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Partial Harvesting of Hardwood Sawtimber in Kentucky and Tennessee, 2002–2014

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Cover photo: The Central Hardwoods forests found in Kentucky and Tennessee are important to the economic and ecological well-being of those States.

All photographs by Thomas J. Brandeis,
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FOREWORD

The U.S. Department of Agriculture Forest Service, Southern Research Station's (SRS) Forest Inventory and Analysis (FIA) research work unit and cooperating State forestry agencies conduct annual forest inventories of resources in the 13 southern States (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia), the Commonwealth of Puerto Rico, and the U.S. Virgin Islands. In order to provide more frequent and nationally consistent information on America's forest resources, all Forest Service research stations and their respective FIA work units conduct annual surveys with a common sample design. These surveys are mandated by law through the Agricultural Research Extension and Education Reform Act of 1998 (Farm Bill).

The primary objective in conducting these inventories is to gather the multi-resource information needed to formulate sound forest policies, provide information for economic development, develop forest programs, and provide a scientific basis to monitor forest ecosystems. These data provide an overview of forest resources that may include, but are not limited to, forest area, forest ownership, forest type, stand structure, timber volume, growth, removals, mortality, management activity, down woody material, and invasive species. The information presented is applicable at the State and survey unit level; although it provides the background for more intensive studies of critical situations, it is not designed to reflect resource conditions at small scales. More detailed information about sampling methodologies used in the annual FIA inventories can be found in "The Enhanced Forest Inventory and Analysis Program-National Sampling Design and Estimation Procedures" (Bechtold and Patterson 2005).

Data tables included in FIA reports provide an array of forest resource estimates, but additional tables can be obtained at https://fia.fs.fed.us/tools-data/default.asp. Additional information about the FIA program can be obtained at https://fia.fs.fed.us/.

Most hardwood tree volume in Kentucky and Tennessee was removed and utilized as part of partial harvests.

HIGHLIGHTS

- In Kentucky from 2006 to 2014, harvested hardwood volumes ranged from a high of 231.2 million cubic feet in 2007 and a low of 158.1 million cubic feet in 2014. In Tennessee from 2002 to 2014, harvested hardwood volumes ranged from a high of 287.6 million cubic feet in 2012 and a low of 238.8 million cubic feet in 2010.

- Most hardwood tree volume was removed and utilized as part of partial harvests (defined here as harvests where more than 50 percent of the stand volume is retained), followed by clearcut harvests. Commercial thinnings, salvage cuttings, and timber stand improvements accounted for only a small portion of the harvest removals.

- On average over the study period, the percentage of the stand's total volume per acre removed during partial harvests was 47.4 in Kentucky and 44.5 in Tennessee.

- In both States for 2014, the top three species in terms of hardwood volume removed in partial harvest operations were white oak, yellow-poplar, and chestnut oak.

- Trees were increasingly likely to be left in partially harvested stands as their tree grade decreased in quality, regardless of the tree species. Relative to a grade 1 tree, a grade 2 tree was twice as likely to be left. A grade 3 tree was 5-6 times, a grade 4 was 5 times, and a grade 5 was 6-7 times as likely to be left relative to a grade 1 tree.

Hardwood logs being transported from a logging operation in Tennessee.

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Abstract

Partial harvesting is the predominant but not exclusive cutting treatment applied to the hardwood forests of Kentucky and Tennessee. Hardwood harvest in Kentucky showed a slight downward trend from 2006 to 2014, with most of the volume harvested in partial logging operations. Tennessee did not show this same downward trend, and the amount of hardwood volume harvested from 2002 to 2014 remained relatively steady with the exception of slight decreases during the economic downturn of 2007 to 2009. In these partial harvests, less than half of the stands' volume was removed. The tree species being cut and utilized were those typically considered commercially valuable species, in particular white oak (*Quercus alba*), yellow-poplar (*Liriodendron tulipifera*), and chestnut oak (*Quercus montana*). Trees were increasingly likely to be left in partially harvested stands as their tree grade decreased in quality, regardless of the tree species. Tree grade 1 trees, the highest quality, were the most likely to be harvested. U.S. Department of Agriculture Forest Service Forest Inventory and Analysis (FIA) data show that the lower-graded trees are much more likely (6-7 times as likely for a tree grade 5 tree) to be left in the stand after partial harvesting. This reinforces previously published observations that the relative proportion of sawlog volume in higher-grade trees has shown some declines overall in these states, indicating an increase in the proportion of sawlog volume that is in lower-graded trees. The hope is that this study will spur further investigation into hardwood sawlog quality trends in Kentucky and Tennessee and careful consideration of the drivers behind them.

Keywords: Central Hardwoods region, forest inventory, harvesting, logistic regression, tree grade.

INTRODUCTION

While pine forests garner much of the attention, hardwood forests are also important to the economic and ecological well-being of the Southeastern United States. This is particularly true of the hardwood-dominated forests of Kentucky and Tennessee, which fall primarily within the Central Hardwoods and Southeastern mixed forest ecoregions of the United States (Bailey 1983). The more than 450 hardwood sawmills producing more than 2.2 billion cubic feet of hardwood lumber in these two States are important components of their rural economies (Bentley and others 2014a, 2014b). Changes in the condition of the hardwood forest resource would be of great concern to all those involved in its management.

Multiple studies using U.S. Department of Agriculture Forest Service Forest Inventory and Analysis (FIA) data have suggested a progressive degradation of the hardwood saw-log resource in Kentucky and Tennessee at a time when overall sawtimber volume was on the rise (Brandeis and others 2015, 2017; Oswalt 2015; Oswalt and King 2014; Oswalt and others 2012). Specifically, from 2001 to 2013, there were statistically significant decreases in the percentage of saw-log volume in tree grade 1 in Kentucky and a decrease in the percentage of tree grade 2 in Tennessee, with erratic, possible increases in tree grade 4 in both States (Brandeis and others 2017).

To further investigate possible changes in the hardwood sawtimber resource over time, this study focused on hardwood sawtimber from partial harvesting from 2006-2014 for Kentucky and 2001-2014 for Tennessee. In this report, an overview of hardwood harvesting in Kentucky and Tennessee is presented with a more focused study of trees removed in partially harvested stands, looking specifically at the frequency of tree harvest by diameter and species. The distribution of hardwood trees harvested for sawtimber by their tree grade, and the probability of being cut and utilized in partially harvested stands, is also examined.

DATA USED AND METHODS APPLIED

Forest Inventory Methods

The FIA program maintains a permanent plot network across the United States, associated territories, and commonwealths that share a consistent sampling design, plot layout, and field data collection procedures. Every 6,000 acres of land on the continental United States has one permanent, systematically located forest inventory and monitoring plot. Each of these plots contains a cluster of four subplots with a total sampled area of one-sixth acre. The forested portion of each plot may be subdivided into different condition classes based on differing reserved status, ownership, forest type, stand size class, regeneration

status, and tree density. More information on this program and detailed documentation on its methods and estimation procedures can be found in Bechtold and Patterson (2005). National and regional variations of field data collection procedures, such as the southern regional field manual (U.S. Department of Agriculture Forest Service 2014), are also available.

Where there is forest within plots, FIA field crews identify and measure all trees with a d.b.h. (diameter at breast height, 4.5 feet) ≥ 5 inches. FIA field crews individually track and remeasure each tree at 5-year intervals in Kentucky and Tennessee. Tree height and d.b.h., along with deductions for defect and cull, are used to estimate net tree volume using volume equations detailed in Oswalt and Conner (2011). Volume of the whole merchantable bole of the tree is estimated for all trees with d.b.h. ≥ 5 inches. [This is the variable VOLCFNET in the publically accessible FIA Database (FIADB), the calculation of which is described in Oswalt and Conner (2011) and Woudenberg and others (2010)].

Tree Grading Procedures

Tree grade describes the quality of the standing live tree. Better grades indicate that greater quantities of clearer lumber can be sawn from the stem. Hardwood tree grade, as used in the FIA program, is defined as the log grade of the 16-foot butt log or the log grade of the best 12-foot section within the 16-foot butt log, whichever is greater. Log grade is based on the specifications for Forest Service standard grades for hardwood factory lumber logs, as described by Rast and others (1973).

FIA field crews note one of five possible tree grades. They judge grading within the lower 16 feet of stem, and the stem section actually graded represents the best 12 feet of log within that zone. Tree grades 1 through 4 are in descending order of quality. A grade 1 tree has a minimum d.b.h. of 16 inches and a larger percentage of clear wood free of defects within the saw-log. Grades 2, 3, and 4 are of smaller minimum d.b.h. or have a lower percentage of clear wood in the saw-log. Grade 5 trees do not meet the requirements for grades 1 through 4 but have a saw-log located somewhere in the tree other than in the butt portion (e.g., upper stem or branch) or have at least two non-contiguous 8-foot logs. Additional detailed rules for tree grading can be found in the FIA southern regional field manual (U.S. Department of Agriculture Forest Service 2014).

Data Queried from the FIA Database

I queried the FIADB in January to March of 2017 to extract data on all hardwood and selected sawtimber-size hardwood trees measured in Kentucky and Tennessee from 2001 to 2014. (Both States were on a 5-year remeasurement cycle during the entire period between 2001 and 2014. Annualized inventory data were available for 1999 and 2000, but due to the limited number of plots sampled in those years, I chose to limit our query of the data.) While the national FIA program is responsible for designing field data collection protocols, providing training, and conducting Quality Assurance/Quality Control (QA/QC) assessments, respective State forestry agencies in Kentucky and Tennessee collect the data. FIA data acquisition and information management personnel confirmed the consistency of forest inventory field manual and database procedures for taking tree measurement used for volume estimation, cull deduction, tree grading, and volume calculation.

I focused on data for trees that had been removed and utilized, that is, cut and taken from the stand to make use of their wood fiber. Trees that were removed as part of land clearing and not utilized or that could not be harvested due to their location on land in a reserved status were not included in this study. I gave further focus to trees that were removed and utilized as part of a harvest operation, defined as a silvicultural treatment that affected at least 1 acre and involved the removal of one or more trees from the stand. Where harvesting occurred, I categorized it according to the southern FIA field data collection manual (U.S. Department of Agriculture Forest Service 2014):

- Clearcut harvest – The removal of the majority of the merchantable trees in a stand; residual stand stocking is less than 50 percent.

- Partial harvest – Removal primarily consisting of highest quality trees. Residual stand stocking consists of lower quality trees because of high-grading or selection harvest (i.e., uneven-aged, group selection, high-grading, species selection).

- Seed tree/shelterwood harvest – Crop trees are harvested leaving seed source trees either in a shelterwood or as seed trees. Also includes the final harvest of the seed trees.

- Commercial thinning – The removal of trees (usually poletimber-sized) from poletimber-sized stands leaving sufficient stocking of growing-stock trees to feature in future stand development. Also included are thinning in sawtimber-sized stands where poletimber-sized (or log-sized) trees have been removed to improve the quality of those trees featured in the final harvest.

- Timber Stand Improvement, or TSI (cut trees only) – The cleaning, release or other stand improvement involving non-commercial cutting applied to an immature stand that leaves sufficient stocking.

- Salvage or sanitation cutting – The harvesting of dead or damaged trees or of trees in danger of being killed by insects, disease, flooding, or other factors in order to save their economic value.

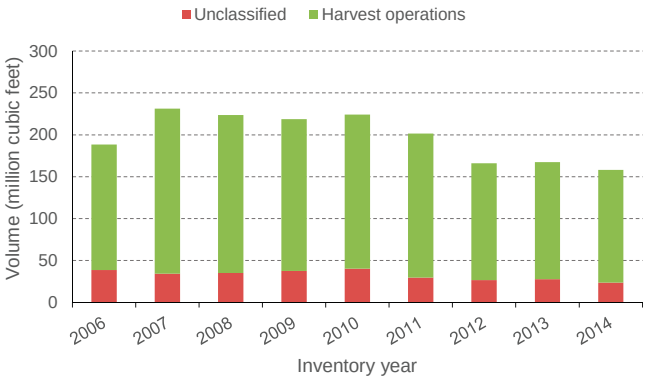
HARVEST TRENDS

Total Harvested Volumes by Harvest Operation Type

Figures 1A (Kentucky) and 1B (Tennessee) show estimates of average annual harvest removals of live hardwood trees (at least 5 inches d.b.h.) by inventory year and whether removals were part of a harvest operation. Each inventory year represents the average of removals that took place on plots during the previous 5 years. For example, harvest removals in inventory year 2006 are trees measured in 2001 (time 1) but found to have been removed when the plot was remeasured in 2006 (time 2). Most of the removed and utilized volume came from areas classified as having harvest operations, but a significant portion (15-20 percent in Kentucky and 11-43 percent in Tennessee) came from stands where the harvesting activity covered < 1 acre or did not meet the requirements for being classified as a harvesting operation. There was a notable decrease in harvested hardwood volumes in Kentucky after 2010 while Tennessee showed a slightly increasing trend over the same time period.

Most hardwood tree volume removed and utilized as part of a harvest operation in Kentucky and Tennessee came from partial harvests, followed by clearcut harvests (figs. 2A and 2B). Commercial thinnings and salvage cuttings account for only a small portion of the harvest removals, and while there were some timber stand improvement removals observed in Kentucky in 2007-2011, the amounts were relatively very small.

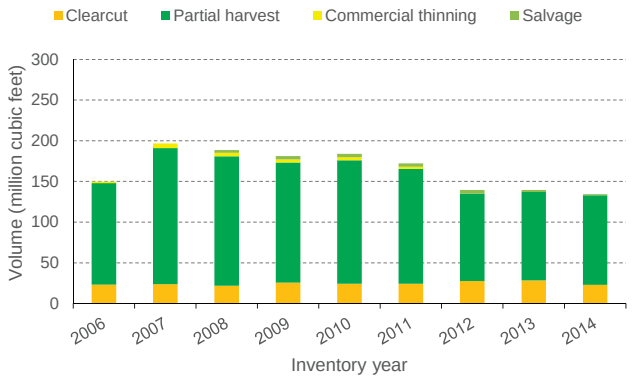
(A)



(B)

Figure 1—Estimate for average annual harvest removals of live hardwood trees (at least 5 inches d.b.h.) in cubic feet of volume, on forest land, by inventory year and whether the removal was classified as a harvest operation or unclassified, (A) Kentucky, 2006-2014, and (B) Tennessee, 2002-2014.

(A)



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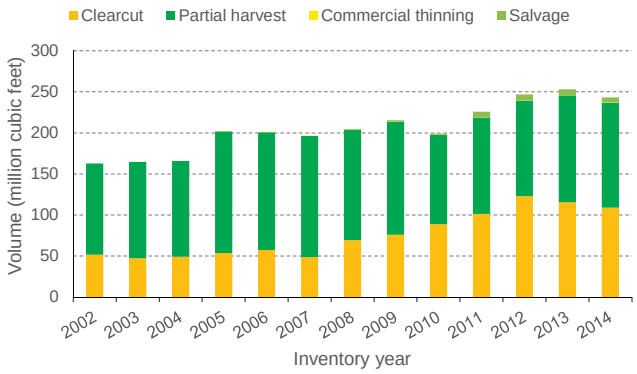


Figure 2—Estimate for average annual harvest removals of live hardwood trees (at least 5 inches d.b.h.) in cubic feet of volume, on forest land, by inventory year and harvest operation type, (A) Kentucky, 2006-2014, and (B) Tennessee, 2002-2014.

Harvest Volumes per Acre

On average over the study period, the percentage of the stand's total volume per acre removed during partial harvests was 47.4 in Kentucky and 44.5 in Tennessee (fig. 3). These percentages represent the volume measured on the plots at time 1 and the volume estimated to have been removed at time 2, then expanded to the per-acre basis. Percent stand volume removals over 100 percent for clearcutting operations reflect that the time 2 volume removed estimates include the growth that occurred on the plot between the two measurement periods. For partially harvested stands, the percentage of volume removed in both States fluctuated annually with no discernible trends (fig. 4).

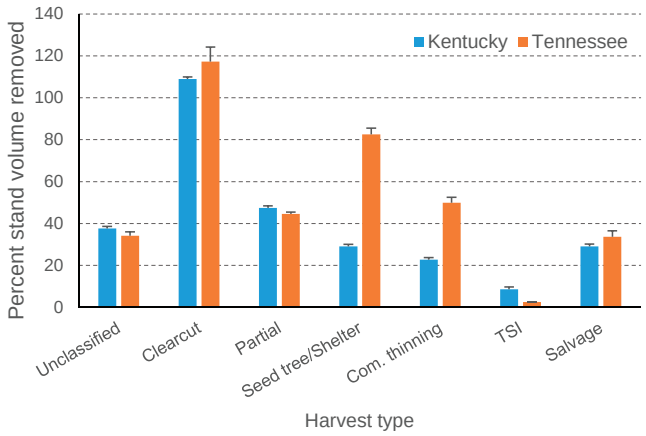


Figure 3—Average percentage of stand volume per acre removed by harvest type in Kentucky, 2006-2014, and Tennessee, 2002-2014, with standard errors of the mean.

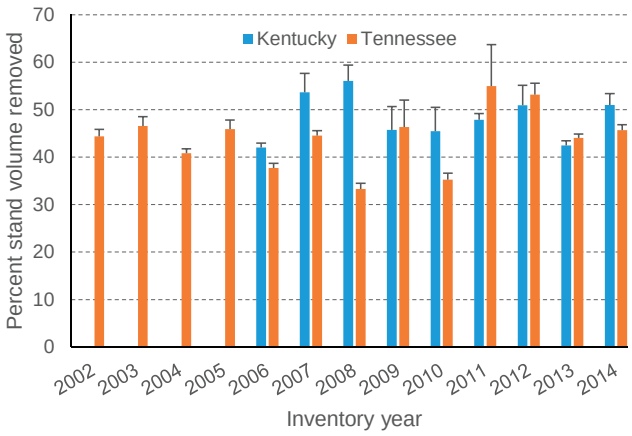
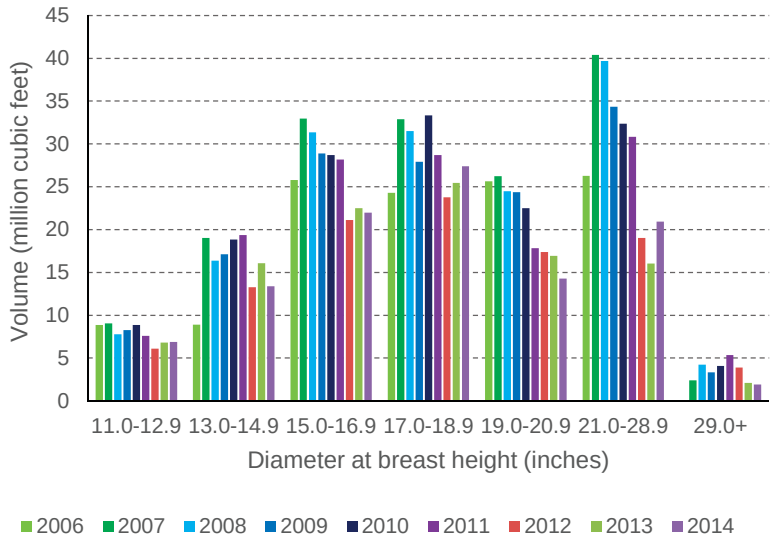


Figure 4—Average percentage of stand volume per acre removed by inventory year in Kentucky, 2006-2014, and Tennessee, 2002-2014, with standard errors of the mean.

Partial Harvest Volumes by Diameter Class

The average annual hardwood harvest removals by d.b.h. class in Kentucky reflect the overall decrease in harvested volume seen in figures 1A and 2A, with each d.b.h. class showing less volume harvested from it over time (fig. 5A). This trend is not seen in Tennessee, where instead I see a decrease in average annual harvested volume in 2009 and 2010, and in some diameter classes in 2011 as well, and then an increase in the subsequent years (fig. 5B). These short-term decreases may reflect the economic downturn of 2007 to 2011 which is only slightly evident in the total harvest estimates shown in figure 1B.

(A)



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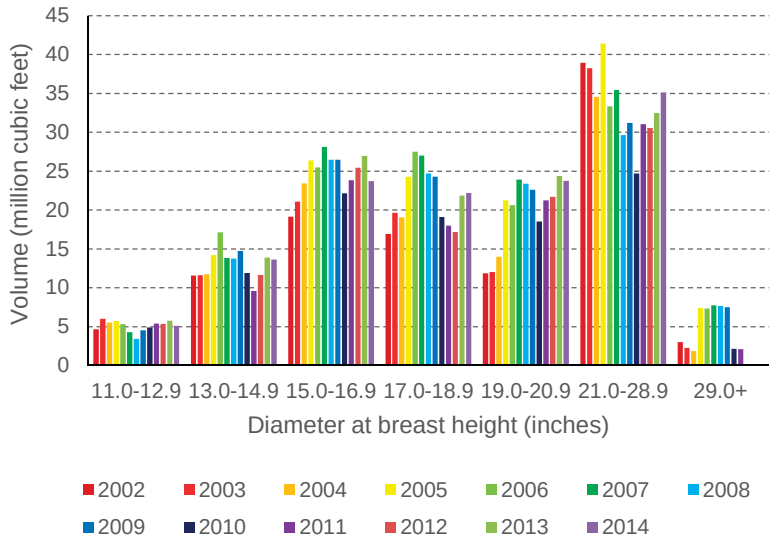


Figure 5—Average annual harvested hardwood volume removals from partial harvesting operations in cubic feet of volume in (A) Kentucky, 2006-2014, and (B) Tennessee, 2002-2014, by diameter class and inventory year.

Partial Harvest Volumes by Species

In both States, the top three species in terms of hardwood volume removed in partial harvest operations in the most current inventory year were white oak, yellow-poplar, and chestnut oak (tables 1 and 2). Both States shared most of the same species in very similar rankings.

Harvest removal volumes from the top six species followed notably different trends in Kentucky and Tennessee (figs. 6A and 6B). White oak and yellow-poplar trees were clearly harvested the most in both States and by the 2012-2014 period, the relative proportions of harvested hardwood volume of these two species were very similar. Prior to those years, however, white oak comprised the greater portion of harvested hardwood volume in Kentucky while yellow-poplar did so in Tennessee, particularly from 2007 to 2011.

HARVEST PROBABILITY BY TREE GRADE

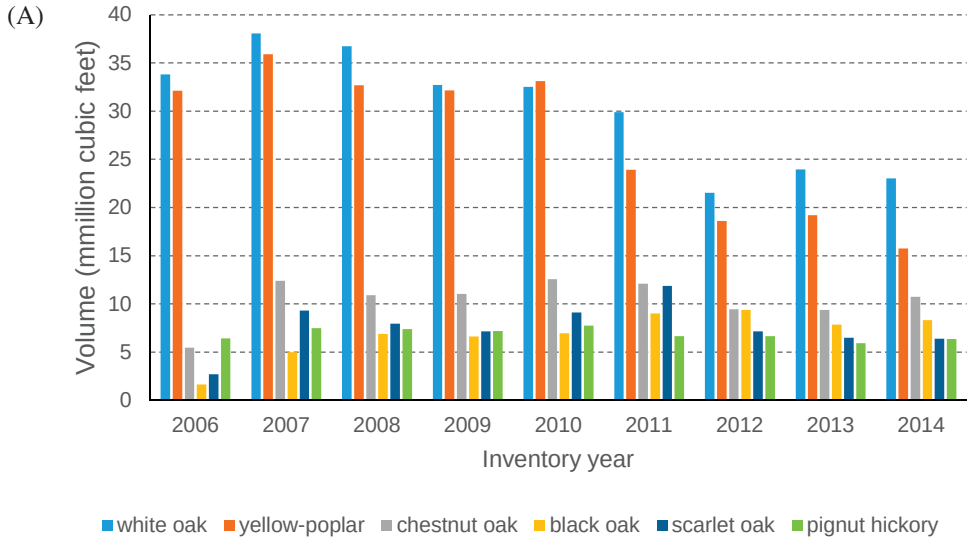
The null hypothesis was that hardwood trees of a lower quality (as expressed by their tree grade) have a higher likelihood of being left uncut in stands where partial harvesting has occurred. To test this hypothesis, I applied logistic regression mixed models with both fixed and random effects to the data from Kentucky and Tennessee. In Kentucky, data from three annualized forest inventory cycles (cycles 5, 6, and 7) spanned the years of 2005 through 2014 (table 3). Tennessee had data from four annualized inventory cycles (cycles 6-9) spanning the years 2000-2014. The total tree count includes all hardwood trees, both harvested and retained, with and without being given a tree grade (e.g., non-merchantable trees with d.b.h. less than 11 inches).

Table 1—Top 20 hardwood species by harvested removal volume (million cubic feet) from partial harvest operations, Kentucky, 2014

Genus	Species	Common name	Removal volume
Quercus	*alba*	White oak	23.03
Liriodendron	*tulipifera*	Yellow-poplar	15.76
Quercus	*prinus*	Chestnut oak	10.75
Quercus	*velutina*	Black oak	8.32
Quercus	*coccinea*	Scarlet oak	6.38
Carya	*glabra*	Pignut hickory	6.36
Acer	*rubrum*	Red maple	5.63
Quercus	*rubra*	Northern red oak	5.39
Acer	*saccharum*	Sugar maple	4.77
Carya	*alba*	Mockernut hickory	3.47
Quercus	*muehlenbergii*	Chinkapin oak	2.68
Fraxinus	*pennsylvanica*	Green ash	2.03
Quercus	*palustris*	Pin oak	1.97
Fagus	*grandifolia*	American beech	1.72
Quercus	*falcata*	Southern red oak	1.13
Juglans	*nigra*	Black walnut	1.05
Quercus	*shumardii*	Shumard oak	0.89
Celtis	*occidentalis*	Hackberry	0.75
Fraxinus	*americana*	White ash	0.74
Carya	*laciniosa*	Shellbark hickory	0.69
All other spp.	—	—	6.63
Total			110.14

Table 2—Top 20 hardwood species by harvested removal volume (million cubic feet) from partial harvest operations, Tennessee, 2014

Genus	Species	Common name	Removal volume
Quercus	*alba*	White oak	22.24
Liriodendron	*tulipifera*	Yellow-poplar	19.62
Quercus	*prinus*	Chestnut oak	9.62
Quercus	*rubra*	Northern red oak	9.27
Quercus	*coccinea*	Scarlet oak	8.96
Quercus	*velutina*	Black oak	8.39
Carya	*glabra*	Pignut hickory	6.05
Liquidambar	*styraciflua*	Sweetgum	4.88
Fraxinus	*pennsylvanica*	Green ash	4.20
Carya	*ovata*	Shagbark hickory	4.10
Quercus	*falcata*	Southern red oak	3.37
Fagus	*grandifolia*	American beech	2.96
Carya	*alba*	Mockernut hickory	2.94
Fraxinus	*americana*	White ash	2.87
Acer	*rubrum*	Red maple	2.53
Acer	*saccharum*	Sugar maple	2.17
Tilia	*americana*	American basswood	1.96
Quercus	*pagoda*	Cherrybark oak	1.88
Quercus	*muehlenbergii*	Chinkapin oak	1.79
Carya	*cordiformis*	Bitternut hickory	1.53
All other spp.	—	-—	6.29
Total			127.62



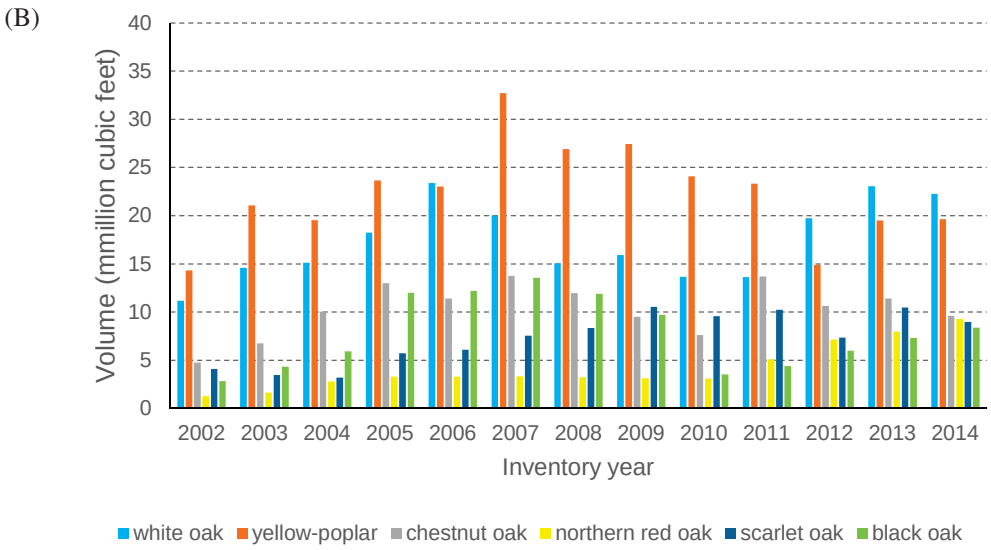


Figure 6—Average annual hardwood harvest volume removals for the top six species in cubic feet of volume in (A) Kentucky, 2006-2014, and (B) Tennessee, 2002-2014.

Table 3—Number of partially harvested conditions, total number of trees in those conditions, total number of graded trees, number of graded trees that were retained and number of graded trees that were harvested in Kentucky (2005–14) and Tennessee (2000–14)

		Numbers of trees			
State	Number of partially harvested conditions	Total all trees	Total graded	Retained	Harvested
Kentucky	1,275	7,246	1,839	1,071	768
Tennessee	2,322	17,891	2,642	1,535	1,107

Harvest removal volumes from the top six species followed notably different trends in Kentucky and Tennessee (figs. 6A and 6B). White oak and yellow-poplar trees were clearly harvested the most in both states and by the 2012-2014 period, the relative proportions of harvested hardwood volume of these two species were very similar. Prior to those years, however, white oak comprised the greater portion of harvested hardwood volume in Kentucky while yellow-poplar did so in Tennessee, particularly from 2007 to 2011.

HARVEST PROBABILITY BY TREE GRADE

The null hypothesis was that hardwood trees of a lower quality (as expressed by their tree grade) have a higher likelihood of being left uncut in stands where partial harvesting has occurred. To test this hypothesis, I applied logistic regression mixed models with both fixed and random effects to the data from Kentucky and Tennessee. In Kentucky, data from three annualized forest inventory cycles (cycles 5, 6, and 7) spanned the years of 2005 through 2014 (table 3). Tennessee had data from four annualized inventory cycles (cycles 6-9) spanning the years 2000-2014. The total tree count includes all hardwood trees, both harvested and retained, with and without being given a tree grade (e.g., non-merchantable trees with d.b.h. less than 11 inches).

For the logistic regression, I created binary variables for whether the tree was harvested or not, and whether it was one of the five possible tree grades prior to harvest on all trees that were cut and utilized. I performed logistic regressions in the Statistical Analysis System (SAS® ver. 9.3) using the GLIMMIX procedure, specifying that the response variable had a binary distribution (harvested or retained) and the link function was logit (SAS Institute Inc. 2011). I treated condition as a random effect to account for the clustering of harvested trees within harvested conditions and therefore specified their lack of independence and the intercepts as random effects with a normal distribution due to the large numbers of conditions (Dai and others 2006).

$$logit(\pi_{ij}) = \alpha + u_j + \beta x_{ij} \qquad (1)$$

Where π is the probability of a tree i being retained on a partially harvested condition j; with condition effects measured by random intercepts α, conditional on tree grade x. This regression model has coefficients for both fixed (β) and random (u_j) effects (Dai and others 2006).

The resulting odds ratio represents the probability of a tree being retained on the partially harvested condition relative to that of the reference level tree being retained. For this analysis, I used tree grade 1 as the reference level. The model intercept is the log of the odds of a tree with the reference level grade not being harvested, and the odds ratios are the exponents of each tree grade's estimate. I combined analyses for all species. Exploration of the data by individual species did not show trends that differed appreciably from those for all species.

The interpretation of these results is as follows: in Kentucky in partially harvested stands from 2005 to 2014, a tree grade 2 tree was 2.01 times as likely to be left as a tree grade 1 tree, within a 95 percent confidence interval (CI) of 1.27 to 3.18 times. A tree grade 3 tree was 6.42 times as likely to be left as a tree grade 1 tree, within a 95 percent CI of 4.17 to 9.89. A tree grade 4 tree was 5.32 times as likely to be left, and a grade 5 tree was 6.80 times as likely to be left as a grade 1 tree. The Tennessee data showed very similar results as the Kentucky data. Trees were increasingly likely to be left in partially harvested stands as their tree grade decreased in quality, regardless of the tree species.

CONCLUSIONS

Partial harvesting is the predominant but not exclusive cutting treatment applied to the hardwood forests of Kentucky and Tennessee, and its use across both States remained mostly stable across the study period. Overall, hardwood harvest in Kentucky showed a slight downward trend from 2006 to 2014, with most of the volume harvested in partial logging operations. Tennessee did not show this same downward trend, however, and the amount of hardwood volume harvested from 2002 to 2014 remained relatively steady with the exception of slight decreases in some (but not all) years during the period of the economic downturn (generally recognized as 2007 to 2011). In Tennessee, the proportion of harvested volume removed and utilized that did not come from plots that FIA cruisers described as having a commercial harvest operation was notable, reaching a high of 43.3 percent in 2002. This seems to indicate the presence of numerous, smaller-scale (< 1 acre in extent) instances of tree harvesting or that FIA should categorize more of these harvests as harvest operations. Tennessee also had higher percentages of the total harvest from clearcut logging operations than did Kentucky. Other harvest operations noted by FIA in the Southern United States, including commercial thinnings, salvage cuttings, and timber stand improvements, accounted for only a small portion of the harvest removals in both States.

In these partial harvests, less than half of the stands' volume was removed. The distribution of diameters of trees being harvested appears to have remained unchanged and

tracks the statewide total volume removed estimates. Total volumes removed decreased in equal proportions across all diameter classes in Kentucky and increased in recent years in Tennessee. The tree species being cut and utilized were those typically considered commercially valuable species, in particular white oak, yellow-poplar, and chestnut oak.

Trees were increasingly likely to be left in partially harvested stands as their tree grade decreased in quality, regardless of the tree species. Tree grade 1 trees, the highest quality, were the most likely to be harvested. The FIA data show that the lower-graded trees are much more likely (6-7 times as likely for a tree grade 5 tree) to be left in the stand after partial harvesting. This reinforces the observations made in Brandeis and others (2017) and other studies that the relative proportion of sawlog volume in higher-grade trees has shown some declines overall in these States and indicates an increase in the proportion of sawlog volume in lower-graded trees.

The hope is that this study will spur further investigation into hardwood sawlog quality trends in Kentucky and Tennessee and careful consideration of the drivers behind them. Decisionmakers will need clear, scientifically based and statistically robust information upon which to base their management decisions. High-quality hardwood lumber is a valuable resource for rural communities across the Central Hardwoods region, one worthy of careful tending and management.

ACKNOWLEDGMENTS

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White oak (*Quercus alba*) lumber is in high demand for the making of many wood products such as barrel staves being sawn at this mill.

Brandeis, Thomas J. 2017. Partial harvesting of hardwood sawtimber in Kentucky and Tennessee, 2002–2014. e-Gen. Tech. Rep. SRS–227. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 10 p.

Partial harvesting is the predominant but not exclusive cutting treatment applied to the hardwood forests of Kentucky and Tennessee. Hardwood harvest in Kentucky showed a slight downward trend from 2006 to 2014, with most of the volume harvested in partial logging operations. Tennessee did not show this same downward trend, and the amount of hardwood volume harvested from 2002 to 2014 remained relatively steady with the exception of slight decreases during the economic downturn of 2007 to 2009. In these partial harvests, less than half of the stands' volume was removed. The tree species being cut and utilized were those typically considered commercially valuable species, in particular white oak (*Quercus alba*), yellow-poplar (*Liriodendron tulipifera*), and chestnut oak (*Quercus montana*). Trees were increasingly likely to be left in partially harvested stands as their tree grade decreased in quality, regardless of the tree species. Tree grade 1 trees, the highest quality, were the most likely to be harvested. U.S. Department of Agriculture Forest Service Forest Inventory and Analysis (FIA) data show that the lower-graded trees are much more likely (6-7 times as likely for a tree grade 5 tree) to be left in the stand after partial harvesting. This reinforces previously published observations that the relative proportion of sawlog volume in higher-grade trees has shown some declines overall in these States, indicating an increase in the proportion of sawlog volume that is in lower-graded trees. The hope is that this study will spur further investigation into hardwood sawlog quality trends in Kentucky and Tennessee and careful consideration of the drivers behind them.

Keywords: Central Hardwoods region, forest inventory, harvesting, logistic regression, tree grade.

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