluded in Nov. of 1996. The uneven-aged sites (numbered 2, 4, and 7) were marked according to The Missouri Department of Conservation guidelines to achieve a target or guiding curve with a “*q*” of approximately 1.5. In the individual-tree selection (uneven-aged) treatment trees were marked across all size classes, however, only trees 10.0 in. dbh or larger were tallied for volume. Group selection openings were also distributed throughout forest stands. These openings ranged in size from 70 to 140 ft in diameter based on aspect. All marked trees greater than or equal to 10.0 in. dbh were harvested or girdled. No trees designated as “DEN” (wild-life) trees were to be cut. In the even-aged treatment sites (numbered 3, 5, and 9) some forest stands were marked as intermediate thin harvests. The intermediate thin harvest was designed to release good growing stock in stands that were considered too young for a clearcut regeneration harvest. Older stands were regenerated by clearcutting that ranged in size from 5 to 20 ac. All hardwoods greater than or equal to 10.0 in. dbh were harvested or girdled. All hardwood trees less than 10.0 in. dbh were slashed following the regeneration harvest. No shortleaf pine seed trees or den and snag trees were cut in the clearcut harvest. The area treated included 320 ac clearcut (even-aged), 411 ac intermediate thin (even-aged), and 2,124 ac of individual-tree selection (uneven-aged). These treated areas were comprised of 24 forest stands that were clearcut (even-aged), 40 stands intermediate thinned (even-aged), and 110 stands harvested using individual-tree selection (uneven-aged).

Preharvest plot conditions averaged 79.2, 92.1, and 92.0 trees/ac for the clearcut (even-aged), intermediate thin (even-aged), and individual-tree selection (uneven-aged) treatments, respectively. Furthermore, the basal area aver-

aged 93.4, 98.7, and 106.3 ft²/ac for the same three treatments, respectively.

There were a total of 26 individual logging crews that were used to harvest the treatment plots. Logging crews were randomly assigned forest stands from each of the harvest treatments so that all crews operated across stands representative of each of the treatments. The logging system consisted of four-wheel rubber-tired skidders, manual felling, and knuckle-boom loader. Trees were bucked into log lengths in the woods and skidded to the log landings. This harvest system and bucking procedures are standard for the Ozark area.

Logging Damage Survey

After harvest treatments, field crews collected tree damage data from 66 0.5-ac plots on even-aged management sites and 120 plots on the uneven-aged sites. The difference in number of sample treatment plots is a function of the area harvested by treatment, i.e., there were nearly twice as many forest stands harvested using uneven-aged methods as compared to even-aged treatment methods. Of the even-aged plots, 28 were clearcut harvested and 38 received an intermediate thinning treatment. All sample plots were located within treatment units to avoid the potential problems associated with edge effects. The data collected on each 0.5-ac plot included: site, plot, and tree number; species; dbh (in.); crown class; tree condition (live, cavity, snag, or blow-down); harvest method; wounds (no.); height to the bottom of the wound (ft); length of the wound parallel to the axis of the bole (ft); width of the widest part of the bole wound (ft); whether there was logging activity within the dripline of the residual tree's crown; distance of damaged residual tree to the logging activity (ft); crown damage (%); kind of logging activity around damaged tree; and root damage (no.). Surface area of bole wounds was determined by multiplying length times width as defined above. Skid trail information included length (ft) by type of trail (primary/secondary) in each plot. In addition, the depth of ruts was categorized (in.) as 0–4, 4–8, and >8.

Residual tree root damage was observed as uprooted trees, severed roots, or root abrasions. Severed and abraded roots were noted as present or not within the skid trail. Damage to root systems was measured by determining the surface area of skid trails and soil rutting. In another study on MOFEP, soil excavations exposed an average of 1.0 m of root, and multiple-pass and single-haul skid trails averaged 1.3 versus 0.7 injuries per meter of discovered root, respectively (Bruhn et al. 2002). Therefore, we used the surface area in skid trails as an indicator of the spatial extent of root injury.

Data were collected and input to a database file. After editing of the data set, summary statistics were generated using the Statistical Analysis System (SAS). In addition, a logistic regression model was fit to data on tree size and distance to logging activity. This equation computed the probability of whether or not a subject tree would receive a bole wound based on tree size and distance from logging activity.

Results and Discussion

Soil Impacts

Logging operations can damage the soil resource by causing soil displacement, soil compaction, and soil erosion. Soil compaction occurs most frequently on primary skid trails and landings. The majority of soil compaction results after the first few passes of the skidding equipment (Froehlich et al. 1981, Shetron et al. 1988).

We documented how much area was impacted by haul roads and primary and secondary skid trails. The percentage of area impacted by primary and secondary skid trails and haul roads accounted for 11% ($\pm 4\%$) of the total area for the clearcut (even-aged), 9% ($\pm 5\%$) for the intermediate thin (even-aged), and 12% ($\pm 7\%$) for the uneven-aged treatments. Although skid trails and log decking areas were not laid out before logging operations, analysis of rut depth data showed that less than 1% of the area had ruts that exceeded depths of 4 in., and there was no significant differences between treatments. In a logging damage study in Missouri (Ficklin et al. 1997) and Arkansas (Stokes et al. 1995) showed similar surface area impacts of 9.7 and 14.4%, respectively. Elsewhere in the United States, studies of conventional logging reported that skid trails may cover from 20 to 40% of the ground surface after a single harvest (Dyrness 1965, Froehlich et al. 1981, Turcotte et al. 1991). The more multiple-pass skid trails that cover the area, the more probable will be the degradation to soil properties.

The low amount of damage in our study may be the result of the extraordinary timber sale administration practices that were followed in the conduct of the harvest. These extraordinary practices included the following. First, there were public meetings held for anyone interested in bidding on the MOFEP timber sales. At this meeting, a thorough explanation and specific instructions were given as to the importance of the project, how the sales would be administered, and how the cutting blocks were set up. After the successful bidders had chosen their cutting crews, there was another meeting held with them to explain the contract and terms of the sale. Subsequently, timber-sale administrators spent more time on these sales than they normally would; it became their full-time job. They developed good rapport with the logging crews and they sensed that the crews wanted to do a good job, as evidenced by the fact that the bidders put their best crews on the sales. Finally, the sales did not take place during spring sap flow when the bark can be easily removed from the bole by impacts from skidders and logs.

Root Damage: Direct Effects

Logging damage to tree roots was measured within the dripline of the leave tree, or within a distance of 1.0 to 1.5 times the maximum crown radius of the leave tree. A common perception is that most tree roots lie within an area defined by the crown dripline; however, tree feeder roots extend well beyond the dripline (Stone and Kalisz 1991). The extent of skid trails and other logging activity was determined within this crown dripline area, but we also included impacts up to 1.5 times the maximum crown radius

of the residual tree to account for possibly larger root systems. Root damage within 1.5 times the maximum crown radius of the leave tree was minimal. Combining all treatments, 99.3% of the residual trees had no evidence of root damage. Such low levels of root damage may be because virtually all of the skid trails that were measured had little (<4 in. depth) to no rutting. Nevertheless, without extensive below-ground excavation, it is impossible to determine the extent of damage caused by root wrenching.

On all 28 clearcut (even-aged) plots, there was a total of 5 trees found uprooted, or 0.2% of the total number of trees and 0.8% of the mean basal area of the preharvest stand (Table 1). A similar comparison of pre- and postharvest data shows that for the intermediate thin (even-aged) treatment, the number of uprooted trees was 0.8% and their basal area was 1.0% of preharvest levels. For the individual-tree selection (uneven-aged) treatment, the number of trees uprooted represented 0.8% of the preharvest number of trees and 0.7% of preharvest mean basal area. The diameter (dbh) range of uprooted trees was 4.7 to 10.1 in., with a mean of 6.2 in.

Root Damage: Indirect Effects

Indirect effects refer to the kind of logging activity within the dripline of the leave tree crown or within a distance of 1.5 times the maximum radius of the leave tree crown. These logging activities include one- or two-pass skid trails, primary skid trails, haul roads, and decking areas. The length (ft) and width (ft) of the skid trails, haul roads, and decking areas were measured where they crossed each 0.5-ac plot.

Almost 37% of the leave trees experienced some degree of skidding, loading, and hauling activity within the tree crown area in all treatments combined. By extending the distance of 1.5 times the maximum crown radius, we found that the roots of another 13% of the leave trees were potentially impacted by some logging activity. In short, 50% of the leave trees had some logging activity within a distance of 1.5 times the crown radius of the leave tree.

In the clearcut (even-aged) treatment, 54% of the residual trees had one-pass and two-pass skid trails, primary skid trails, and haul roads within 1.5 times the maximum crown radius distance. The intermediate thin (even-aged) and individual single-tree selection (uneven-aged) treatments had 45 and 47%, respectively, of their residual trees' crowns with some logging activities within their extended crown

Table 1. A comparison of preharvest plot conditions versus postharvest uprooted trees.

Treatment	Preharvest		Postharvest	
	Trees (no./ac)	Basal area (ft ² /ac)	Uprooted trees (no./ac)	Basal area (ft ² /ac)
Clearcut (even-aged)	79.2	93.4	1.7	0.7
Intermediate thin (even-aged)	92.1	98.7	1.8	1.0
Individual tree selection (uneven-aged)	92.0	106.3	1.6	0.7

area (i.e., 1.5 times the maximum crown radius). The residual basal area in the clearcut treatment represents pine and hardwood snags that were not harvested to meet habitat management guidelines for birds. On average, there were 8 residual trees per acre greater than 4.5 in. in diameter totaling 6 ft² of basal area per acre in clearcuts. In contrast, postharvest basal area per acre (≥ 4.5 in. dbh) was 54 ft² for the intermediate thin (even-aged) and 57 ft² for the individual-tree selection (uneven-aged) treatments.

For all harvest treatments combined, the mean distance was 11.4 ft between the residual tree and the skid trail, haul road, or decking area. For the most part, trees in the undesirable growing stock class were either removed in the thinning or slashed after the clearcut. However, some residuals are in the undesirable class because of Department of Wildlife Guidelines requiring retention of cavity and snag trees. For all treatments combined, 80.2% of the residual trees (12,760) were acceptable growing stock.

In general, increasing the area in skid trails increases the amount of soil disturbance in a forest stand and increases the probability that residual trees along the trail side incur some type of basal wound (Nyland and Gabriel 1971). By preplanning the skidding system and working closely with the loggers, managers can reduce the area in skid trails, haul roads, and landings by 3 to 6% (Nyland and Gabriel 1971). However, there is some degree of impact that is unavoidable (e.g., 10 to 15% of the forest stand area).

Bole Damage

Bole wounds represent a potential degradation to the health, quality, and value of the crop tree. For the even-aged intermediate thin treatment, 93.9% of the residual trees had no bole wounds, whereas for the individual-tree selection (uneven-aged) treatment, there were no bole wounds on 91.5% of the leave trees.

The mean basal area of residual leave trees in the individual-tree selection (uneven-aged) treatment was 56.9 ft²/ac, of which 4.8 ft²/ac of the basal area was in trees that had 1 or more bole wounds. This represents about 8.4% of the total mean basal area. For the intermediate thin (even-aged) treatment, the total mean residual basal area was 54.4 ft²/ac. There was 3.2 ft²/ac of basal area in trees that had 1 or more bole wounds, and this represents about 5.9% of the total mean basal area. The small amount of residual basal area in the clearcut (even-aged) stands represents shortleaf pine seed trees, snag, and den trees that were not harvested to meet Missouri Department of Conservation wildlife habitat requirements.

The mean number of bole wounds per leave tree was highest in the individual-tree selection (uneven-aged) treatment (Table 2). Surprisingly, the difference in numbers of bole wounds between the clearcut (even-aged) and individual-tree selection (uneven-aged) treatments was not substantial. Thus, the severity of damage to boles did not vary much among treatments. Despite substantially more residual basal area on the intermediate thin (even-aged) and individual-tree selection (uneven-aged) treatments than on the clearcut (even-aged) treatments, the percentage of area

Table 2. Mean number and size of bole wounds of leave trees.

Treatment	No. of wounded trees	Mean no. of wounds/tree	Mean wound (in. ²)
Clearcut (even-aged)	19	1.1 $\pm$ 0.31	177.9 $\pm$ 270.14
Intermediate thin (even-aged)	150	1.2 $\pm$ 0.49	106.1 $\pm$ 163.05
Individual tree selection (uneven-aged)	557	1.4 $\pm$ 0.86	140.8 $\pm$ 302.15

NOTE: The wound size (in.²) was calculated by multiplying the length of the wound by the width of the wound at its widest point. Mean wound size was calculated by harvest treatment.

impacted by logging activities and percentage of trees near logging activities were similar among the harvest treatments.

In our study, distance from logging activity to the leave tree and tree diameter were significantly related to the probability of that tree having at least one bole wound. As the distance to the skid trail increases the probability of having one or more bole wounds decreases for any given tree size (Figure 2). Smaller trees have a higher probability of one or more bole wounds at any given distance than larger trees. For example, a 10.0-in. tree has a 1 in 5, or 20%, chance of being wounded if the logging activity is within 5 ft from the tree. For the same size tree, there is only about a 2% chance of damage if the activity is 20 ft from the tree. Also, as distance to logging activity increases and tree diameter increases the probability of damage decreases. Large trees (20 to 25 in. dbh) within 10 ft of the skid trail are less likely to be injured during skidding than are smaller (5 in. dbh) trees close to the skid trail. Overall, residual leave tree injury (skidding and felling) for the individual-tree selection (uneven-aged) treatment was 11.1% for this study. Tree injury includes damage to the crown and bole of the tree. In logging damage studies by Ficklin et al. (1997), Stokes et al. (1995), and Nyland and Gabriel (1971), it was found that residual leave tree injury (skidding and felling) after individual-tree selection harvesting in Missouri oak-hickory forests was 22.0%, 9.4% in Ontario tolerant hardwood forests, and 33.0% in northern hardwood forests,

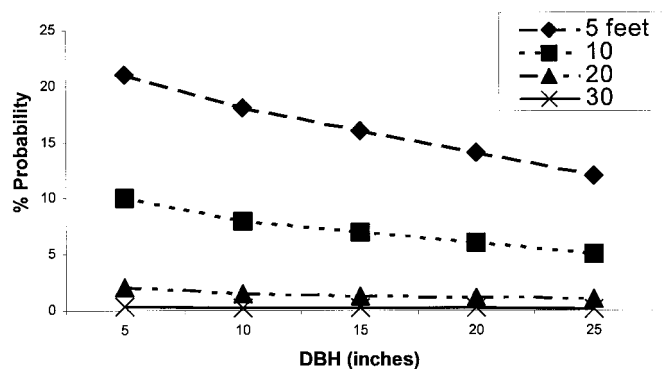


Figure 2. Probability of leave trees having one or more bole wounds in relation to dbh and distance from the skid trail or haul road.

respectively. The wounded trees in our study comprise the acceptable growing-stock quality class. These trees will grow to sawtimber size over decades, during which decay has the time to progress to advanced stages.

The mean height (ft) measured from groundline to the base of the bole wound is 3.0, 2.4, and 3.2 for the clearcut (even-aged), intermediate thin (even-aged), and individual-tree selection (uneven-aged) treatments, respectively. These bole wounds extend into the butt log and can represent a significant reduction in volume and value and, quite possibly, the health of the leave tree over time. The butt log represents the majority of the tree's total volume, and the highest log grade is usually found in this section. If the butt log has to be cut short to remove the decay, then there is less volume in the butt log, as both the small- and large-end diameters are decreased.

Wounds that contact mineral soil lead to greater amounts of decay because the wound surface is moist and therefore provides a better environment for infection. Basal scars that contact mineral soil and that have surface areas greater than 81.8 in.² will usually develop significant internal decay in hardwoods with time (10–20 years) (Anderson and Rice 1993). For all of the treatments combined, 27% of the bole wounds were in contact with mineral soil. For the intermediate thin (even-aged) treatment, 34% of the leave trees with bole wounds were in contact with mineral soil, and 25% for the individual-tree selection (uneven-aged) treatment.

In the clearcut (even-aged) treatment, 19 of the trees surveyed ($n = 399$) after logging had bole injuries. Out of these 19 bole-injured trees, 4 (Figure 3) were in the dominant crown class and 8 in the co-dominant class. These trees represent the shortleaf pine seed trees and cavity (den) trees. In the intermediate thin (even-aged) treatment, 150 of the survey trees ($n = 2367$) had bole wounds, and 46 of these were in the co-dominant class, whereas 9 of the injured trees were in the dominant class. Of the 6,534 trees surveyed in the individual-tree selection (uneven-aged) treatment, 555 had bole injuries. Of these trees, 69 were in the dominant class and 250 in the co-dominant crown class. There were fewer dominants in the intermediate thin (even-aged) treatment stands because residual trees were smaller,

poletimber-sized trees, and the dominant and co-dominant "wolf" trees had been removed in the thinning. The average tree size for the individual-tree selection (uneven-aged) treatment was over 1.0 in. larger than the intermediate thin (even-aged) treatment for both the dominant and co-dominant crown classes.

Crown Damage

Residual tree crown damage included limbs that were broken off during felling. The impacts of felling damage were evaluated by estimating the percent of the leave tree crown that was damaged during the felling operation. Regardless of harvest treatment or crown class, 1% of all leave trees had 10% or more damage to the crown. The other 99% were either not damaged or received less than 10% damage. Both the intermediate thin (even-aged) and individual-tree selection (uneven-aged) treatments had less than 1% of their mean basal area per acre in the more than 10% crown damage class. In a similar study located in the southeastern Ozarks, Ficklin et al. (1997) found that 22% of residual trees had some type of logging damage, and 8.6% of the leave trees had crown damage.

Summary

This study shows that logging operations in Missouri Ozark forests can be done in a manner that minimizes damage to the soil and residual stand when regenerating stand by clearcut or individual-tree selection, or thinning younger stands of poletimber. The amount of the stand area in skid trails, roads, and landings ranged from 9 to 12% for the treatments, which is minimal relative to values reported elsewhere in the United States. A small proportion of residual trees had bole wounds, ranging from 5% in clearcuts to 8% in individual-tree selection. Trees that suffered bole injury averaged slightly more than one wound per tree, regardless of harvest treatment. The probability of a tree receiving a bole injury during skidding depended on tree diameter and distance from the skid trail. Crown damage was insignificant for any harvest treatment.

To minimize residual impacts of damage to the tree and soil, the number and spatial extent of skid trails needs to be reduced by carefully preplanning the location of these trails at the time the trees are marked. By carefully preplanning the skid trails as well as working with the skidder operator, advanced regeneration and high-value crop trees can be protected.

Group and individual-tree selection harvest methods will require multiple harvesting entries. Due to the close proximity of the leave tree to the logging activity, it is imperative that planned careful logging be implemented by trained logging crews. Foresters and loggers need to work closely in laying out skid trails to minimize potential damage to crown and bole of trees retained in the stand. Directional felling is another important harvesting technique that can protect the crown and bole of residual trees and also facilitate the skidding of logs. It is a good idea to include the foreman, skidder operator, and timber harvester in the preplanning session.

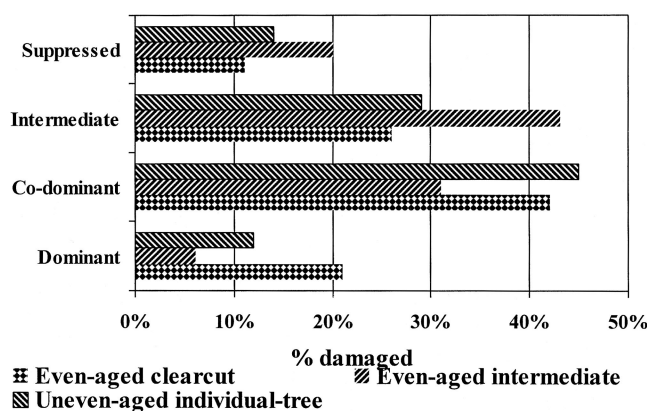


Figure 3. Distribution of trees with bole wounds by crown class and harvest treatment.

Planned careful logging does not take place in a vacuum. It is not solely the responsibility of either the harvest operator or forester, but both, working in concert to insure that careful logging practices are identified in the stand prescription. The timber harvest contract and or agreement can be used to specify good practices in the conduct of logging. The contract can specify how haul roads, landings, and skid trails are to be closed and/or maintained. It can also serve to set utilization standards as well as tolerances for residual tree damage. Sale administration is essential for a successful harvest. All forest operations must be monitored regularly, but especially during critical periods such as road building, skid trail layout, inclement weather, and as harvest operations near completion.

The relatively low levels of damage to crown and bole of the leave trees in this study are the result of a good logging job—the result of the close working relationship between the loggers and the forestry staff on the treatment sites.

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