



Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Southern Research Station | Resource Bulletin SRS-246 | September 2025

Kentucky's Forests, 2019



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Cover photo: Fog settles in the valleys at the Red River Gorge in Kentucky.

Following page photo: Sky bridge arch in the Red River Gorge, Kentucky.

All photos USDA Forest Service photo by Belinda Esham.

September 2025

<https://doi.org/10.2737/SRS-RB-246>



Forest Service
Research & Development
Southern Research Station
Resource Bulletin SRS-246



Southern Research Station
200 W.T. Weaver Blvd.
Asheville, NC 28804

Kentucky's Forests, 2019

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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. To provide more frequent and nationally consistent information on America's forest resources, all 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) (AREERA 1998).

The primary objective in conducting these inventories is to gather the multiresource 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 are used to provide an overview of forest resources that may include, but is not limited to, forest area, forest ownership, forest type, stand structure, timber volume, growth, removals, mortality, management activity, down woody material, carbon storage and sequestration, 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 information about Forest Service resource inventories is available in *Forest Resource Inventories: An Overview* (USDA Forest Service 1992). 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 are designed to provide an array of forest resource estimates, but additional tables can be obtained at the FIA DataMart 2.1.0 home page (USDA Forest Service 2025).

Additional information about any aspect of this or other FIA surveys may be obtained from:

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Southern Research Station
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ACKNOWLEDGMENTS

The SRS gratefully acknowledges the continued productive partnership with the Kentucky Division of Forestry (KDF) of the Kentucky Energy and Environment Cabinet. This partnership extends from field data collection, data review, through to review of the final published results in documents such as this one. We thank Billy Thomas, Cooperative Extension Service, University of Kentucky and Dr. Christopher Oswalt, SRS FIA for their review of the manuscript. We also thank James Brown of SRS FIA Data Acquisition for editing the data, Andres Baeza-Castro of SRS FIA Information Management for data review and processing, and the SRS technical publications team for technical edit, layout, and overall production of this report.

The following KDF and SRS FIA field personnel made field measurements or checked the quality of the data collected for this most recent survey. SRS FIA appreciates their hard work and their consistent efforts to obtain high-quality data.

Kentucky Division of Forestry

Haley Frazier
Kelsey Phillips
Steve Rogers
Tammy Rogers
John Yri

SRS FIA

Brian Allen
Shannon Anderson
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Adam Barnard
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Luke Goode
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Matthew Hinds
Sean Howard
Haley Loyd
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Suzy Sanders
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Nick Valentine
Mitch Vaughan
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A rainbow in the mist at Cumberland Falls State Park, Kentucky.

HIGHLIGHTS

- In 2019 Kentucky's forest land totaled 12.4 million acres, 98 percent of which is available for timber production. Across the State, forest land area has been stable at or near 50 percent (44–49 percent) of the land base for as long as FIA has been keeping records nearly 60 years.
- Based on a remeasurement of Kentucky's plots (measured at both time 1 and time 2), 207,500 acres of forest land were diverted to agricultural land use in 2019, while 231,000 acres of forest land were diverted to urban or developed land use.
- Forest land in Kentucky is owned primarily by nonindustrial private landowners, which comprise 87 percent of the area. Forest industry land only comprises 1 percent of forest land in the State.
- Kentucky is known as a “hardwood State” as 96 percent of all forest land within the State is occupied by hardwood forest type groups.
- In 2019, the majority of stands (73 percent) were in the large diameter size class. The area of forest land classified as large diameter has been increasing in recent years. In 2004, an estimated 65 percent of all forest land in Kentucky was in large diameter stands.
- There were 106 individual tree species identified in the 2019 inventory of Kentucky forests. A total population of 7.4 billion trees (d.b.h. ≥ 1 inch) are estimated to be living and growing in forests of the State.
- Red maple (*Acer rubrum*) is by far the most common hardwood species and eastern red cedar (*Juniperus virginiana*) was the most commonly encountered softwood species in 2019.
- The trees with d.b.h. ≥ 5 inches hold over 27.6 billion cubic feet (bcf) of volume. While red maple has the greatest number of trees (12 percent of all trees), they only account for 4.5 percent of total wood volume in Kentucky's forests. There were greater volumes of wood in yellow poplar (*Liriodendron tulipifera*) (9.7 percent of total volume), white oak (*Quercus alba*) (7.7 percent of total volume), and chestnut oak (*Quercus montana*) (4.7 percent of total volume).
- In an ownership pattern common across the Southern United States, the majority of the wood volume (87 percent) is owned by nonindustrial private landowners.
- Based on estimates of net change (gross growth—mortality—removals) from remeasured plots, total volume increased each year (on average) over 358 million cubic feet of sound volume between 2016 and 2019.
- In 2019, 91 percent of the total net annualized growth of 586 million cubic feet per year was on hardwood trees and 9 percent on softwoods.
- While harvest removals have declined slightly over time, harvest removals in 2019 accounted for about 235 million cubic feet of volume.
- While stable recently (last 3–5 years), average annual mortality has experienced a slight increase over the time period between 2009 and 2019 with a current rate of 281 million cubic feet per year.
- There is an average of 10 standing dead trees ≥ 5 inches d.b.h. per acre of forest land in Kentucky with slightly higher numbers on public land versus private land. There are approximately 137 million standing dead trees statewide.
- Invasive plant presence/absence was monitored on 2,438 forested plots in Kentucky. At least one nonnative invasive plant was observed on 81.1 percent of the plots. In 2019, the highest concentrations of monitored forest invasives was in the Bluegrass survey unit. The most common forest invasive plant monitored by FIA was Japanese honeysuckle (*Lonicera japonica*) impacting over 760,000 acres of forest land across the State.

INTRODUCTION

This resource bulletin consolidates data from the eighth complete survey of Kentucky's forest resources conducted during the period 2014–2019 by the U.S. Department of Agriculture (USDA) Forest Service, Forest Inventory and Analysis (FIA) program in cooperation with the Kentucky Division of Forestry (KDF) of the Kentucky Energy and Environment Cabinet. Data on the extent, condition, and classification of forest land and associated timber volumes, as well as growth, removals, and mortality rates, are described and interpreted. Data on forest health and forest landowner characteristics are also evaluated. Estimates of forest resources are reported at multiple scales. The two most common scales discussed in this report are State and unit. The State of Kentucky is divided into seven FIA units that approximate broad physiographic sections of the State delimited by political boundaries. The seven FIA units are (1) Eastern, (2) Northern Cumberland, (3) Southern Cumberland, (4) Bluegrass, (5) Pennyroyal, (6) Western Coalfield, and (7) Western (fig. 1).

In 1999, the Southern Research Station (SRS) FIA program and the KDF began implementing the new annual survey strategy in Kentucky. The strategy involves rotating measurements of five systematic samples (or panels), each of which represents about 20 percent of all plots in the State. A panel generally takes 1 year to

complete and covers only one growing season. For Kentucky, data collection for all five panels was completed in 5–7 years. This analysis focuses primarily on changes and trends in recent years and their implications for Kentucky's forests, forest landowners, and citizens (see the appendix 1—Inventory Methods section for further information on data collection methodology). The inventory dates of 2019, 2014, 2009, and 2004 are repeated throughout this report. The inventory year of 2019 represents data that were collected from 2014 to 2019. The inventory year of 2014 represents data that were collected from 2009 to 2014. The inventory year of 2009 represents data that were collected from 2005 to 2009. The inventory year of 2004 represents data that were collected from 2000 to 2004. Estimates of components of change (i.e., growth, removals, and mortality) are calculated based on plot measurements collected at two points in time. For example, estimates of change for the period between 2014 and 2019 are calculated using plots collected from 2009 to 2014 as compared to the same plots being remeasured from 2014 to 2019. The 2019 inventory accounted for a total of 4,288 plots. Of those, 2,438 were forested across the State. There were 309, 331, 399, 405, 458, 388, and 148 forested plots measured in the Eastern, Northern Cumberland, Southern Cumberland, Bluegrass, Pennyroyal, Western Coalfield, and Western units, respectively, excluding national forests. A total of 2,413 plots measured for the

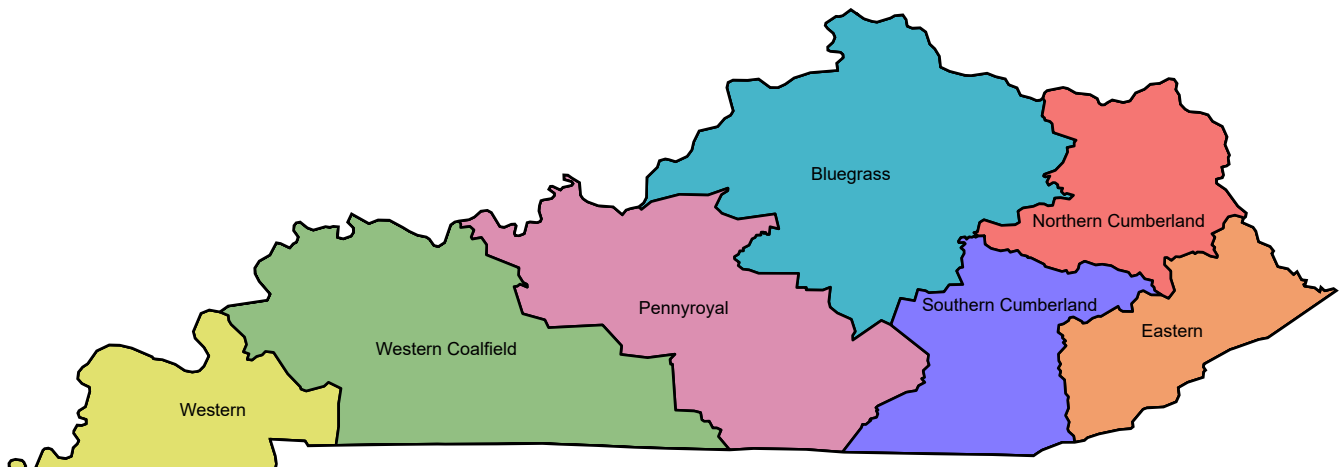


Figure 1—Forest Inventory and Analysis survey unit boundaries, Kentucky.



Breathtaking view from the Breaks Interstate Park in eastern Kentucky.

2014 inventory were remeasured during the 2019 inventory. The remeasured plots were used to calculate estimates of growth, removals, and mortality, commonly referred to as GRM. Note: These data were accessed and compiled from the FIA database (FIADB) in March, April, May, and June of 2019. Publicly available data from the FIADB are regularly updated when data collection and/or processing anomalies are found and corrected. Additionally, new data are added on a regular basis which may be reflected by small changes in the past or current estimates.

History of Kentucky's Forest Inventory

Seven previous inventories have been completed in Kentucky. The inventories of 1949, 1963, 1975, 1988, 2004, 2009, and 2014 (Alerich 1990, Barnard and Bowers 1977, Gansner 1968, Oswalt et al. 2022, Turner et al. 2008, USDA CSFES 1952) provide statistics for measuring changes and trends over the past 60 years. Traditionally, FIA reporting of forest resource statistics has been oriented toward sustaining timber resources to meet the

demand for forest products. Over time, the idea of “sustainability” has evolved from a concept driven by commodity production to one that is defined by a diversity of values including timber resources, wildlife habitat, species richness, and cultural benefits, among others. The USDA Forest Service FIA program has evolved alongside the broader concept of sustainability. The FIA program now reports on a diverse set of variables and attempts to help answer numerous questions about the forest resources of each State, including Kentucky.

Updates of Past Estimates

Currently, the FIA program is using version 1.9.3.00 of the National Information Management System (NIMS) to meet national FIA program standards in processing data. The 2014 Kentucky forest resources report was based on data processed through version 8.1 of the FIA NIMS system. The 2004 Kentucky forest resources report (Turner et al. 2008) was based on data processed through version 2.2 of the FIA NIMS and the 2009 report was based on data processed through version 4.0 of the FIA NIMS. Changes

in NIMS versions can include programmatic changes that at times alter standard definitions and/or estimate derivation. For example, some forest types may have been retired or consolidated, while others might include changes to component tree species lists. To ensure the most valid comparisons possible across annual inventories, all data collected on the annual design (Bechtold and Patterson 2005) are reprocessed through a newer version of the FIA NIMS when significant changes are made. The data and estimates available to the public and the estimates presented in this report can reflect that reprocessing; therefore, some historical estimates may not match previously published reports. Estimates published in this report supersede estimates for the same period published in previous reports. The SRS FIA program has made available some historic data in electronic form in the FIADB (version 9.3.00). Historic data were converted to the current format of the FIADB. For Kentucky, electronic data are now available for all inventories from 1988 to 2021. Common comparisons in this report are made for the period between 2004 and 2019 for many forest land attributes and for the period between 1988 and 2016 for many timberland attributes.

AREA

Trends in Forest Land

Kentucky occupies about 25.8 million acres in the Southern United States, with the Mississippi River delineating its western border, the Ohio River delineating its northern border, and the Appalachian Mountains in the east (fig. 2). Forest land totals 12.4 million acres, 98 percent of which is available for timber production (table 1). Across the State, forest land area has been stable at or near 50 percent (44–49 percent) of the land base for as long as FIA has been keeping records, 60 years (table 2). The only notable change in forest land has occurred in the Western and Western Coalfield units (fig. 3) where a 12 percent and 5.5-percent increase respectively have occurred between 2004 to 2019.

The FIA program records land use on both nonforest and forest plots (see the Forest Inventory and Analysis national core field guides for details on land use categories and how they are delineated on FIA plots) (USDA Forest Service 2012, 2014). We are then able to create a matrix of land-use change using the remeasured plots that are also used to calculate tree level growth,

Forest Area

(percent)

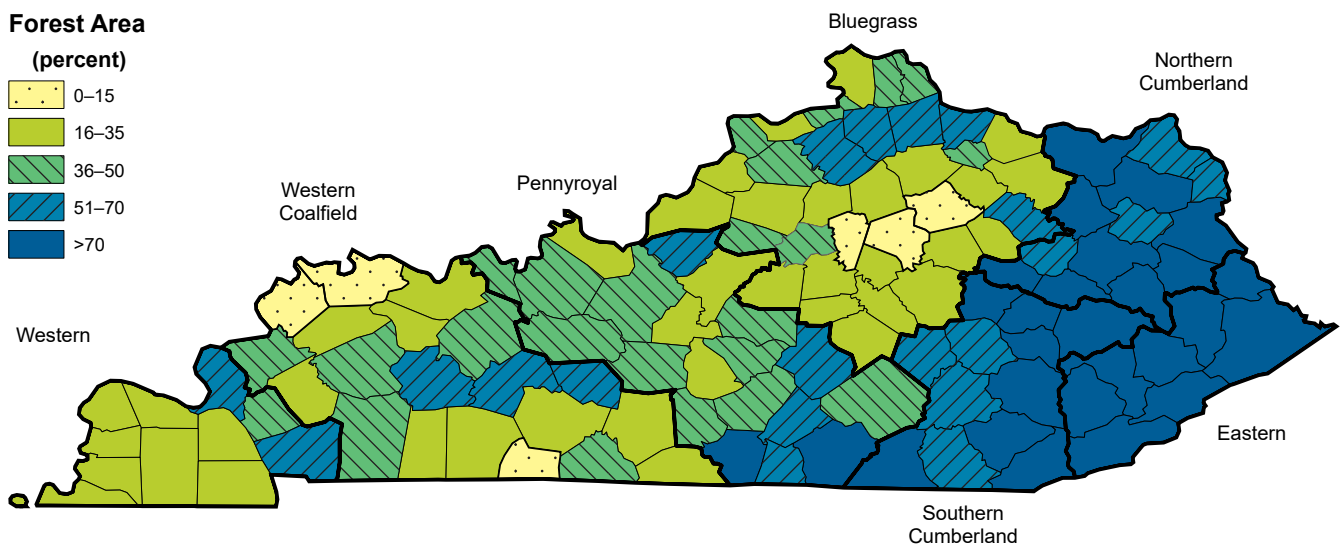
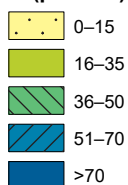


Figure 2—Forest land area as a percentage of total land area for counties, Kentucky, 2019.

Table 1—Area by survey unit and land status, Kentucky 2019

Unit	Total area	All forest	Unreserved			Reserved			Nonforest land	Census water
			Total	Timberland	Unproductive	Total	Productive	Unproductive		
thousand acres										
Eastern	2,134.6	1,755.4	1,747.1	1,747.1	0.0	8.3	8.3	0.0	373.3	6.0
Northern Cumberland	2,513.6	1,876.5	1,851.0	1,851.0	0.0	25.6	25.6	0.0	598.3	38.9
Southern Cumberland	2,785.3	2,142.1	2,097.1	2,097.1	0.0	44.9	44.9	0.0	627.6	15.6
Bluegrass	5,697.6	1,772.8	1,762.0	1,762.0	0.0	10.7	10.7	0.0	3,801.5	123.3
Pennyroyal	4,904.8	2,248.4	2,213.6	2,207.8	5.8	34.8	34.8	0.0	2,566.1	90.3
Western Coalfield	5,512.3	1,811.7	1,759.8	1,759.8	0.0	51.9	51.9	0.0	3,659.3	41.3
Western	2,311.9	783.5	763.9	763.9	0.0	19.6	19.6	0.0	1,387.7	140.6
All survey units	25,860.1	12,390.3	12,194.6	12,188.7	5.8	195.8	195.8	0.0	13,013.8	456.0

Numbers in rows and columns may not sum to totals due to rounding.

0.0 = no sample for the cell or value of >0.0 but <0.5.

removals, and mortality [see Scott et al. (2005) for the methods used to calculate these components of change]. Forest and nonforest conditions on forested plots are categorized by land use which allows us to apply that condition's expansion factor to the land use and estimate area change.

While very little overall change in the total area of forest has occurred, changes are occurring. Forests are dynamic and transitions to and from other land uses are common. Most changes in

Table 2—Forest land area and percent forest land for forest surveys, Kentucky, 1959–2019

Year	Forest land area	Percent ¹
	<i>thousand acres</i>	
1959	11,497.00	44.5
1963	11,700.00	45.2
1975	11,900.00	46.0
1988	12,674.75	49.0
2004	12,283.43	47.5
2009	12,400.65	47.9
2014	12,442.48	48.0
2019	12,390.32	47.9

¹ Based on current U.S. Census Bureau estimate of 25.9 million acres of land in Kentucky.



View of Pine Mountain from the Combs Overlook in Jenkins, Kentucky.

forest land in the State can be attributed to both agriculture and development (fig. 4). Based on a remeasurement of Kentucky's plots (measured at both time 1 and time 2), 207,500 acres of forest land were diverted to agricultural land use, while 231,000 acres of forest land were diverted to urban or developed land use (table 3). Once forest land has been converted to developed land, studies suggest that it is unlikely to ever return to

a forested condition. In contrast, agricultural land does revert to forest land if economic conditions change. A total of 438,400 acres were recorded as diversions for the 2019 inventory and a total of 327,800 acres reverted back to forests. The largest diversions to agriculture occurred in the Bluegrass survey unit (table 3). Overall, the Bluegrass survey unit experienced the largest negative change.

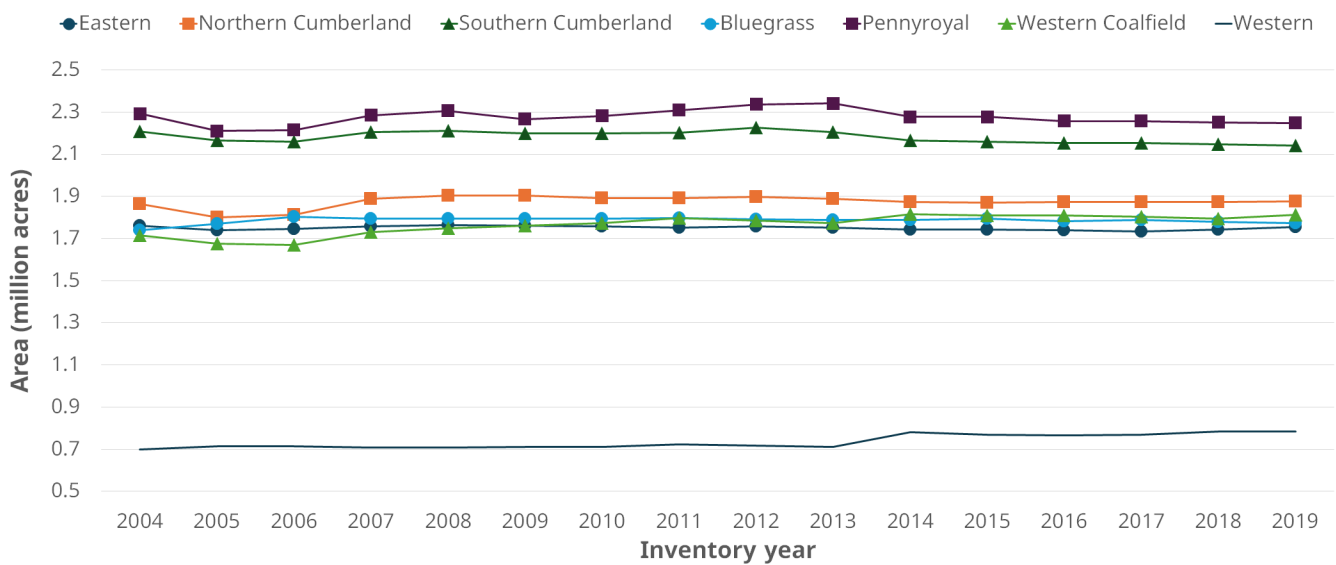


Figure 3—Forest land area by survey unit, Kentucky 2004–2019.

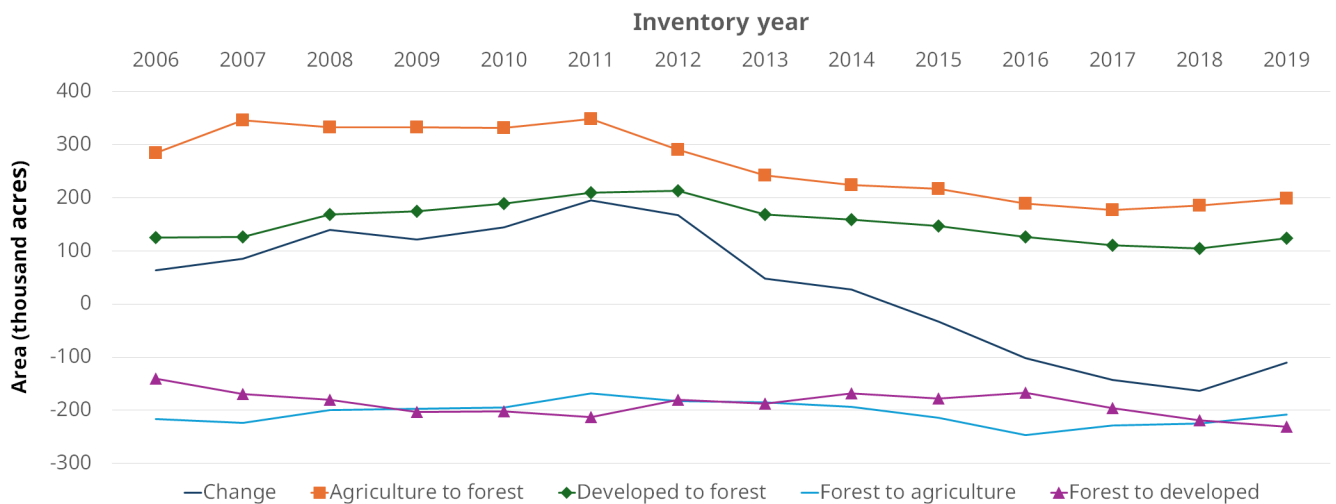


Figure 4—Forest reversions and diversions and net change for forest land in Kentucky 2006–2019.

Table 3—Changes in forest land by survey unit, Kentucky 2019

Survey unit	Change ¹	Additions			Diversions		
		Total additions	Agriculture ²	Developed ³	Total diversions	Agriculture ²	Developed ³
		thousand acres					
Eastern	-0.9	52.1	1.7	50.5	-53.1	-7.6	-45.5
Northern Cumberland	-1.5	32.2	22.0	10.2	-33.6	-15.3	-18.3
Southern Cumberland	-40.8	17.9	6.9	11.0	-58.7	-12.5	-46.2
Bluegrass	-21.4	67.1	53.8	13.3	-88.5	-55.1	-33.4
Pennyroyal	-28.7	52.7	42.2	10.5	-81.3	-47.0	-34.4
Western Coalfield	-14.5	66.1	40.7	25.4	-80.6	-54.4	-26.2
Western	-2.9	39.7	31.5	8.2	-42.6	-15.6	-27.0
All survey units	-110.7	327.8	198.8	129.1	-438.4	-207.5	-231.0

Numbers in rows and columns may not sum to totals due to rounding.

¹ Change is the difference between diversions (a loss) and additions (a gain) of forest land.

² Agriculture includes cropland, pasture, idle farmland, orchards, Christmas tree plantations, maintained wildlife openings, and rangeland.

³ Developed includes business; manufacturing; residential; rights-of-way (roads, railways, power/oil/gas lines, and canals); recreation areas (parks, skiing, golf courses, etc.); mining; and water.

Ownership

Forest land in Kentucky that is owned by nonindustrial private landowners comprises 87 percent of the area (table 4). Forest industry land comprises only 1 percent of forest land in the State. Forest land stewarded by the Forest Service in the State comprises 779,600 acres. Forest land in private ownership percentage is highest in the Bluegrass survey unit (95 percent) while lowest in the Western (76 percent) survey unit. Forest Service and other federally managed forest land is highest in the Southern Cumberland survey unit. The survey unit with the most acreage in private ownership is Pennyroyal (fig. 5).

Forest Types and Stand Size

Even though Kentucky is known as a “hardwood State” as 96 percent of all forest land within the State is occupied by hardwood forest-type groups (table 4), there are many other forest types that occupy the remaining 4 percent. Forest type groups in which oaks predominate are the most common across the State, with the oak-hickory comprising 76.0 percent of the forest. Loblolly-shortleaf pine, a forest-type group very common across the South, covers only 1.5 percent of

all forests and combined with other eastern softwoods (1.7 percent) and white-red-jack pine groups (0.4 percent), softwood forest-type groups represent only 3.6 percent of forests across the State.

Armed with the knowledge about stand size, resource managers can better understand the structure of the forested stands and the habitat that exist on the landscape. In addition, trend analysis of stand size (a classification based on stocking and the diameter of the majority of live trees in a stand) facilitates an understanding of the successional status and potential future development of the forest and the populations of its inhabitants.

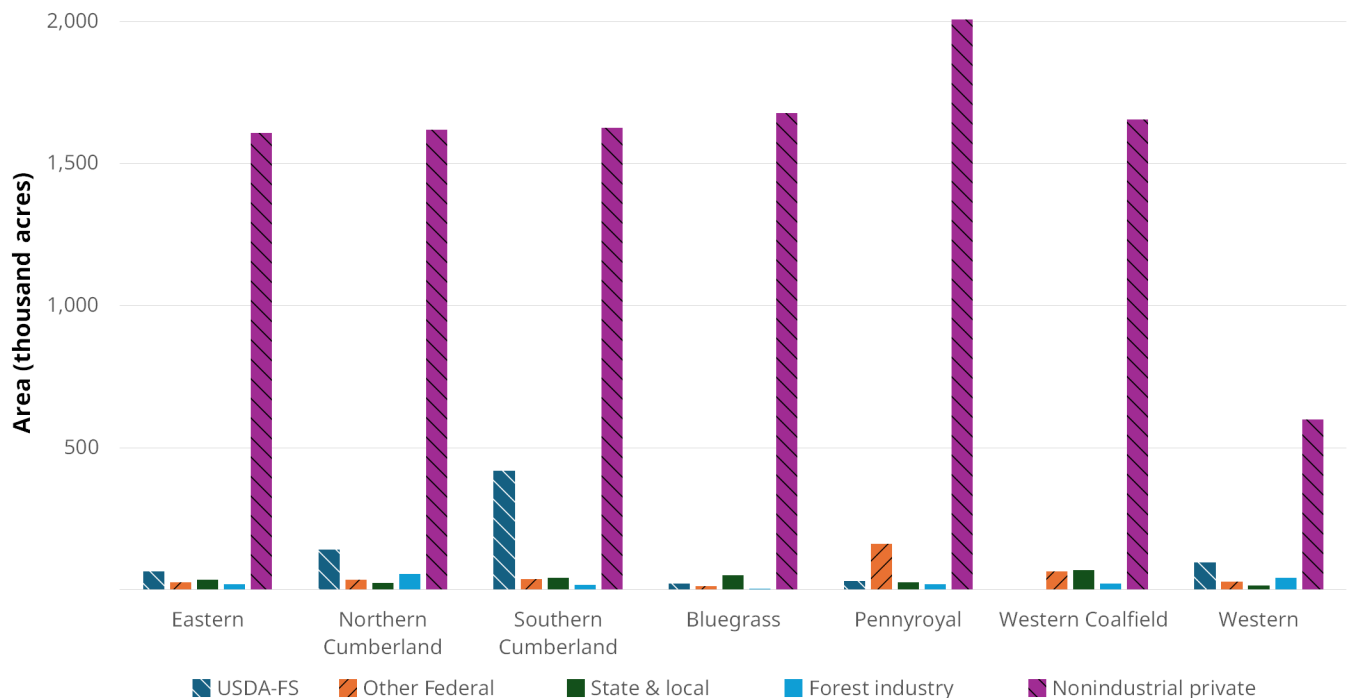
The stand-size classes utilized by FIA are small, medium, and large diameter (formerly sapling-seedling, poletimber, and sawtimber, respectively), as well as nonstocked. Small diameter stands are forested areas where the majority of the trees are <5.0 inches diameter at breast height (d.b.h.). Medium diameter stands are at least 5.0 inches d.b.h. but are not large enough to be considered large diameter. To be large diameter size, a softwood species must be

KENTUCKY'S FORESTS, 2019

Table 4—Area of forest land by forest-type and ownership group, Kentucky 2019

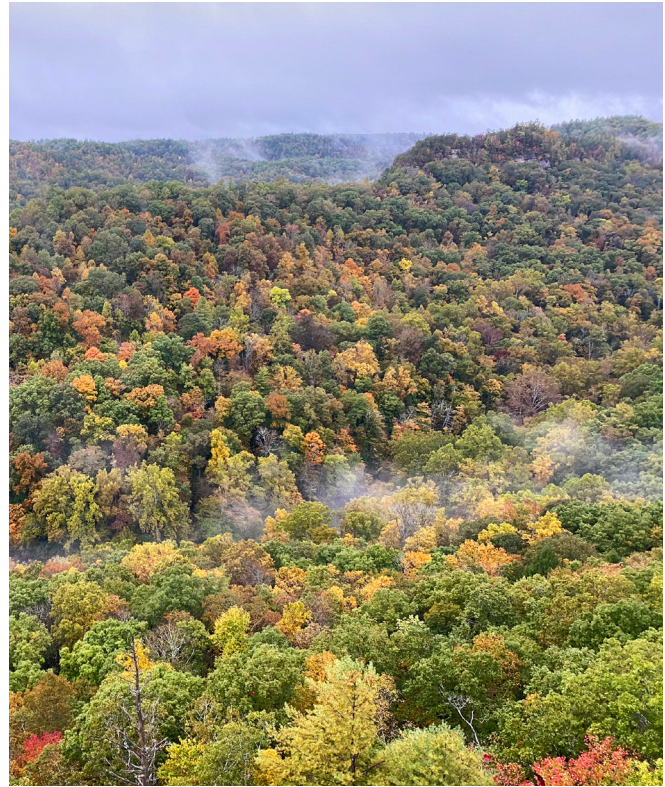
Forest-type group		All ownerships	Ownership group				
			USDA Forest Service	Other Federal	State and local	Forest industry	Nonindustrial private
thousand acres							
Softwood types	White-red-jack pine	52.9	10.6	3.3	0.0	0.0	39.1
	Loblolly-shortleaf pine	189.8	0.0	12.8	6.5	7.8	162.7
	Other eastern softwoods	208.8	0.0	11.6	0.0	0.0	197.2
	Total softwoods	451.5	10.6	27.7	6.5	7.8	399.0
Hardwood types	Oak-pine	506.1	15.2	16.0	11.0	0.0	464.0
	Oak-hickory	9,365.0	708.0	242.6	183.5	121.0	8,109.8
	Oak-gum-cypress	138.6	0.0	11.8	15.1	13.5	98.2
	Elm-ash-cottonwood	691.0	2.0	30.4	18.3	27.5	612.8
	Maple-beech-birch	1,163.4	42.4	35.6	29.5	10.1	1,045.8
	Other hardwoods	21.6	0.0	4.6	1.4	0.0	15.5
	Exotic hardwoods	23.9	0.0	0.0	0.0	3.3	20.6
Total hardwoods		11,909.4	767.6	341.1	258.8	175.4	10,366.6
Nonstocked		29.4	1.5	0.0	0.0	0.0	27.9
All groups		12,390.3	779.6	368.8	265.3	183.1	10,793.5

Numbers in rows and columns may not sum to totals due to rounding.
 0.0 = no sample for the cell or a value of >0.0 but <0.5.

**Figure 5**—Forest land area by ownership group and survey unit in Kentucky, 2019.

≥ 9.0 inches, while hardwood species must be ≥ 11.0 inches. Nonstocked means that although the land is considered forested, there are not enough trees on it to categorize it into a particular stand-size class. Generally, these are forested areas that have recently been harvested, but new tree growth has not regenerated to an adequate level of stocking at the time of the field inventory.

In 2019, the majority of stands (73 percent) were in the large diameter size class (fig. 6). The area of forest land classified as large diameter has been increasing in recent years. In 2004, an estimated 65 percent of all forest land in Kentucky was in large diameter stands. In 2014, the percentage of large diameter stands had increased to 71 percent and by 2019 to 73 percent. The largest declines occurred in the medium diameter size stands with a decline from 24 percent to 19 percent from 2004 to 2019, respectively. At the same time, stands classified as small diameter declined from 11 percent in 2004 to 8 percent in 2019. A loss of small- and medium-diameter stands is a long-term occurrence in Kentucky and neighboring States.



Fog settles in the valleys at the Red River Gorge in Kentucky.

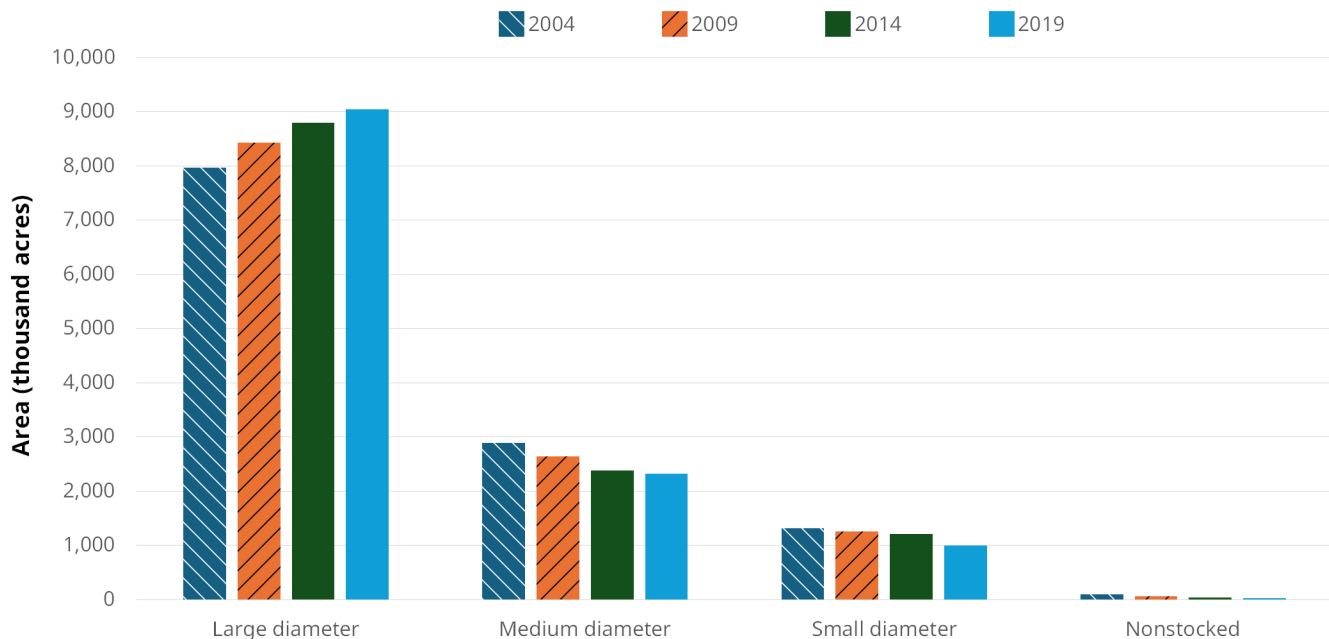
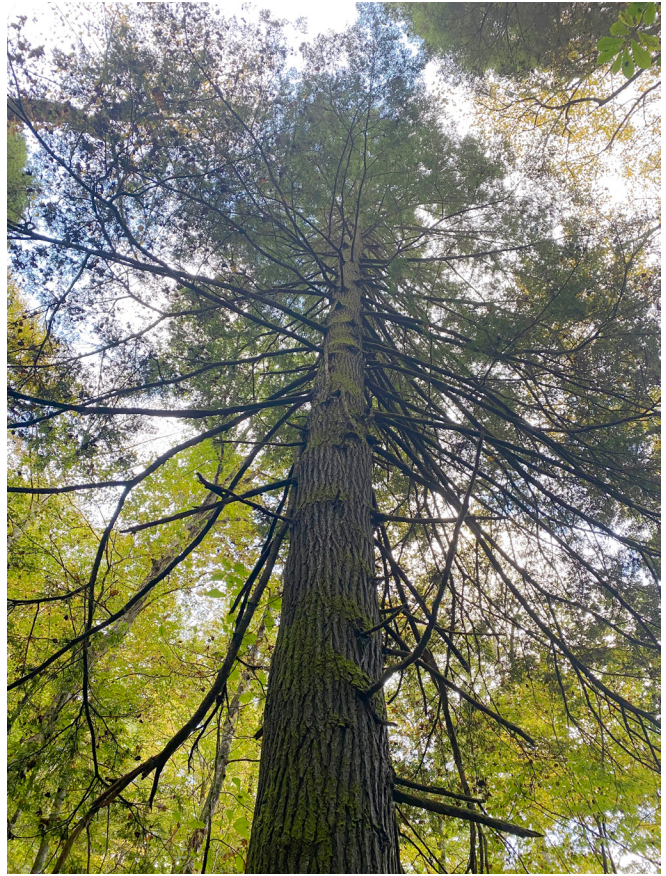


Figure 6—Forest land area by stand-size class for total area, Kentucky 2004, 2009, 2014, 2019.

NUMBER OF TREES, VOLUME, AND BIOMASS

There were 106 individual tree species identified in the 2019 inventory of Kentucky forests. A total population of 7.4 billion trees (d.b.h. ≥ 1 inch) are estimated to be living and growing in forests of the State. Hardwood tree species are, of course, the most common and have been for a long time (fig. 7). Red maple (*Acer rubrum*) is by far the most common hardwood species and eastern red cedar (*Juniperus virginiana*) was the most encountered softwood species (table 5).

The trees with d.b.h. ≥ 5 inches hold over 27.6 billion cubic feet (bcf) of volume (fig. 8). While red maple has the greatest number of trees (16 percent of all trees), they only account for 7.6 percent of total wood volume in Kentucky's forests (table 6). There were greater volumes of wood in yellow poplar (16.6 percent of total volume), white oak (13.1 percent of total volume), and chestnut oak (8.0 percent of total volume) (table 6). While only 2 different oak species are accounted for in the top 20 most numerous tree species, 6 different oak species are among the top 20 most voluminous tree species. This suggests that many of the oak



Healthy eastern hemlock in eastern Kentucky.

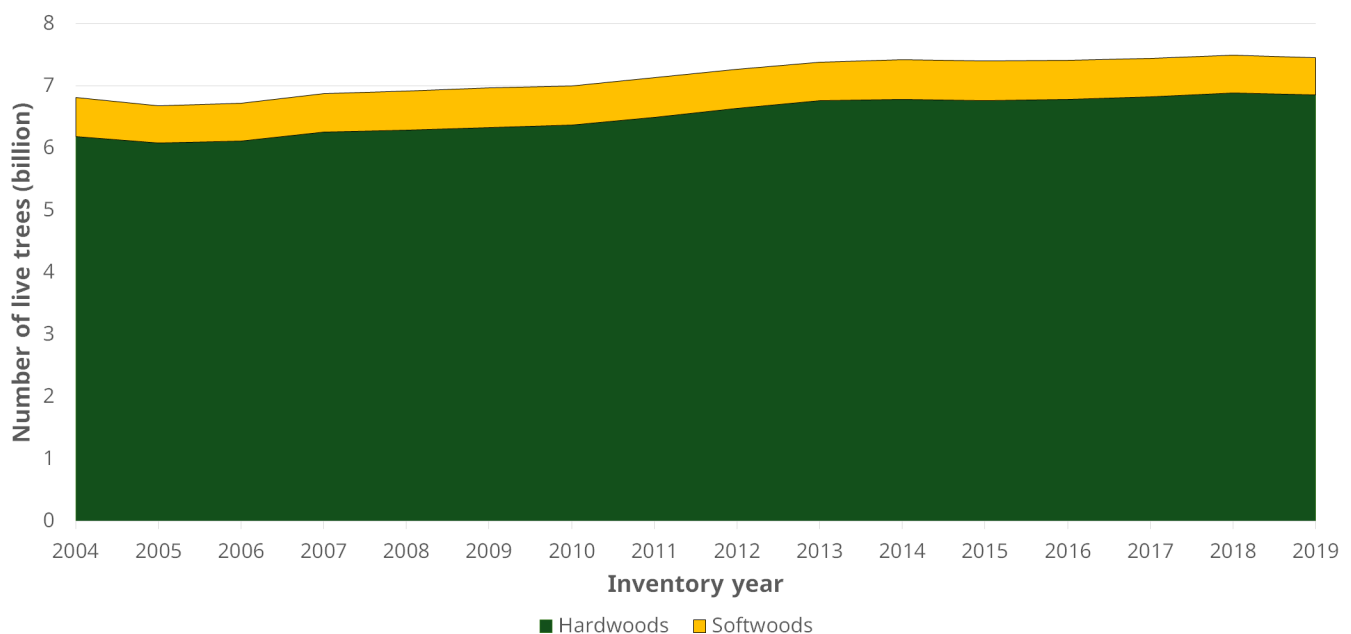


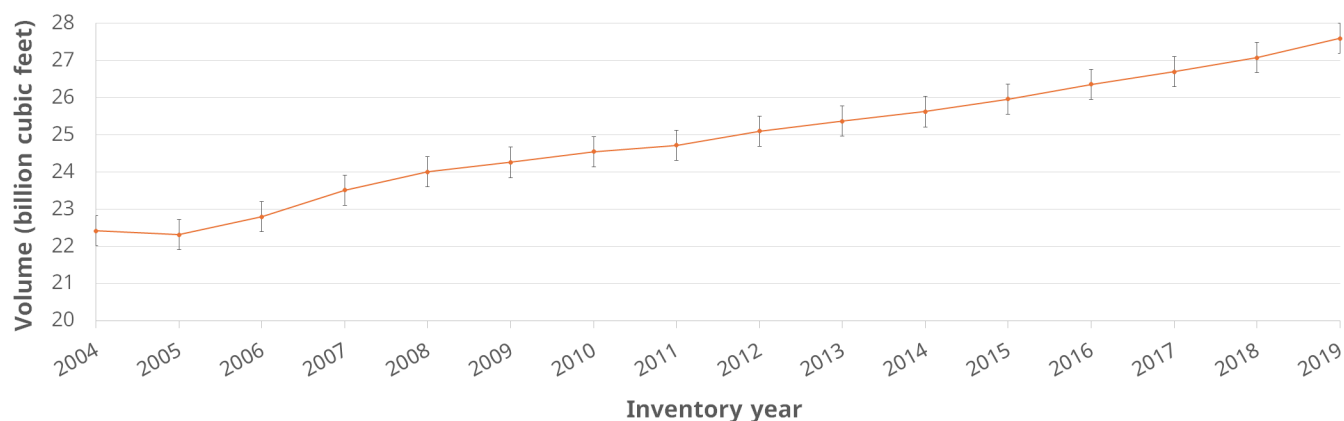
Figure 7—Number of live trees (≥ 1 inch d.b.h.) on forest land by major species group, Kentucky, 2019.

Table 5—Number of live trees (≥ 1 inch d.b.h.) by species and ratio of saplings to sawtimber by tree-size class on forest land, Kentucky, 2019

Species	Total	Tree size-class			Sap-saw- ratio
		Sawtimber	Poletimber	Sapling	
Red maple	891,880,987	30,553,700	126,534,971	734,792,317	24.05
Sugar maple	699,746,183	34,200,408	115,836,121	549,709,654	16.07
Yellow-poplar	551,060,944	Y62,747,601	102,924,173	385,389,170	6.14
American beech	503,906,779	22,402,503	43,121,905	438,382,371	19.57
Eastern redcedar	345,108,508	27,314,273	76,955,157	240,839,078	8.82
Sourwood	290,096,193	1,714,988	39,335,794	249,045,411	145.22
Blackgum	277,606,124	7,566,625	33,999,272	236,040,227	31.19
Eastern redbud	238,550,058	78,237	8,160,832	230,310,989	2,943.76
White oak	205,098,768	56,107,049	48,798,316	100,193,403	1.79
Flowering dogwood	188,544,632	—	8,156,159	180,388,472	N/R
Winged elm	182,903,900	1,461,124	18,984,407	162,458,369	111.19
Green ash	163,996,607	9,438,534	21,778,704	132,779,369	14.07
Sassafras	160,508,744	3,409,995	21,054,249	136,044,500	39.9
Pignut hickory	130,132,232	26,379,145	39,448,891	64,304,196	2.44
Chestnut oak	129,085,221	38,763,308	33,606,872	56,715,041	1.46
Sweetgum	122,362,259	9,929,816	23,692,244	88,740,199	8.94
Black cherry	114,855,095	6,559,198	21,557,006	86,738,891	13.22
American hornbeam	113,899,189	89,355	3,431,929	110,377,905	1,235.27
Virginia pine	111,734,680	12,782,939	17,730,599	81,221,141	6.35
Hackberry	97,156,302	5,940,394	21,666,322	69,549,586	11.71

D.b.h. = Diameter at breast height; N/R = no ratio.

— = no sample for the cell.

**Figure 8**—Net merchantable bole volume of live trees (≥ 5 inches d.b.h.) on forest land for the period 2004 to 2019.

species are larger, older, and occupy more of a dominant canopy position.

If we look at timberland, a subset of all forest land which excludes lands reserved from timber harvesting by statute, we can examine trends in wood volume further back in time by including those forest inventories in Kentucky that were previously limited to timberland. Net volume has increased steadily for hardwood species, and to a lesser extent softwood species (fig. 9), to reach its current level of 25.0 billion cubic feet (bcf) in hardwoods and 1.8 bcf in softwoods. Hardwood volume is predominately in naturally regenerated stands and perhaps even the relatively small percentage of hardwood volume in planted stands could be hardwood trees that regenerated naturally within softwood plantations rather than planted hardwood trees.

In an ownership pattern common across the Southern United States, the majority of the wood volume (87 percent) is owned by nonindustrial private landowners (table 7). In 2019, 11 percent of the volume was on lands stewarded by Federal agencies such as the USDA Forest Service, while the other 2 percent of the volume was growing on State and local public lands.

The distribution of wood volume across tree diameter classes has important implications for forest management planning and the wood

Table 6—Net merchantable bole volume of live trees (≥ 5 inches d.b.h.) in cubic feet, by species and major ownership group on forest land, Kentucky, 2019

Species	Total	Major ownership group	
		Public	Private
		cubic feet	
Yellow-poplar	3,582,486,900	452,019,105	3,130,467,794
White oak	2,832,189,903	640,561,277	2,191,628,626
Sugar maple	1,748,625,126	175,820,841	1,572,804,285
Chestnut oak	1,738,623,936	390,444,274	1,348,179,662
Red maple	1,639,346,451	246,485,861	1,392,860,590
Pignut hickory	1,228,774,202	157,215,918	1,071,558,283
American beech	1,170,564,938	144,140,981	1,026,423,957
Northern red oak	1,005,016,992	190,661,917	814,355,075
Black oak	883,120,496	229,339,354	653,781,142
Scarlet oak	869,495,170	175,402,965	694,092,205
Mockernut hickory	645,215,031	92,098,007	553,117,024
Eastern redcedar	631,819,531	49,765,106	582,054,425
Sweetgum	547,379,419	68,393,635	478,985,784
American sycamore	546,214,499	36,498,531	509,715,968
Shagbark hickory	487,237,161	45,275,474	441,961,687
Green ash	465,673,401	53,611,169	412,062,231
White ash	432,972,943	38,521,448	394,451,495
Chinkapin oak	417,970,441	23,515,776	394,454,665
Blackgum	376,844,260	43,930,823	332,913,437
Virginia pine	364,283,040	50,961,785	313,321,256

D.b.h = Diameter at breast height.

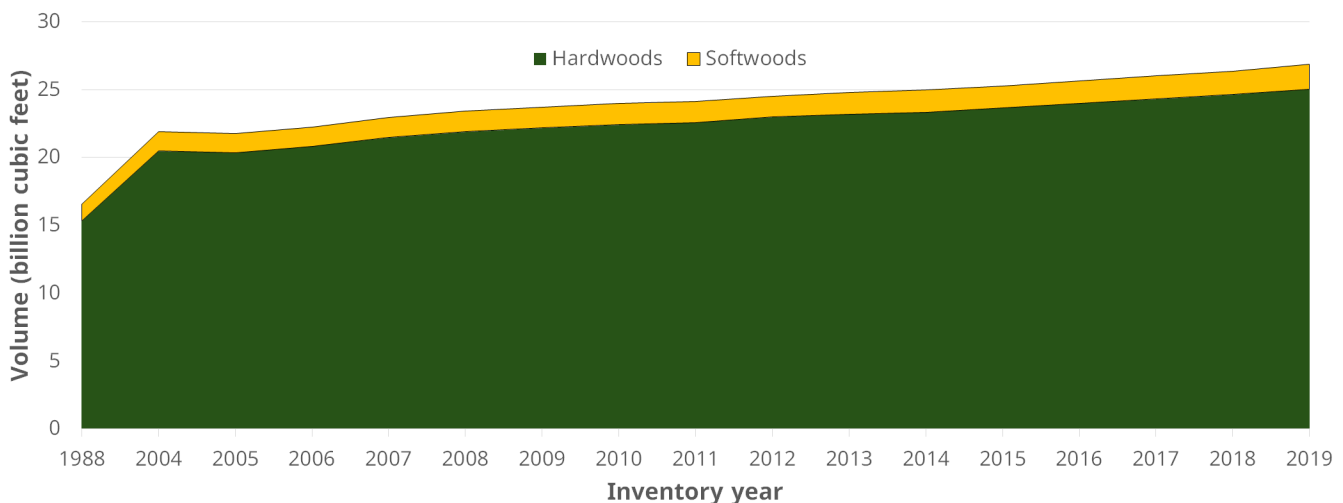


Figure 9—Net merchantable bole volume of live trees (≥ 5 inches d.b.h.) by major species group on timberland, Kentucky, 1988–2019.

KENTUCKY'S FORESTS, 2019

Table 7—Net merchantable bole volume of live trees (≥5 inches d.b.h.) in cubic feet, by species group and ownership group on timberland, Kentucky, 2019

Species group	Total	Ownership group			
		National Forest	Other Federal	State and local	Private
		cubic feet			
Loblolly and shortleaf pine	293,959,155	9,942,824	946,377	30,809,195	252,260,759
Other yellow pines	417,919,294	20,339,653	6,275,215	11,154,329	380,150,097
Eastern white and red pine	183,431,494	65,321,341	—	—	118,110,153
Eastern hemlock	260,943,039	93,004,101	22,155,396	1,055,570	144,727,971
Cypress	62,170,402	—	—	—	62,170,402
Other eastern softwoods	603,963,359	1,353,984	18,943,403	2,201,289	581,464,684
Select white oaks	3,185,674,648	473,132,243	61,686,400	47,742,897	2,603,113,108
Select red oaks	1,240,271,690	91,367,239	37,910,261	21,693,505	1,089,300,685
Other white oaks	1,962,104,278	284,537,651	60,179,412	61,284,041	1,556,103,175
Other red oaks	2,163,834,887	305,509,182	51,066,194	53,409,215	1,753,850,295
Hickory	2,763,411,294	173,967,368	43,815,564	54,877,296	2,490,751,066
Yellow birch	848,192	—	—	—	848,192
Hard maple	1,716,296,311	63,657,341	34,104,081	36,505,184	1,582,029,705
Soft maple	1,827,478,556	169,863,849	66,057,268	43,977,506	1,547,579,933
Beech	1,142,690,932	90,183,948	20,359,512	5,723,515	1,026,423,957
Sweetgum	521,496,475	11,198,879	14,113,366	17,198,446	478,985,784
Tupelo and blackgum	377,313,877	35,217,532	2,012,021	4,692,891	335,391,433
Ash	921,072,113	19,208,104	43,940,466	13,540,620	844,382,923
Cottonwood and aspen	81,115,876	264,049	—	—	80,851,827
Basswood	282,155,801	17,546,111	309,136	263,908	264,036,646
Yellow-poplar	3,477,544,093	242,841,804	87,589,532	16,644,962	3,130,467,794
Black walnut	341,336,421	—	4,876,194	7,378,496	329,081,732
Other eastern soft hardwoods	2,169,024,673	36,194,892	55,858,242	47,954,973	2,029,016,566
Other eastern hard hardwoods	450,517,363	29,126,709	4,694,080	5,943,088	410,753,486
Eastern noncommercial hardwoods	424,227,438	28,923,555	7,433,388	8,024,727	379,845,768
Total	26,870,801,662	2,262,702,360	644,325,507	492,075,652	23,471,698,143

D.b.h. = Diameter at breast height.

— = no sample for the cell.

Sampling error (SE) percent (confidence level 68 percent).

For 95-percent confidence level, multiply SE percentage by 1.96.

products industry. While total volume on timberland has increased over time, most of that increase has occurred in diameter classes between 10 to 25 inches while the smallest and largest diameter classes have remained relatively unchanged (fig. 10). In 2019, most volume was, of course, on private lands (fig. 11). Public forest land has a diameter distribution with a peak slightly larger than private forests lands. The peak of the distribution for publicly stewarded forest lands is the 15.0–16.9 inch diameter class while the peak is 13.0–14.9 for private forest lands (fig. 11).

Sound bole volume and biomass are highly related, so, similar to volume, the majority of tree biomass

in Kentucky forests is accounted for by hardwood species (table 8). In fact, four species groups (select white oak, other white oaks, select red oaks, and other red oaks) accounted for 34 percent of all aboveground biomass of live trees (≥ 1 inch d.b.h.). Total aboveground biomass of live trees was over 876 million dry short tons (table 8). While most of the aboveground live tree biomass for species groups such as oaks was found growing in trees located in a dominant or codominant crown class, for species like maples, the aboveground live tree biomass was more evenly split between the dominant/codominant classes and the intermediate/overtopped classes (table 8).

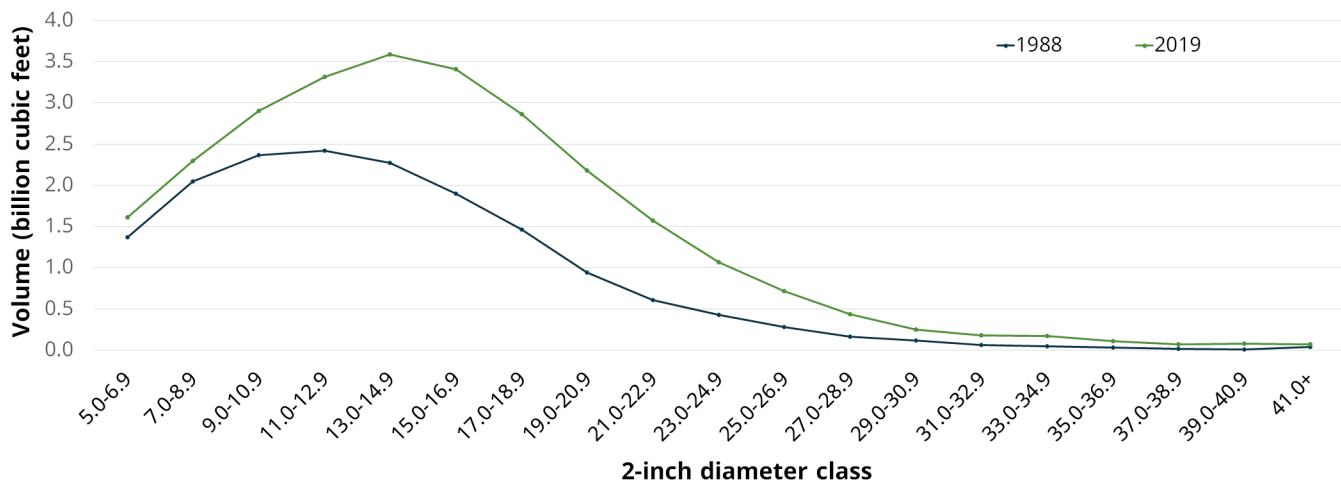


Figure 10—Net merchantable bole volume of live trees (≥ 5 inches d.b.h.) by 2-inch diameter class on timberland, Kentucky, 1988 and 2019.

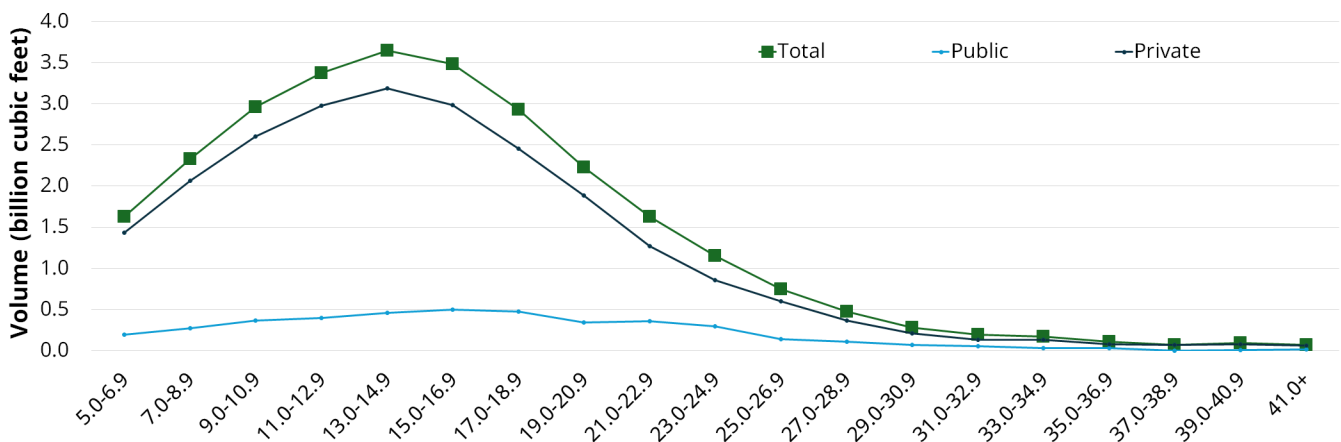


Figure 11—Net merchantable bole volume of live trees (≥ 5 inches d.b.h.) by major ownership group on forest land, Kentucky, 2019.

KENTUCKY'S FORESTS, 2019

Table 8—Aboveground biomass of live trees (≥ 1 inch d.b.h.) in dry short tons, by species group and crown class on forest land, Kentucky, 2019

Species group	Total	Crown class				
		Open grown	Dominant	Codominant	Intermediate	Overtopped
	million dry short tons					
Loblolly and shortleaf pine	6,298,378	147,111	156,755	5,504,366	247,152	242,993
Other yellow pines	10,944,082	13,024	216,148	9,011,392	1,010,406	693,112
Eastern white and red pine	3,598,477	2,862	—	2,915,923	291,624	388,067
Eastern hemlock	7,295,874	—	—	3,940,910	654,525	2,700,439
Cypress	1,432,742	—	—	1,267,390	116,940	48,412
Other eastern softwoods	18,309,444	81,606	134,854	9,071,930	4,310,756	4,710,299
Select white oaks	112,803,216	710,091	3,469,602	96,722,243	6,348,963	5,552,316
Select red oaks	42,642,016	117,932	1,437,277	37,933,643	1,691,777	1,461,387
Other white oaks	68,979,307	131,917	802,577	60,034,569	4,893,352	3,116,891
Other red oaks	73,636,450	977,888	1,473,735	65,939,492	3,211,548	2,033,787
Hickory	107,333,551	209,775	3,083,259	87,046,156	8,739,771	8,254,590
Yellow birch	31,570	—	—	27,059	—	4,511
Hard maple	65,975,159	32,557	800,175	41,088,137	9,634,030	14,420,260
Soft maple	61,917,682	44,422	307,326	39,302,723	8,726,058	13,537,152
Beech	45,004,003	—	937,032	32,619,769	4,603,281	6,843,921
Sweetgum	12,881,298	15,165	240,805	10,651,422	969,625	1,004,281
Tupelo and blackgum	11,539,316	25,950	53,435	5,745,029	2,058,613	3,656,290
Ash	24,490,408	28,549	875,797	18,552,905	2,568,667	2,464,490
Cottonwood and aspen	1,388,064	10,742	378,912	908,899	81,769	7,742
Basswood	5,684,621	—	108,465	4,319,368	527,877	728,911
Yellow–poplar	80,135,332	173,251	4,211,982	67,347,091	4,375,299	4,027,708
Black walnut	11,908,720	95,810	178,986	9,937,915	1,171,241	524,767
Other eastern soft hardwoods	63,576,676	481,900	1,249,565	42,676,982	9,152,863	10,015,365
Other eastern hard hardwoods	19,544,249	43,945	347,571	11,133,215	3,573,522	4,445,996
Eastern noncommercial hardwoods	19,356,229	135,071	48,819	5,631,706	4,290,298	9,250,335
Total	876,707,370	3,479,570	20,513,077	669,330,236	83,249,959	100,134,527

D.b.h. = Diameter at breast height.

— = no sample for the cell.

GROWTH, REMOVALS, AND MORTALITY

Based on estimates of net change (gross growth–mortality–removals) from remeasured plots, total

volume increased each year (on average) over 358 million cubic feet (mcf) of sound volume between 2011 and 2019 (table 9). The yellow-poplar group experienced the largest average annual increase (100 mcf per year) of any other single species group.

Table 9—Average annual net change (net growth minus removals) of sound bole volume of trees (≥5 inches d.b.h.) in cubic feet, by species and ownership group on forest land, Kentucky, 2019

Species group	Ownership group				
	Total	National Forest	Other Federal	State and local	Private
	million cubic feet				
Loblolly and shortleaf pine	2,912,374	7,843	678,378	987,945	1,238,208
Other yellow pines	3,524,687	51,270	753,805	268,925	3,163,446
Eastern white and red pine	8,442,731	1,937,542	0	0	6,505,189
Eastern hemlock	7,247,313	2,805,422	478,941	178,512	3,784,437
Cypress	-4,082,373	0	-183,363	0	-3,899,010
Other eastern softwoods	-24,464,024	-2,098,585	752,360	206,063	-23,323,863
Select white oaks	59,888,939	9,597,468	1,658,197	1,731,472	46,901,802
Select red oaks	9,702,025	1,665,665	1,720,624	-1,207,259	7,522,996
Other white oaks	14,463,851	2,410,451	1,203,434	1,687,844	9,162,122
Other red oaks	17,795,698	1,414,275	467,288	800,616	15,113,518
Hickory	55,729,170	2,397,576	1,438,175	1,404,125	50,489,293
Yellow birch	-20,761,422	-177,667	0	-737,200	-19,846,554
Hard maple	38,889,480	1,361,932	863,385	1,192,784	35,471,380
Soft maple	49,490,502	3,664,206	1,787,568	1,442,909	42,595,819
Beech	18,953,226	412,515	414,396	389,257	17,737,059
Sweetgum	5,142,992	44,751	941,131	585,772	3,660,841
Tupelo and blackgum	4,603,198	368,078	1,372,806	173,877	6,170,205
Ash	25,021,368	94,667	962,671	1,643,500	24,435,206
Cottonwood and aspen	-44,494,199	-399,857	-1,402,967	-108,126	-42,583,249
Basswood	915,455	90,634	51,600	-21,038	909,551
Yellow-poplar	100,225,944	5,296,751	5,060,290	808,779	89,060,123
Black walnut	7,966,957	3,031	359,972	339,133	7,331,413
Other eastern soft hardwoods	47,658,109	768,495	685,838	1,602,075	44,601,701
Other eastern hard hardwoods	11,920,030	754,196	119,697	179,690	11,105,840
Eastern noncommercial hardwoods	13,971,167	489,248	348,977	375,661	12,757,281
Total	358,684,023	31,892,748	17,444,994	10,088,374	299,257,905

D.b.h. = Diameter at breast height.

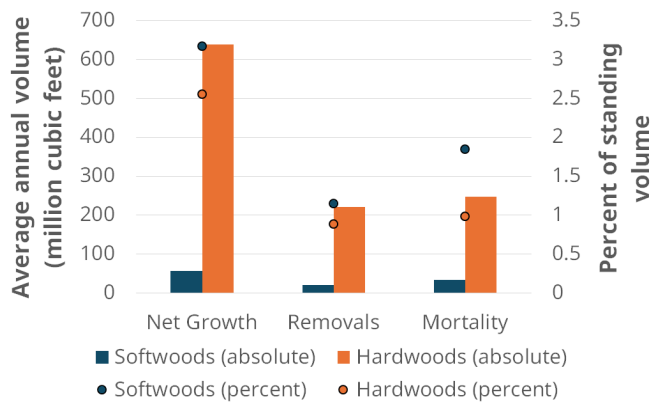


Figure 12—Average annual net growth, removals, and mortality of sound bole volume of trees (≥5 inches d.b.h.), as an absolute value (left axis) and as a percent of total standing stock (right axis) by major species group on forest land, Kentucky, 2019.

In 2019, 91 percent of the total net annualized growth of 644 million cubic feet per year was on hardwood trees and 9 percent on softwoods (fig. 12). Similarly, 92 percent of total annualized removals was from hardwood removals and 7 percent was due to softwood removals (fig. 12). The ratio of net growth to removals, a valuable statistic to gauge the health and sustainability of current populations looking forward, for both hardwood and softwood species as individual groups was above 2 to 1 for each. The ratio for both groups indicates that annually, on Kentucky forests, at least twice as much volume is grown than is being removed through harvesting and/or land use changes. In fact, removals represent 1.0 and 1.0 percent of the total standing volume for softwoods and hardwoods, respectively (fig. 12).

Average annual removals (all) and harvest removals slightly declined during the period from 2009 to 2019 (fig. 13). Mortality increased slightly over the same time period. Net growth declined but seems to be rebounding. While harvest removals have declined slightly over time (fig. 13), harvest removals in 2019 accounted for about 243 million cubic feet of volume. Since harvest removals made up 89 percent of all removals, hardwood harvest removals accounted for 93 percent of all harvest removals in the State. Hardwood harvest removals are concentrated in the larger diameter stands, corresponding to the greater use of hardwoods for sawn lumber rather than pulp products (fig. 14). Softwood harvest removals are concentrated in smaller diameter stands even though softwood trees are used for both sawn lumber and pulp products. Due to the nature of FIA plot collection there is a time-lag between some events being observed in inventory data summaries. Overall, the demand for wood products has increased as the housing market improved.

While stable recently (2015 to 2019), average annual mortality has experienced an increase over the time period between 2009 and 2019 with a rate of 281 million cubic feet per year. Softwood mortality is relatively stable across time while hardwood mortality is driving the overall increase across the State (fig. 15).

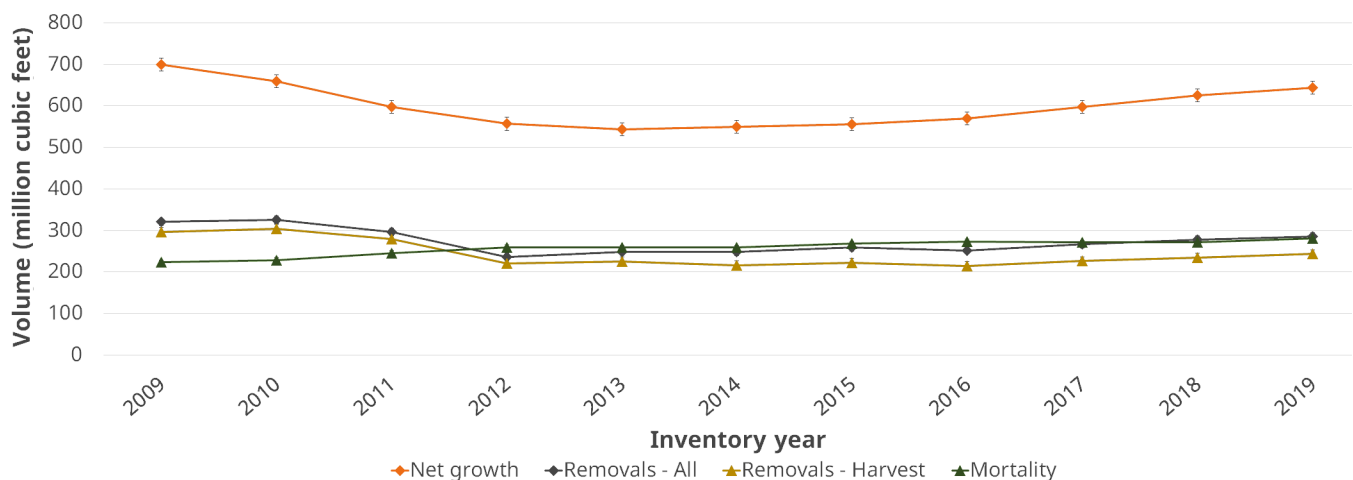


Figure 13—Average annual net growth, all removals, harvest removals, and mortality of sound bole volume of trees (≥5 inches d.b.h.) on forest land, Kentucky, 2009–2019.

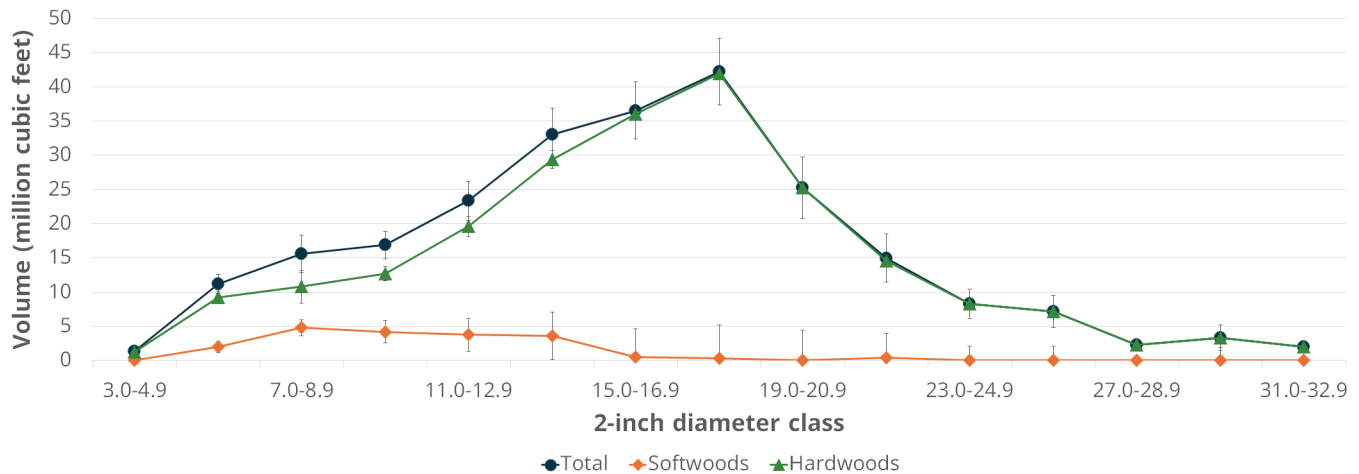


Figure 14—Average annual harvest removals of sound bole volume of trees (≥5 inches d.b.h.) across 2-inch diameter classes by major species group on forest land, Kentucky, 2019.

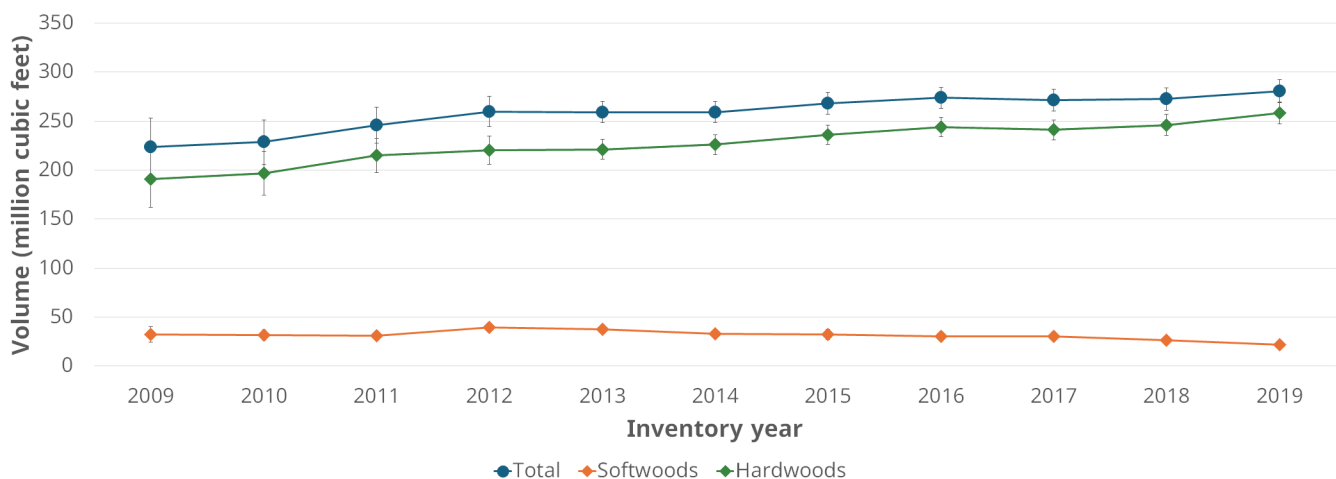


Figure 15—Average annual mortality of sound bole volume of trees (≥5 inches d.b.h.) by major species group on forest land, Kentucky, 2019.

DISTURBANCE AND INVASIVE PLANTS

Disturbance

At the close of the previous statewide inventory (2014), weather and insects were, respectively, the first and second leading causes of forest disturbance in Kentucky (Oswalt et al. 2022). Since that time, insect damage increased substantially and surpassed weather as the leading disturbance agent in the State, affecting 303,000 acres of forest land annually (table 10).

Table 10 presents the area of forest land disturbed annually by forest-type group and disturbance

class for Kentucky in 2019. Oak/hickory, the most common forest-type group in the State (table 4), was disturbed to some degree by all agents and most frequently by insects. Weather disturbances were concentrated in the elm/ash/cottonwood and oak/hickory forest-type groups whereas fire disturbances were limited almost solely to the oak/hickory forest-type group. Disturbances by the “other natural causes” class, primarily vegetation (e.g., vines), were substantial, and observed in all forest-type groups except white/red/jack pine. Disturbances by diseases and humans were minimal. Disturbances by domestic animals (e.g., livestock) were more common than disturbances by wild animals (e.g., beaver, deer).

Table 10—Area of forest land disturbed annually by forest-type group and disturbance class, Kentucky, 2019

Forest-type group ²		Disturbance class ¹							
		Insects	Disease	Weather	Fire	Domestic animals	Wild animals	Human	Other natural
<i>thousand acres</i>									
Softwood types	White-red-jack pine	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Loblolly-shortleaf pine	1.9	0.0	0.0	0.6	0.7	0.0	0.0	2.9
	Other eastern softwoods	3.3	0.0	1.2	0.0	2.8	0.3	0.0	2.1
	Total softwoods	5.2	0.0	1.2	0.6	3.4	0.3	0.0	5
Hardwood types	Oak-pine	22.6	0.0	3.9	0.3	3.9	0.0	0.2	6.6
	Oak-hickory	217.9	0.8	23.9	30.6	31.5	5.6	3.5	63
	Oak-gum-cypress	1.9	0.0	4.3	0.0	0.5	0.0	0.0	1.1
	Elm-ash-cottonwood	19.5	0.0	33.1	0.0	2.2	5.2	0.0	18.1
	Maple-beech-birch	34.9	0.0	2.6	0.8	3.3	0.3	1.3	9.5
	Other hardwoods	0.9	0.0	0.0	0.0	0.3	0.0	0.0	1.2
	Exotic hardwoods	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.1
	Total hardwoods	297.8	0.8	67.8	31.7	41.7	11	4.9	100.4
	Nonstocked	0.0	0.0	1.0	0.0	0.0	0.0	0.1	1.8
All groups		303.0	0.8	70.0	32.3	45.1	11.3	5.1	107.3

Numbers in columns may not sum to totals due to rounding.

¹ Based on current conditions.

² Based on past conditions.

Standing Dead Trees and Mortality Agents

In 2019, the number of standing dead trees ≥ 5.0 inches d.b.h. in Kentucky was estimated at 137.4 million (table 11). This was an increase of 8.1 million trees from 2016 (Oswalt et al. 2022). Vegetation (e.g., suppression, competition, vines) and insects were the most frequently identifiable causes of death for standing dead trees (table 11). Weather was identified as the cause of death for only 3.8 percent of all standing dead trees, despite being a substantial disturbance agent (table 10).

The distribution of trees ≥ 5.0 inches d.b.h. across species groups among all live trees (table 12) and all standing dead trees (table 11) was generally similar. Notable exceptions include ash (*Fraxinus* spp.), which comprised 3.4 percent of all live trees and 25.5 percent of all standing dead trees, other eastern hard hardwoods (5.8 percent of all live trees and 16 percent of all standing dead trees), and hickory (*Carya* spp.) (4.8 percent of all live trees and 3.6 percent of all standing dead trees).

KENTUCKY'S FORESTS, 2019

Table 11—Number of standing dead trees (≥5.0 inches d.b.h.) on forest land by species group and cause of death, Kentucky, 2019

Species group		Cause of death									
		All classes	Insect	Disease	Fire	Animal	Weather	Vegetation	Unknown/ other	Logging/ human	Not available
		million trees									
Softwood	Loblolly and shortleaf pines	1.30	0.04	0.04	0.00	0.00	0.04	0.15	0.19	0.04	0.79
	Other yellow pines	7.72	0.41	0.20	0.00	0.00	0.25	1.28	1.35	0.28	3.95
	Eastern white and red pines	1.17	0.00	0.00	0.00	0.00	0.04	0.19	0.23	0.04	0.68
	Eastern hemlock	1.06	0.42	0.00	0.04	0.00	0.00	0.11	0.15	0.08	0.26
	Cypress	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	Other eastern softwoods	11.43	0.00	0.00	0.00	0.00	0.20	3.82	0.63	0.07	6.72
	Total softwoods	22.73	0.88	0.24	0.04	0.00	0.53	5.55	2.55	0.50	12.44
Hardwood	Select white oaks	8.08	0.03	0.72	0.04	0.07	0.26	2.17	1.01	0.38	3.40
	Select red oaks	1.84	0.00	0.21	0.00	0.00	0.22	0.55	0.36	0.12	0.38
	Other white oaks	4.39	0.00	0.26	0.07	0.00	0.11	0.88	0.70	0.23	2.13
	Other red oaks	6.24	0.03	0.91	0.04	0.00	0.75	1.16	1.29	0.08	1.98
	Hickory	3.61	0.11	0.16	0.00	0.00	0.44	1.39	0.74	0.23	0.54
	Hard maple	3.56	0.00	0.22	0.00	0.00	0.28	1.16	0.87	0.26	0.77
	Soft maple	5.21	0.00	0.19	0.04	0.00	0.48	1.91	1.53	0.35	0.72
	Beech	0.84	0.00	0.03	0.04	0.00	0.11	0.11	0.23	0.03	0.28
	Sweetgum	1.59	0.04	0.04	0.00	0.31	0.28	0.39	0.38	0.00	0.15
	Tupelo and blackgum	0.94	0.00	0.00	0.03	0.00	0.08	0.34	0.26	0.07	0.15
	Ash	25.54	21.78	0.26	0.00	0.32	0.39	0.70	0.50	0.22	1.38
	Cottonwood and aspen	0.16	0.00	0.00	0.00	0.00	0.05	0.04	0.04	0.00	0.04
	Basswood	0.48	0.00	0.00	0.00	0.00	0.04	0.18	0.15	0.00	0.11
	Yellow-poplar	4.75	0.00	0.15	0.04	0.08	0.23	2.01	1.00	0.07	1.16
	Black walnut	1.74	0.00	0.08	0.00	0.00	0.00	0.65	0.15	0.04	0.83
	Other eastern soft hardwoods	24.35	0.32	0.84	0.11	0.19	0.87	8.82	4.09	0.49	8.63
	Other eastern hard hardwoods	16.03	0.03	0.24	0.08	0.12	0.07	4.21	1.63	0.27	9.36
	Eastern noncommercial hardwoods	5.28	0.03	0.15	0.08	0.00	0.07	2.45	0.37	0.23	1.90
	Total hardwoods	114.63	22.40	4.45	0.57	1.08	4.74	29.13	15.28	3.09	33.89
All species		137.36	23.28	4.69	0.61	1.08	5.27	34.68	17.83	3.59	46.34

D.b.h. = Diameter at breast height.

Table 12—Number of live trees ≥ 5.0 inches d.b.h. by species group, Kentucky, 2019

Species group	Total	Percentage
Eastern noncommercial hardwoods	979,362,374	13.13
Other eastern soft hardwoods	952,650,079	12.77
Soft maple	905,363,231	12.14
Hard maple	700,610,402	9.40
Yellow-poplar	551,060,944	7.39
Beech	503,906,779	6.76
Other eastern hard hardwoods	433,431,367	5.81
Hickory	358,853,907	4.81
Other eastern softwoods	345,108,508	4.63
Tupelo and blackgum	277,724,655	3.72
Select white oaks	275,233,100	3.69
Ash	256,896,005	3.44
Other red oaks	172,660,547	2.32
Other white oaks	167,151,362	2.24
Sweetgum	122,362,259	1.64
Other yellow pines	121,541,629	1.63
Select red oaks	100,775,093	1.35
Eastern hemlock	73,770,761	0.99
Black walnut	61,841,013	0.83
Basswood	34,482,152	0.46
Loblolly and shortleaf pines	33,050,882	0.44
Eastern white and red pines	23,860,643	0.32
Cottonwood and aspen (East)	2,550,208	0.03
Cypress	1,450,746	0.02
Yellow birch	1,054,014	0.01
Urban-specific hardwoods	487,812	0.01
Total	7,457,240,476	100.00

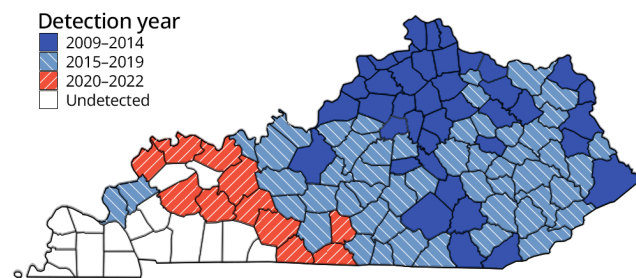
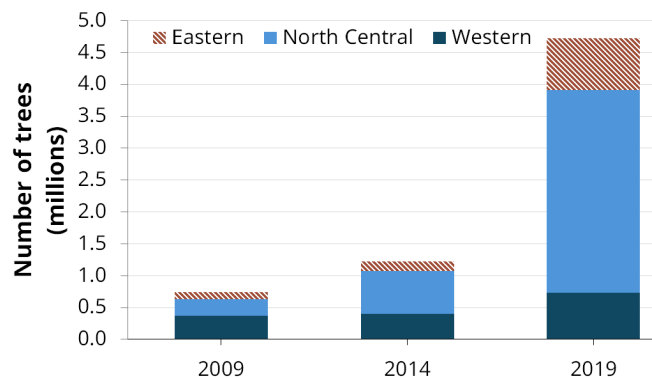
Insects, Diseases, and Species of Concern

Emerald Ash Borer

The emerald ash borer (*Agrilus planipennis*) is an exotic beetle native to Asia that was first observed in the United States in 2002 (Herms and

McCullough 2014). It was detected in Kentucky (Shelby and Jessamine Counties) in 2009 (KDF 2009) and has since spread throughout most of the State (fig. 16). The emerald ash borer is highly destructive to Kentucky's three ash (*Fraxinus* spp.) species, with white (*F. americana*) and green ash (*F. pennsylvanica*) being most impacted and blue ash (*F. quadrangulata*) being more resistant. Infested white and green ash trees almost always succumb to mortality, typically within a few years of infestation (Klooster et al. 2014).

Since 2009, average annual mortality of ash trees has increased throughout the State, and especially so in the Bluegrass survey unit (fig. 17). In 2019, average annual mortality among ash trees was the greatest of all species groups in the State (table 13). There are more standing dead ash trees ≥ 5.0 inches d.b.h. across the State than any other species group and more than all softwood species groups combined (table 11).

**Figure 16**—Spread of emerald ash borer across the State of Kentucky, 2019.**Figure 17**—Average annual mortality of ash (*Fraxinus* spp.) trees (≥ 5.0 inches d.b.h.) on forest land by region, Kentucky, 2009–2019. The eastern region includes the Eastern, Northern Cumberland, and Southern Cumberland FIA survey units. The north central region corresponds to the Bluegrass FIA survey unit. The western region includes the Pennyroyal, Western, and Western Coalfield FIA survey units.

KENTUCKY'S FORESTS, 2019

Table 13—Average annual mortality of live trees on forest land by species group and ownership group, Kentucky, 2019

Forest-type group		Ownership group ¹					
		All ownerships	USDA Forest Service	Other Federal	State and local government	Forest industry	Nonindustrial private
		million cubic feet per year					
Softwood types	Loblolly and shortleaf pines	3.1	0.2	0.0	0.0	0.1	2.9
	Other yellow pines	10.4	0.7	0.1	0.8	0.0	8.7
	Eastern white and red pines	2.0	0.6	0.0	0.0	0.0	1.4
	Eastern hemlock	1.5	0.4	0.4	0.0	0.0	0.7
	Cypress	0.0	0.0	0.0	0.0	0.0	0.0
	Other eastern softwoods	5.0	0.0	0.4	0.0	0.0	4.6
	Total	22.1	1.8	1.0	0.8	0.1	18.3
Hardwood types	Select white oaks	11.8	1.8	0.7	0.2	0.2	8.8
	Select red oaks	10.9	0.4	0.5	0.2	0.6	9.2
	Other white oaks	10.4	1.2	0.2	0.0	0.1	8.9
	Other red oaks	30.1	7.2	1.0	0.6	0.0	21.3
	Hickory	14.7	1.1	1.0	0.4	0.0	12.3
	Yellow birch	0.0	0.0	0.0	0.0	0.0	0.0
	Hard maple	10.9	0.2	0.3	0.2	0.5	9.7
	Soft maple	15.9	1.7	1.2	0.1	2.6	10.2
	Beech	6.9	0.9	0.0	0.0	0.0	6.0
	Sweetgum	4.7	0.3	0.0	0.1	0.1	4.2
	Tupelo and blackgum	3.1	0.2	1.5	0.0	0.1	1.3
	Ash	65.0	0.6	0.4	3.2	1.6	59.3
	Cottonwood and aspen	2.0	0.0	0.0	0.0	0.0	2.0
	Basswood	1.3	0.1	0.1	0.0	0.0	1.1
	Yellow-poplar	17.6	1.0	0.6	0.2	0.1	15.7
	Black walnut	1.6	0.0	0.0	0.0	0.1	1.4
	Other eastern soft hardwoods	38.8	0.2	1.0	0.7	0.4	36.4
	Other eastern hard hardwoods	7.8	0.2	0.3	0.1	0.1	7.1
	Eastern noncommercial hardwoods	5.3	0.5	0.2	0.1	0.1	4.5
	Urban-specific hardwoods	0.0	0.0	0.0	0.0	0.0	0.0
	Total	258.6	17.6	8.8	6.1	6.5	219.6
All groups		280.6	19.4	9.9	7.0	6.6	237.8

Numbers in rows and columns may not sum to totals due to rounding.

0.0 = no sample for the cell or a value of >0.0 but <0.05.

¹ Based on current conditions.

With the recent increase in mortality, the number of live ash trees ≥ 5.0 inches d.b.h. on forest land in Kentucky declined precipitously from 2014 to 2019 (fig. 18). In contrast, over the same time period, the number of live ash saplings (trees with d.b.h. ≥ 1.0 inch and < 5.0 inches) remained relatively stable and the number of ash seedlings (trees < 1.0 inch d.b.h.) increased (fig. 18). The persistence of ash in Kentucky largely depends on the ability of this advanced regeneration to withstand emerald ash borer attack and survive to maturity.

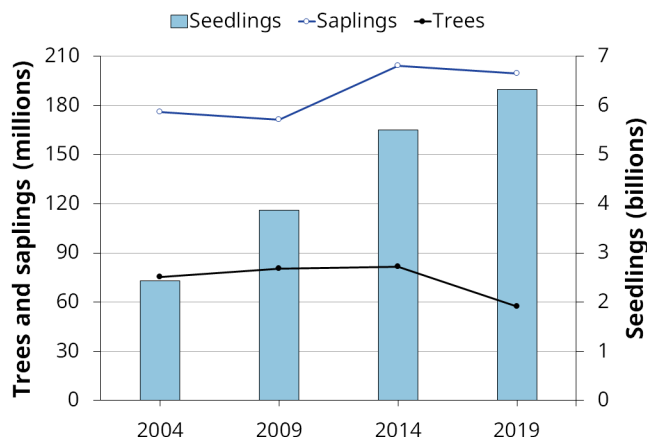


Figure 18—Number of live ash (*Fraxinus* spp.) trees (≥ 5.0 inches d.b.h.), saplings (≥ 1.0 inch and < 5.0 inches d.b.h.), and seedlings (< 1.0 inch d.b.h.) on forest land, Kentucky, 2004–2019.

Laurel Wilt Disease

Laurel wilt is a vascular disease of plants in the laurel (*Lauraceae*) family caused by the fungus *Harringtonia lauricola* and vectored by the redbay ambrosia beetle (*Xyleborus glabratus*) (Fraedrich et al. 2008, Harrington et al. 2008). Both the pathogen and beetle are native to Asia; however, laurel wilt was detected in the United States on redbay (*Persea borbonia*) trees near Savannah, GA, in 2002 (Rabaglia et al. 2006). In Kentucky, laurel wilt was detected on sassafras (*Sassafras albidum*) trees in Christian, Logan, and Todd Counties in 2019 (Lloyd et al. 2020). Since then, the disease has spread to 10 additional counties within the State (fig. 19).

Although sassafras occurs throughout Kentucky (fig. 19), the arrival of laurel wilt coincided with the conclusion of the latest State forest inventory. Therefore, no effect of its presence was detected. Close monitoring in subsequent inventories is warranted because mortality is rapid following onset of the disease, with up to 100 percent mortality in some locations (Mayfield et al. 2022).

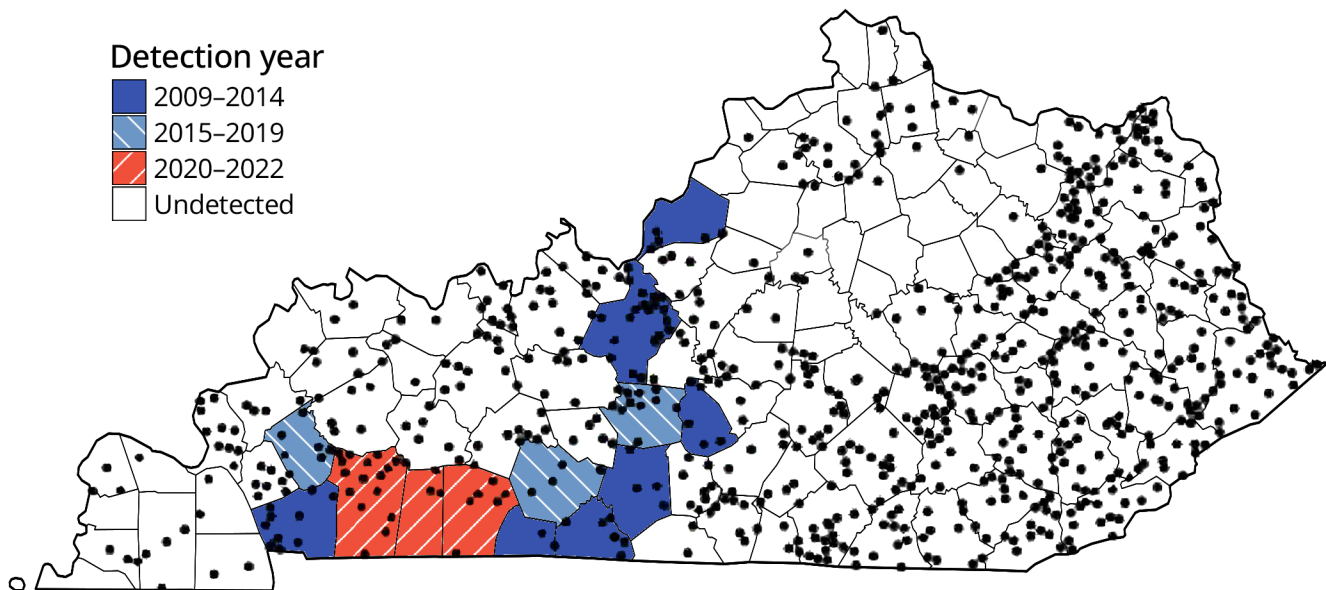


Figure 19—Inventory plots with sassafras present and detection of laurel wilt disease by county and year from 2019 to 2021.

Estimates of sassafras conditions are included in the “other eastern soft hardwoods” FIA species group throughout this report. Results from a special query of the FIA database for sassafras individually (USDA Forest Service 2024a) indicated that in 2019, there were 24.5 million sassafras trees ≥ 5.0 inches d.b.h. in Kentucky. These were observed in eight forest-type groups (table 14), with concentrations in three oak/hickory forest-type group forest types: white oak/red oak/hickory (28.7 percent), yellow-poplar/white oak/northern red oak (12.0 percent), and sassafras/persimmon (10.8 percent). Sassafras trees were approximately equally distributed across the codominant, intermediate, and overtopped crown classes (table 14).

Nonnative Plants

Nonnative invasive plant (NNIP) monitoring by SRS FIA is limited to species recognized as problematic in the region. During the course of

the latest statewide inventory, the presence of NNIP species was evaluated on 2,438 forested plots in Kentucky. At least one NNIP species was observed on 81.1 percent of the plots. Although the greatest number of NNIP species observed on a single plot was 12, observations of more than 4 NNIP species were uncommon (16.5 percent of the plots). A concentration of plots with five or more NNIP species was located in the Bluegrass region and plots with zero NNIP species were located primarily in the Northern Cumberland and Southern Cumberland units (fig. 20). Three NNIP species were recorded on more than 1,000 plots and four were observed on only one plot (table 15). Except Japanese climbing fern (*Lygodium japonicum*), all NNIP species observed during the previous (2014) Kentucky inventory were observed again. Three species were observed for the first time: Leatherleaf mahonia (*Mahonia bealei*), glossy buckthorn (*Frangula alnus*), and sacred bamboo (*Nandina domestica*).

Table 14—Number of sassafras trees (≥ 5.0 inches d.b.h.) on forest land, by forest-type group and crown class, Kentucky, 2019

Forest-type group		Total	Crown class			
			Open grown/dominant	Codominant	Intermediate	Overtopped
		millions				
Softwood types	Loblolly-shortleaf pine	0.04	0.00	0.04	0.00	0.00
	Other eastern softwoods	0.21	0.00	0.11	0.07	0.03
	Total softwoods	0.24	0.00	0.15	0.07	0.03
Hardwood types	Oak-pine	1.01	0.00	0.35	0.37	0.29
	Oak-hickory	21.25	0.07	7.16	6.42	7.59
	Oak-gum-cypress	0.07	0.00	0.00	0.03	0.04
	Elm-ash-cottonwood	0.07	0.00	0.04	0.03	0.00
	Maple-beech-birch	1.74	0.00	0.59	0.63	0.52
	Other hardwoods	0.08	0.00	0.04	0.04	0.00
	Total hardwoods	23.21	0.07	7.82	7.16	8.16
All groups		24.46	0.07	8.32	7.59	8.48

Numbers in rows and columns may not sum to totals due to rounding.
D.b.h. = Diameter at breast height.

Invasive species observed

- 0
- 1-4
- 5-12

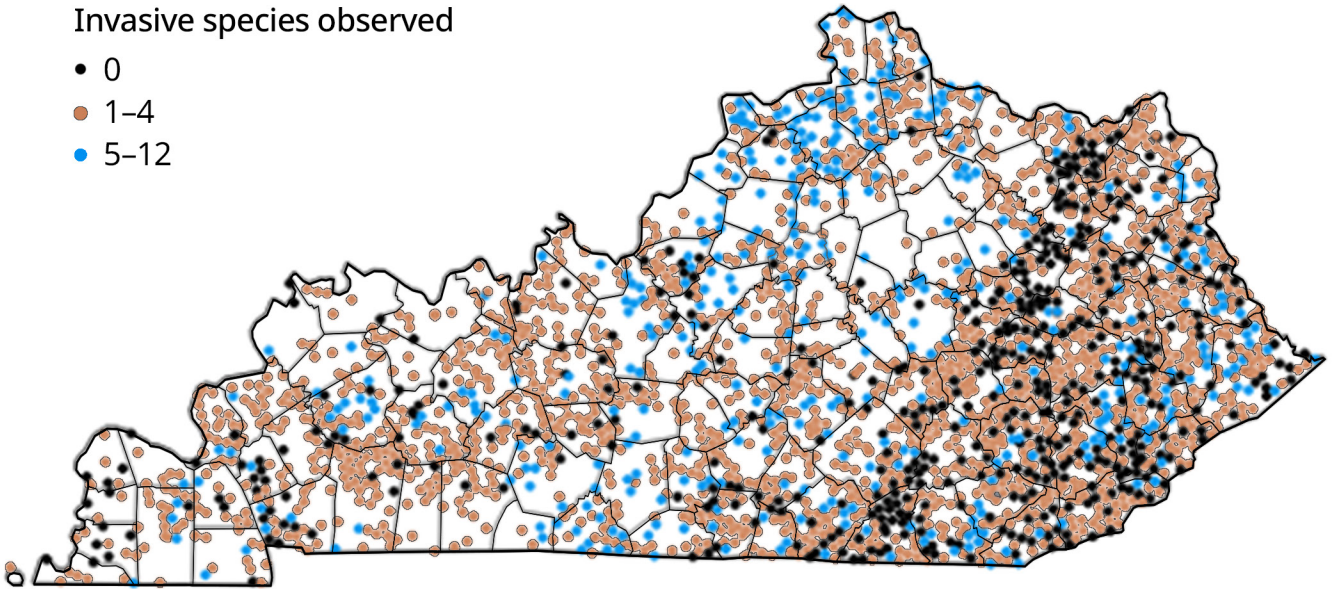


Figure 20—Distribution of plots with nonnative invasive plants across the State of Kentucky, 2019.



Kentucky Division of Forestry, QA Forester, Haley Frazier measures diameter at breast height on an FIA plot in Kentucky.

Table 15—Number of forested plots on which nonnative invasive plant species were observed in Kentucky, by inventory year, 2009–2019

Common name	Scientific name	2009 ^a	2014 ^b	2019 ^c
Japanese honeysuckle	<i>Lonicera japonica</i>	1,258	1,431	1,499
Rose	<i>Rosa</i> spp.	994	1,172	1,295
Nepalese browntop	<i>Microstegium vimineum</i>	278	660	1,045
Honeysuckle	<i>Lonicera</i> spp.	230	322	435
Oleaster	<i>Elaeagnus</i> spp.	62	146	306
Privet	<i>Ligustrum</i> spp.	28	149	259
Tree of heaven	<i>Ailanthus altissima</i>	143	181	252
Winter creeper	<i>Euonymus fortunei</i>	26	111	205
Garlic mustard	<i>Alliaria petiolata</i>	59	134	169
Burningbush	<i>Euonymus alatus</i>	25	51	132
Sericea lespedeza	<i>Lespedeza cuneata</i>	80	112	101
Tall fescue	<i>Schedonorus arundinaceus</i>	330	91	73
Princesstree	<i>Paulownia tomentosa</i>	34	51	65
Callery pear	<i>Pyrus calleryana</i>	0	5	56
Chinese silvergrass	<i>Miscanthus sinensis</i>	11	26	47
Oriental bittersweet	<i>Celastrus orbiculatus</i>	0	14	46
Japanese barberry	<i>Berberis thunbergii</i>	0	5	40
Lespedeza	<i>Lespedeza</i> spp.	23	28	35
Silktree	<i>Albizia julibrissin</i>	27	26	28
Yam	<i>Dioscorea</i> spp.	31	19	19
Periwinkle	<i>Vinca</i> spp.	14	16	14
Crownvetch	<i>Securigera varia</i>	0	10	13
Kudzu	<i>Pueraria montana</i> var. <i>lobata</i>	5	7	11
Japanese knotweed	<i>Polygonum cuspidatum</i>	0	2	8
Japanese privet	<i>Ligustrum japonicum</i>	3	9	7
Ivy	<i>Hedera</i> spp.	0	6	5
Bamboo	<i>Bambusa</i> spp.	4	3	2
Cogongrass	<i>Imperata cylindrica</i>	0	1	2
Wisteria	<i>Wisteria</i> spp.	0	3	2
Beale's barberry	<i>Mahonia bealei</i>	0	0	1
Glossy buckthorn	<i>Frangula alnus</i>	0	0	1
Sacred bamboo	<i>Nandina domestica</i>	0	0	1
Thorny olive	<i>Elaeagnus pungens</i>	0	1	1
Japanese climbing fern	<i>Lygodium japonicum</i>	0	1	0

^a 2,439 plots were evaluated.^b 2,469 plots were evaluated.^c 2,438 plots were evaluated.

TIMBER PRODUCTS OUTPUT AND UTILIZATION

Timber Products

A diverse forest products industry in Kentucky is comprised of a variety of mills, ranging from small- to large-sized softwood and hardwood sawmills, post, veneer, bioenergy and other miscellaneous mills to very large pulpmills. Since 2015, the total number of sawmills, pulpwood mills, and other primary wood-processing plants distributed across the State has moderately increased. In 2015, there were 209 primary wood using mills, 226 in 2017, 231 in 2018, and 229 in 2019.

This section presents estimates from FIA Resource Use Monitoring, which includes data from Kentucky's Timber Products Output (TPO) surveys and Harvest Utilization studies, covering the 2015–2019 period. Timber Products Output surveys are used to determine the types and amount of roundwood products (i.e., saw logs, pulpwood, plywood and veneer logs, etc.) received by primary wood using mills, the county of origin, species used and how the mills disposed of wood residues produced. Industry surveys conducted in 2015, 2017, 2018, and 2019 were used to determine the output for timber products and planned byproducts. Data used for this section were compiled from the NRUM Tools–Timber Products Output (TPO) Interactive Reporting Tool and National Resource Use and Monitoring Data Download and can be found at <https://research.fs.usda.gov/programs/nrum#data-and-tools-> (USDA Forest Service 2024b).

Prior to 2018, FIA collected TPO information through a biennial survey of all active primary mills. From 2018 forward, data collection has been based on an annual mill sample where roughly 40 percent of active mills are sampled using a stratified sample design (Westfall et al. 2022). The sample design was implemented to provide for annualized TPO data, both to meet users' needs and the requirements of the 2014 Farm Bill

provisions for FIA (AREERA 1998). The surveys and harvest utilization studies were conducted by SRS and KDF personnel. These data are used to augment the FIA annual inventory of all-live timber removals to derive the proportions that are used for timber products. Individual TPO studies, or industry surveys, are necessary to track trends and capture changes in product output levels.

In 2015, volume harvested and delivered for products (including residential fuelwood) from all sources totaled 210.6 million cubic feet (7.8 million green tons) (table 16). Output volumes slightly declined in 2017 to 209.9 million cubic feet (8.1 million green tons) continued to decrease in 2018 to 202.9 million cubic feet (7.7 million green tons). Output volumes moderately decreased in 2019 to 193.5 million cubic feet (7.3 million green tons). Hardwood output volume was relatively stable across the reporting period. Volume harvested for hardwood products in 2015 totaled 146.5 million cubic feet (5.5 million green tons) and accounted for 89 percent of the total industrial product volume, while the volume increased slightly in 2017 to 148.3 million cubic feet (5.8 million green tons). In 2018, there was a moderate decrease from the 2017 output hardwood volume totals to 138.4 million cubic feet (5.4 million green tons). Volume harvested for hardwood products rebounded in 2019 to 148.5 million cubic feet (5.7 million green tons). The percentage of hardwood roundwood harvested increased to a high of 95 percent in 2019. Softwood output volume showed more volatility for the report period but trended downward overall. Volume harvested for softwood products in 2015 totaled 18 million cubic feet (543,000 green tons) and the volume moderately increased in 2017 to 24.7 million cubic feet (857,000 green tons). In 2018, there was a moderate increase from the 2017 output softwood volume totals to 27.5 million cubic feet (958,000 green tons). Volume harvested for softwood products sharply decreased in 2019 to 8.1 million cubic feet (280,000 green tons). The percentage of softwood roundwood harvested decreased to a low of 5 percent in 2019.

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Table 16—Output of industrial roundwood products by product, species group and year, Kentucky, 2019

Product	Species group	2015	2017	2018	2019	2015	2017	2018	2019
		<i>thousand cubic feet</i>				<i>million green tons</i>			
Saw logs	Softwood	3,809	18,867	21,468	2,427	134,879	668,054	759,559	85,899
	Hardwood	120,117	128,475	123,607	126,257	4,604,925	4,948,269	4,684,292	4,784,031
	Total	123,926	147,342	145,075	128,684	4,739,804	5,616,323	5,443,851	4,869,930
Bioenergy/ fuelwood	Softwood	1,211	995	697	697	42,465	34,889	24,433	24,433
	Hardwood	1,803	1,789	2,195	5,190	66,862	66,331	81,420	192,473
	Total	3,014	2,784	2,892	5,887	109,327	101,220	105,853	216,906
Poles, posts, pilings	Softwood	4,294	—	—	—	102,612	—	—	—
	Hardwood	3	—	—	—	86	—	—	—
	Total	4,297	0	0	0	102,698	0	0	0
Miscellaneous ¹	Softwood	8,718	4,792	5,346	5,016	305,068	154,211	173,836	169,371
	Hardwood	24,597	18,031	12,601	17,023	903,972	799,022	597,101	703,559
	Total	33,315	22,823	17,947	22,039	1,209,040	953,233	770,937	872,930
Total (Industrial)	Softwood	18,032	24,654	27,511	8,140	542,559	857,154	957,828	279,703
	Hardwood	146,520	148,295	138,403	148,470	5,508,983	5,813,622	5,362,813	5,680,063
	Total	164,552	172,949	165,914	156,610	6,051,542	6,670,776	6,320,641	5,959,766
Residential fuelwood ²	Undifferentiated	46,056	36,936	36,936	36,936	1,727,100	1,385,100	1,385,100	1,385,100
	Total	46,056	36,936	36,936	36,936	1,727,100	1,385,100	1,385,100	1,385,100
Total	Softwood	18,032	24,654	27,511	8,140	542,559	857,154	957,828	279,703
	Hardwood	146,520	148,295	138,403	148,470	5,508,983	5,813,622	5,362,813	5,680,063
	Undifferentiated	46,056	36,936	36,936	36,936	1,727,100	1,385,100	1,385,100	1,385,100
	Total	210,608	209,885	202,850	193,546	7,778,642	8,055,876	7,705,741	7,344,866

Numbers in rows and columns may not add to totals due to rounding.

¹ Includes mulch, shavings and other miscellaneous products.

² Residential fuelwood volume from the latest U.S. Dept. of Energy estimates.

— = No data.

The total number of sawmills moderately increased from 197 to 203 from 2015 to 2019. Sawlog output peaked in 2017 and declined in 2018 and 2019. In 2015, 123.9 million cubic feet were produced, increasing in 2017 to 147.3 million cubic feet. Saw log production declined in both 2018 and 2019, to 145.1 and 128.7 million cubic feet respectively. Sawlog output increased 4 percent over the 2015–2019 report period and 22 percent from 2011 to 2019. At 126.3 million cubic feet (4.8 million green tons) hardwoods accounted for 98 percent of sawlog output volume while softwood

output volume totaled 2.4 million cubic feet (85,000 green tons) in 2019. Sawn products were the leading product produced in the State for the 2015 to 2019 reporting period. The 203 sawmills in the State accounted for 82 percent of the total industrial product output in 2019.

Volume used for bioenergy and commercial fuelwood totaled 5.9 million cubic feet (217,000 green tons) and accounted for 4 percent of total industrial product output in 2019, the peak for this report period. In 2017, biofuel and commercial

fuelwood production was the lowest for the report period at 2.8 million cubic feet (101,000 green tons) and 2 percent of total product output. Use of roundwood for bioenergy and commercial fuelwood production remained relatively flat from 2015 to 2018, with a sharp increase of 104 percent from 2018 to 2019. Use of roundwood for bioenergy and commercial fuelwood production increased 95 percent during the 2015 to 2019 reporting period.

Volume harvested for other roundwood products including pulp and paper, post, veneer and plywood, and other nonreported categories totaled 37.6 million cubic feet (1.3 million green tons) and accounted for 23 percent of total industrial product output in 2015. In 2019 other industrial production was 22 million cubic feet (873,000 green tons) and 14 percent of total industrial product output. Other industrial production decreased 41 percent from 2015 to 2019.

Mill Residue

Mill or plant residues are defined as wood material generated in the production of timber products from roundwood at primary manufacturing plants. This material falls into three main categories (1) coarse residues, or material, such as slabs, edgings, trim, veneer cores and ends, which is suitable for chipping; (2) fine residues, or material, such as sawdust, shavings, and veneer residue, which is not suitable for chipping, and (3) bark which is used mainly for industrial fuel.

For many years, most mill residue produced in Kentucky has been utilized either for primary products such as pulp and bioenergy or in secondary products such as mulch and animal bedding, or as fuel at wood product mills.

Table 17 depicts the volume of mill residue by roundwood and residue type. Data on mill residue production and disposal generated from 2015 through 2019 forest industry surveys indicated

107.6 million cubic feet of wood and bark residue was generated from primary processors in 2017, the peak for this reporting period. This total moderately decreased each year to 87.7 million cubic feet in 2019. The most recent survey in 2019 shows sawmills generated most of the mill residue produced totaling 81.9 million cubic feet. In 2019 bark accounted for 18.5 million cubic feet (21 percent), coarse residues accounted for 42.8 million cubic feet (49 percent), and sawdust and shavings accounted for 26.4 million cubic feet (30 percent) of mill residue produced. Residue totals show the largest increase, 18 percent, for all residue types from 2015 to 2017. Overall roundwood residue decreased 18 percent from the 2017 total of 107.6 million cubic feet to 87.7 million cubic feet in 2019.

In 2017, 34 million cubic feet (32 percent), of mill residue produced was used for industrial fuel either at pulp mills for boiler fuel or at sawmills for dry kiln operations, pellets, or residential fuelwood (table 18). From 2017 to 2019 this total declined, with 27.1 million cubic feet used for industrial fuel in 2019. There was a moderate increase of 10 percent from 2018 to 2019 to 27.1 million cubic feet. Bark and fine residues, at 6.2 and 11 million cubic feet, respectively, accounted for 63 percent of mill residue utilized for industrial fuel in 2019 which is below the average of 67 percent for the 2015–2019 period. In 2019, 34 percent of bark residue produced was utilized for fuel, with the remainder of the utilized bark going for miscellaneous products or unused. Mill residue produced in Kentucky from 2015 to 2019 was predominately used for miscellaneous products. During 2015, 2017, 2018, and 2019; 45, 50, 42 and 41 percent of the coarse residue produced was utilized for fiber products, respectively. Bark and wood residues not utilized accounted for <4 percent of all residues produced in the 2015–2019 report period.

Table 17—Primary mill residue volume by roundwood type, species group, and residue type, Kentucky, 2019

Roundwood type and species group	All types						Residue type											
				Bark			Coarse			Sawdust			Shavings					
	2015	2017	2018	2019	2015	2017	2018	2019	2015	2017	2018	2019	2015	2017	2018	2019	2015	2017
<i>thousand cubic feet</i>																		
Saw logs																		
Softwood	2,422	13,581	4,749	2,745	315	1,762	617	357	1,275	7,154	2,502	1,448	831	4,661	1,630	940	1	4
Hardwood	79,998	86,580	78,537	79,200	13,106	14,198	12,879	12,993	41,329	44,775	40,615	40,973	25,446	27,568	25,007	25,227	117	39
Total	82,420	100,161	83,286	81,945	13,421	15,960	13,496	13,350	42,604	51,929	43,117	42,421	26,277	32,229	26,637	26,167	118	43
Bioenergy/ fuelwood																		
Softwood	0	0	0	0	—	0	0	0	—	0	0	0	—	0	0	0	0	0
Hardwood	0	32	32	80	—	32	32	80	—	0	0	0	—	0	0	0	0	0
Total	0	32	32	80	0	32	32	80	0	0	0	0	0	0	0	0	0	0
Poles, Posts, Pilings																		
Softwood	923	0	0	0	923	—	—	—	0	—	—	—	0	—	—	—	0	—
Hardwood	0	0	0	0	0	—	—	—	0	—	—	—	0	—	—	—	0	—
Total	923	0	0	0	923	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellaneous¹																		
Softwood	816	2,317	2,223	2,248	816	2,317	2,223	2,248	0	0	0	0	0	0	0	0	0	0
Hardwood	6,782	5,078	2,386	3,441	6,460	4,703	1,767	2,822	213	248	409	409	109	127	210	210	0	0
Total	7,598	7,395	4,609	5,689	7,276	7,020	3,990	5,070	213	248	409	409	109	127	210	210	0	0
Total																		
Softwood	4,161	15,898	6,972	4,993	2,054	4,079	2,840	2,605	1,275	7,154	2,502	1,448	831	4,661	1,630	940	1	4
Hardwood	86,780	91,690	80,955	82,721	19,566	18,933	14,678	15,895	41,542	45,023	41,024	41,382	25,555	27,695	25,217	25,437	117	39
Total	90,941	107,588	87,927	87,714	21,620	23,012	17,518	18,500	42,817	52,177	43,526	42,830	26,386	32,356	26,847	26,377	118	43

Numbers in rows and columns may not add to totals due to rounding.

¹ Includes mulch, shavings, and other industrial products.

— = No data available.

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Table 18—Disposal of residue at primary wood-using plants by product, species group, and type of residue, Kentucky, 2015–2019

Product and species group		All types				Bark				Coarse				Fine			
		2015	2017	2018	2019	2015	2017	2018	2019	2015	2017	2018	2019	2015	2017	2018	2019
<i>thousand cubic feet</i>																	
Fiber products	Softwood	32	5,268	560	609	0	0	0	0	32	5,268	560	609	0	0	0	0
	Hardwood	21,235	21,955	19,208	18,290	0	0	0	0	19,384	20,753	17,603	17,083	1,851	1,202	1,605	1,207
	Total	21,267	27,223	19,768	18,899	0	0	0	0	19,416	26,021	18,163	17,692	1,851	1,202	1,605	1,207
Industrial fuel	Softwood	1,356	2,077	481	360	777	764	278	197	547	377	98	76	32	936	105	87
	Hardwood	24,976	31,938	24,056	26,753	8,975	8,025	4,726	6,004	6,794	12,030	7,354	9,846	9,207	11,883	11,976	10,903
	Total	26,332	34,015	24,537	27,113	9,752	8,789	5,004	6,201	7,341	12,407	7,452	9,922	9,239	12,819	12,081	10,990
Miscellaneous	Softwood	2,511	6,750	5,910	3,504	1,116	3,037	2,548	2,283	637	629	1,839	369	758	3,084	1,523	852
	Hardwood	36,434	36,790	35,179	33,903	9,885	10,687	9,480	9,238	13,494	11,637	14,653	12,240	13,055	14,466	11,046	12,425
	Total	38,945	43,540	41,089	37,407	11,001	13,724	12,028	11,521	14,131	12,266	16,492	12,609	13,813	17,550	12,569	13,277
Not used	Softwood	260	1,804	19	519	159	279	13	125	59	880	4	393	42	645	2	1
	Hardwood	4,136	1,008	2,514	3,774	706	222	473	653	1,871	603	1,415	2,213	1,559	183	626	908
	Total	4,396	2,812	2,533	4,293	865	501	486	778	1,930	1,483	1,419	2,606	1,601	828	628	909
All products	Softwood	4,159	15,899	6,970	4,992	2,052	4,080	2,839	2,605	1,275	7,154	2,501	1,447	832	4,665	1,630	940
	Hardwood	86,781	91,691	80,957	82,720	19,566	18,934	14,679	15,895	41,543	45,023	41,025	41,382	25,672	27,734	25,253	25,443
	Total	90,940	107,590	87,927	87,712	21,618	23,014	17,518	18,500	42,818	52,177	43,526	42,829	26,504	32,399	26,883	26,383

Numbers in rows and columns may not add to totals due to rounding.



View of Natural Arch in fall, Daniel Boone National Forest, Kentucky.

Land Use Removals

Land use removals (land clearing or set aside forest land), or removal volume attributed to land-use change, accounted for 13 to 16 percent of total removals for each year surveyed 2015–2019 (table 19). The volume of land use removals increased each year during the report period, ranging from 38.1 million cubic feet in 2015 to 51.4 million cubic feet in 2019. The nonmerchantable (nongrowing stock) portion of live trees accounted for 58 percent of land-use change removals for the entire 2015–2019 reporting period.

Logging Residue

The merchantable (growing stock) portions of trees cut and left onsite are underutilized removals by FIA merchantability standards, while the nonmerchantable (nongrowing stock) portions of trees (part of the 1-foot stump or volume in tops <4 inches in diameter) used for products are considered overutilized removals by FIA merchantability standards. Under- and over-utilization factors used to determine

average annual logging residue estimates used in this section were derived from estimates in the Kentucky harvest and utilization studies conducted from 2015 through 2019. Logging residue has been considered a possible source for bioenergy and other timber products during recent years. Logging residue, traditionally, has not had a marketable value. Retrieval of logging residue is a matter of economics and markets. If markets are available and a willingness to pay a reasonable price exists, then more total tree volume (including what has been left as logging residues) is utilized for products.

Woody material typically left on a logging site includes (1) whole trees, ≥ 5 inches d.b.h., or portions of the merchantable boles of severed trees broken and left during the felling operation (merchantable); (2) small trees, <5 inches d.b.h., damaged or killed during harvesting operations (nonmerchantable); and (3) residual stump portions, tops, and limbs or forks not utilized because of insufficient size or quality to fit on the trailers (nonmerchantable).

Table 19—Volume of timber removals by State, species group, removals class and source, Kentucky, 2019

Year	Species group	Roundwood products			Logging residues			Other removals			All removals		
		Growing stock	Nongrowing stock	All sources	Growing stock	Nongrowing stock	All sources	Growing stock	Nongrowing stock	All sources	Growing stock	Nongrowing stock	All sources
thousand cubic feet													
2015	Softwood	16,897	1,135	18,032	1,823	3,615	5,438	470	932	1,402	19,190	5,682	24,872
	Hardwood	144,386	2,134	146,520	36,235	49,083	85,318	15,598	21,129	36,727	196,219	72,346	268,565
	Total	161,283	3,269	164,552	38,058	52,698	90,756	16,068	22,061	38,129	215,409	78,028	293,437
2017	Softwood	23,413	1,240	24,653	1,699	3,370	5,069	408	810	1,218	25,520	5,420	30,940
	Hardwood	146,223	2,072	148,295	36,225	49,070	85,295	17,205	23,306	40,511	199,653	74,448	274,101
	Total	169,636	3,312	172,948	37,924	52,440	90,364	17,613	24,116	41,729	225,173	79,868	305,041
2018	Softwood	26,371	1,140	27,511	2,055	4,075	6,130	458	909	1,367	28,884	6,124	35,008
	Hardwood	136,485	1,917	138,402	39,215	53,120	92,335	17,939	24,299	42,238	193,639	79,336	272,975
	Total	162,856	3,057	165,913	41,270	57,195	98,465	18,397	25,208	43,605	222,523	85,460	307,983
2019	Softwood	7,532	608	8,140	2,138	4,239	6,377	437	867	1,304	10,107	5,714	15,821
	Hardwood	146,132	2,338	148,470	44,724	60,582	105,306	21,265	28,806	50,071	212,121	91,726	303,847
	Total	153,664	2,946	156,610	46,862	64,821	111,683	21,702	29,673	51,375	222,228	97,440	319,668

Numbers in rows and columns may not add to totals due to rounding.

This wood material left on site is known as merchantable and nonmerchantable logging residues.

FIA calculates the merchantable portion of logging residue in a two-stage process. First, for those plots that were classified as timberland during the previous inventory and stayed in timberland for the current inventory cycle, the volume of whole trees cut and not utilized are identified by FIA field crews during the remeasurement phase of the inventory. A removal volume is derived for trees that are classified in this category. Second, underutilization factors derived from felled-tree utilization studies are applied to the volume classified as utilized by field crews for the remainder of the merchantable portion of logging residue.

The total removal volume is from the merchantable and nonmerchantable portions of removal trees. Over-utilization factors from the utilization studies were used to determine how much of the nonmerchantable portion of removals was used for timber products. The nonmerchantable volume is calculated for the land-use change removal estimate and added to the merchantable volume for a total land-use change removal volume. With the nonmerchantable portion of timber products and land-use change values calculated and subtracted from total nonmerchantable removals volume, the remainder is the volume of nonmerchantable logging residues.

The logging residue volume in Kentucky for 2015 totaled 90.8 million cubic feet showing a decrease to 90.4 million cubic feet in 2017, increasing to

98.5 million cubic feet in 2018, and increasing to 111.7 million cubic feet in 2019 (table 19). This volume accounted for 30–35 percent of total timber removals for the previously stated survey years. During 2015, logging residue from the merchantable portion of all-live removals totaled 38.1 million cubic feet (42 percent of total logging residue). Logging residue from the merchantable portion of all-live tree removals generally increased each year up to 2019 at 46.9 million cubic feet (42 percent of total logging residue). The merchantable portion of logging residue for both softwood and hardwood combined accounted for 12 to 15 percent of total live removals for those survey periods. For softwoods, the merchantable portion of logging residue accounted for 5 to 7 percent of the total softwood all-live tree removals for the 2015 through 2018 surveys. The softwood merchantable portion of logging residue was 14 percent of the total softwood all-live tree removals for 2019. The merchantable portion of hardwood logging residue proportion remained stable at 42 percent for 2015, 2017, 2018 and 2019 (36.2., 36.2, 39.2, and 44.7 million cubic feet, respectively). Nonmerchantable sources (such as the residual stump, forks, tops, and limbs) accounted for 52.7 million cubic feet, or 58 percent of total logging residue in 2015. This percentage was steady at 58 percent for each year from 2015 through 2019, and the amount produced decreased to 52.4 million cubic feet in 2017, increased to 57.2 million cubic feet in 2018, and increased to 64.8 million cubic feet in 2019.

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GLOSSARY

All-live tree—All living trees. All size classes, all tree classes, and both saw-log and nonsaw-log species are included. See: FIA tree species list in the field manual.

Average annual mortality—Average annual volume of trees ≥ 5.0 inches d.b.h. that died from human and natural causes during the intersurvey period, excluding those removed by harvesting, cultural operations, land clearing or changes in land use.

Average annual removals—Average annual volume of trees ≥ 5.0 inches d.b.h. removed from the inventory by harvesting, cultural operations (such as timber-stand improvement), land clearing, or changes in land use during the intersurvey period.

Average net annual growth—Average annual net change in volume of trees ≥ 5.0 inches d.b.h./d.r.c. without taking into account losses from cutting (gross growth minus mortality) during the intersurvey period.

Biomass—For the southern region, total aboveground biomass is estimated using allometric equations and is defined as the aboveground weight of wood and bark in live trees ≥ 1.0 inch d.b.h./d.r.c. from the ground to the tip of the tree, excluding all foliage (leaves, needles, buds, fruit, and limbs < 0.5 inch in diameter). Biomass is expressed as oven-dry weight and the units are tons.

Note: the weight of wood and bark in limbs < 0.5 inch in diameter is included in the biomass of small-diameter trees.

Additionally, biomass in the merchantable stem is estimated regionally, where the main and merchantable stems are defined as follows.

Main stem—The central portion of the tree extending from the ground level to the tip for timber species. Woodland species includes from ground level to the tips of all branches of qualifying stems. For timber species trees that fork, the main stem refers to the fork that would yield the most merchantable volume.

Merchantable stem—That portion of the main stem of a timber species tree from a 1-foot stump to a minimum 4-inch top diameter inside or outside bark depending on species. That portion of a woodland species tree from the d.r.c. measurements to the 1.5-inch diameters of all the qualifying stems.

Nationally aboveground and belowground biomass is estimated from each tree's sound volume using a Component Ratio Method that is consistently applied in all FIA regions.

Gross aboveground biomass—Total tree biomass excluding foliage and roots with no deductions made for rotten, missing, or broken-top cubic-foot cull.

Net aboveground biomass—Gross aboveground biomass minus deductions for missing cull, broken-top, and a reduction for a proportion of rotten cull for live or standing dead trees ≥ 5.0 inches d.b.h. (Rotten cull will have a factor to reduce specific gravity separately from sound wood). Live and standing dead trees 1.0 to 4.9 inches only have deductions for broken-top cull. Additional deductions are made for dead trees ≥ 1.0 inch using decay class.

Belowground biomass—Coarse roots only.

Further, the total net aboveground biomass estimated using the Component Ratio Method is divided into the following components:

Top—That portion of the main stem of a timber species tree above the 4-inch top diameter. For woodland species, this component of the biomass is included with branches.

Branches—All the branches of a timber species tree excluding the main stem. That portion of all the branches of qualifying stems of woodland species above the 1.5-inch diameter ends.

Bole—See: Merchantable stem.

Stump—That portion of timber species below 1-foot to ground level. That portion of woodland species from all the d.r.c. measurements to ground level.

Blind check—A reinstallation done by a qualified inspection crew without production crew data on hand; at least two full subplots are completely remeasured along with all the plot level information. The two datasets are maintained separately. Discrepancies between the two sets of data are not reconciled. See: Quality assurance and quality control.

Bole—Trunk or main stem of a tree. (See: Main stem.)

Census water—See: Land use.

Coarse woody debris (CWD)—Downed, dead tree and shrub boles, large limbs, and other woody pieces with a minimum small-end diameter of ≥ 3 inches and a length of ≥ 3 feet not attached to a living or standing dead source.

Cold check—An inspection done either as part of the training process, or as part of the ongoing quality control program. Normally the installation crew is not present at the time of inspection. The inspector has the completed data in-hand at the time of inspection. The inspection can include the whole plot or a subset of the plot. Data errors are corrected. See: Quality assurance and quality control.

Components of change—Volume increment and decrement values that explain the change in inventory between two points in time. Components of change are usually expressed in terms of growing-stock or all-live merchantable volume. These components can be expressed as average annual values by dividing the component by the number of years in the measurement cycle. FIA inventories are designed to measure net change over time, as well as the individual components of change that constitute net change (e.g., growth, removals, mortality). Change estimates are computed for two sequential measurements of each inventory panel. Upon remeasurement, a new initial inventory is established for remeasurement at the next scheduled inventory. As such, computation of change components is not intended to span more than one inventory cycle. Rather, the change estimation process is repeated cycle by cycle. This simplifies field protocols and ensures that change estimation is based on short and relatively constant time intervals (e.g., 5 years). Change estimates for individual panels are combined across multiple panels in the same manner as panels are combined to obtain current inventory parameters such as total standing volume. FIA recognizes the following components of change as prescribed core variables; they usually are expressed in terms of growing-stock or all-live volume, where t is the initial inventory of a measurement cycle, and $t + 1$ is the terminal inventory:

Cut—The volume of trees cut between time t and time $t + 1$. The estimate is based on tree size at the midpoint of the measurement interval (includes cut growth). Tree size at the midpoint is modeled from tree size at time t . Trees felled or killed in conjunction with a harvest or silvicultural operation (whether they are utilized or not) are included, but trees on land diverted from forest to nonforest (diversions) are excluded.

Cut growth—The growth of cut trees between time t and the midpoint of the measurement interval. Tree size at the midpoint is modeled from tree size at time t . This term also includes the subsequent growth on ingrowth trees that achieve the minimum diameter threshold prior to being cut.

Diversion—The volume of trees on land diverted from forest to nonforest (or, for some analyses, this may also include land diverted to reserved forest land and other forest land), whether utilized or not, between time t and time $t + 1$. The estimate is based on tree size at the midpoint of the measurement interval (includes diversion growth). Tree size at the midpoint is modeled from tree size at time t .

Diversion growth—The growth of diversion trees from time t to the midpoint of the measurement interval. Tree size at the midpoint is modeled from tree size at time t . This term also includes the subsequent growth on ingrowth trees that achieve the minimum diameter threshold prior to diversion.

Growth on ingrowth—The growth on trees between the time they grow across the minimum d.b.h./d.r.c. threshold and time $t + 1$.

Ingrowth—The volume of trees at the time that they grow across the minimum d.b.h./d.r.c. threshold between time t and time $t + 1$. The estimate is based on the size of trees at the d.b.h./d.r.c. threshold which is 1.0 inch for all-live trees and 5.0 inches for growing-stock trees. This term also includes trees that subsequently die (i.e., ingrowth mortality), are cut (i.e., ingrowth, cut), or diverted to nonforest (i.e., ingrowth diversion); as well as trees that achieve the minimum threshold after an area reverts to a forest land use (i.e., reversion ingrowth).

Mortality—The volume of trees that die from human or natural causes between time t and time $t + 1$. The estimate is based on tree size

at the midpoint of the measurement interval (includes mortality growth). Tree size at the midpoint is modeled from tree size at time t .

Mortality growth—The growth of trees that died from human or natural causes between time t and the midpoint of the measurement interval. Tree size at the midpoint is modeled from tree size at time t . This term also includes the subsequent growth on ingrowth trees that achieve the minimum diameter threshold prior to mortality.

Reversion—The volume of trees on land that reverts from a nonforest land use to a forest land use (or, for some analyses, land that reverts from any source to timberland) between time t and time $t + 1$. The estimate is based on tree size at the midpoint of the measurement interval. Tree size at the midpoint is modeled from tree size at time $t + 1$.

Reversion growth—The growth of reversion trees from the midpoint of the measurement interval to time $t + 1$. Tree size at the midpoint is modeled from tree size at time $t + 1$. This term also includes the subsequent growth on ingrowth trees that achieve the minimum diameter threshold after reversion.

Survivor growth—The growth on trees tallied at time t that survive until time $t + 1$.

The following components of change may be used to further quantify changes in growing-stock (but not all-live) volume:

Cull decrement—The net gain in growing-stock volume due to reclassification of cull trees to growing-stock trees between two surveys. Cull decrement is the volume of trees that were cull at time t , but growing stock at time $t + 1$. The estimate is based on tree size at the midpoint of the measurement interval. Tree size at the midpoint can be modeled from tree at time t , time $t + 1$, or both.

Cull decrement growth—The growth from the midpoint of the measurement interval to time $t + 1$ on trees that were cull at time t , but growing stock at time $t + 1$. Tree size at the midpoint can be modeled from tree size at time t , time $t + 1$, or both.

Cull increment—The net reduction in growing-stock volume due to reclassification of growing stock trees to cull trees between two surveys. Cull increment is the volume of trees that were growing stock at time t , but cull at time $t + 1$. The estimate is based on tree size at the midpoint of the measurement interval (includes cull increment growth). Tree size at the midpoint can be modeled from tree size at time t , time $t + 1$, or both.

Cull increment growth—The growth to the midpoint of the measurement interval between time t and $t + 1$ of trees that were growing stock at time t , but cull trees at time $t + 1$. Tree size at the midpoint can be modeled from tree size at time t , time $t + 1$, or both.

Condition class—The combination of discrete landscape and forest attributes that identify, define, and stratify the area associated with a plot. Examples of such attributes include condition status, forest type, stand origin, stand size, owner group, reserve status and stand density.

Cull—Portions of a tree that are unusable for industrial wood products because of rot, form, or other defect. Cull is further categorized as the following:

Broken-top cubic-foot cull—The broken-top proportion of a timber species tree's merchantable portion from the break to the actual or projected 4-inch top diameter outside bark, or to where the central stem forks, where all forks are <4.0 inches diameter. For trees 1.0 to 4.9 inches diameter this is the proportion of the main stem missing due to a broken-top.

Form board-foot cull—The part of the tree's saw-log portion that is sound but not usable

for sawn wood products due to sweep, crook, forking, or other physical culls.

Missing cubic-foot cull—The proportion of a tree's merchantable portion that is missing or absent. Does not include any cull deductions above actual length for broken-top timber trees. Does include cull deductions above actual length for broken-top woodland species. Trees with d.b.h./d.r.c. <5.0 inches have a null value in this field.

Percent board-foot cull—Percentage of sound and unsound board-foot volume, to the nearest 1 percent.

Rotten cubic-foot cull—The proportion of a tree's merchantable portion that is in a decayed state. Does not include any cull deductions above actual length for broken-top timber trees. Does include cull deductions above actual length for broken-top woodland species. Trees <5.0 inches d.b.h. have a null value in this field.

Rotten/missing cull—The part of the tree's merchantable portion that is decayed and/or absent due to other factors.

Total board-foot cull—The proportion of a timber species tree's saw-log portion that is rotten, missing, or sound but not useable for sawn wood products due to sweep, crook, forking, or other physical defects (form board-foot cull). Nonsaw-log species and softwoods <9.0 inches d.b.h. and hardwoods <11.0 inches d.b.h. have a null value in this field.

Cull tree—Live trees that are unsuitable for the production of some roundwood products, now or prospectively. Cull trees can include those with decay (rotten cull) or poor form, limbiness, or splits (rough cull). Rough cull is suitable for pulpwood and other fiber products.

Cycle—One sequential and complete set of panels.

Diameter at breast height (d.b.h.)—The diameter for tree stem, located at 4.5 feet above the ground (breast height) on the uphill side of a tree. The point of diameter measurement may vary on abnormally formed trees.

Diameter class—A classification of trees based on diameter outside bark, measured at breast height (d.b.h.) above the ground or at root collar (d.r.c.). Note: Diameter classes are commonly in 2-inch increments, beginning with 2-inches. Each class provides a range of values with the class name being the approximate midpoint. For example, the 6-inch class includes trees 5.0 through 6.9 inches d.b.h.

Disturbance—Natural or human-caused disruption that is ≥ 1.0 acre in size and results in mortality and/or damage to 25 percent of all trees in a stand or 50 percent of an individual species' count or, in the case when the disturbance does not initially affect tree growth or health (e.g. grazing, browsing, flooding, etc.), affects 25 percent of the soil surface or understory vegetation. For initial forest plot establishment the disturbance must be within the last 5 years. For remeasured plots only those disturbances that have occurred since the previous inventory are recognized.

Diversion—See: Components of change.

Down woody material (DWM)—DWM is dead material on the ground in various stages of decay. It includes coarse and fine woody material. Previously named down woody debris (DWD). The depth of duff layer, litter layer, and overall fuelbed; fuel loading on the microplot; and residue piles are also measured as part of the DWM indicator for FIA.

Dry weight—The oven-dry weight of biomass.

Federal land—An ownership class of public lands owned by the U.S. Government. (See: Ownership).

Fine woody debris (FWD)—Downed, dead branches, twigs, and small tree or shrub boles

<3 inches in diameter not attached to a living or standing dead source.

Fixed-radius plot—A circular sampled area with a specified radius in which all trees of a given size, shrubs, or other items are tallied.

Forest floor—The entire thickness of organic material overlying the mineral soil, consisting of the litter and the duff (humus).

Forest industry land—See: Ownership.

Forest land—Land that is at least 10 percent stocked by forest trees of any size, or land formerly having such tree cover, and is not currently developed for a nonforest use. The minimum area for classification as forest land is 1 acre. Roadside, streamside, and shelterbelt strips of timber must be at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams and other bodies of water, or natural clearings in forested areas shall be classified as forest, if <120 feet in width or 1.0 acre in size. Forest land is divided into timberland, reserved forest land, and other forest land (such as woodland).

Forest type—A classification of forest land based upon and named for the tree species that forms the plurality of live-tree stocking. A forest-type classification for a field location indicates the predominant live-tree species cover for the field location; hardwoods and softwoods are first grouped to determine predominant group, and forest type is selected from the predominant group.

Forest-type group—A combination of forest types that share closely associated species or site requirements.

Elm-ash-cottonwood—Forests in which elm, ash, or cottonwood, singly or in combination, constitute a plurality of the stocking. (Common associates include willow, sycamore, beech, and maple.)

Loblolly-shortleaf pine—Forests in which loblolly pine, shortleaf pine, or other southern yellow pines, except longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

Maple-beech-birch—Forests in which maple, beech, or yellow birch, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, elm, basswood, and white pine.)

Oak-gum-cypress—Bottomland forests in which tupelo, blackgum, sweetgum, oaks, or southern cypress, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent of stocking, in which case the stand is classified as oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

Oak-hickory—Forests in which upland oaks or hickory, singly or in combination, constitute a plurality of the stocking, except where pines account for 25 to 50 percent, in which case the stand is classified oak-pine. (Common associates include yellow-poplar, elm, maple, and black walnut.)

Oak-pine—Forests in which hardwoods (usually upland oaks) constitute a plurality of the stocking but in which pines account for 25 to 50 percent of the stocking. (Common associates include gum, hickory, and yellow-poplar.)

Growing-stock trees—Live large-diameter timber species (excludes nonsaw-log species) trees with one-third or more of the gross board-foot volume in the entire saw-log portion meeting grade, soundness, and size requirements or the potential to do so for medium-diameter and small-diameter trees. A growing-stock tree must have one 12-foot log or two noncontiguous 8-foot merchantable logs, now (large diameter) or prospectively (medium diameter and small diameter), to qualify as growing stock.

Hardwoods—Tree species belonging to the botanical divisions Magnoliophyta, Ginkgophyta, Cycadophyta, or Pteridophyta, usually angiospermic, dicotyledonous, broad-leaved and deciduous.

Soft hardwoods—Hardwood species with an average specific gravity of ≤ 0.50 , such as gums, yellow-poplar, cottonwoods, red maple, basswoods, and willows.

Hard hardwoods—Hardwood species with an average specific gravity > 0.50 , such as oaks, hard maples, hickories, and beech.

Hot check—An inspection normally done as part of the training process. The inspector is present on the plot with the trainee and provides immediate feedback regarding data quality. Data errors are corrected. Hot checks can be done on training plots or production plots. See: Quality assurance and quality control.

Land—The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river flood plains.

Land cover—The dominant vegetation or other kind of material that covers the land surface. A given land cover may have many land uses.

Land use—The purpose of human activity on the land; it is usually, but not always, related to land cover.

Southern regional present land use categories are as follows:

Accessible timberland—Land that is within the population of interest, is accessible, is on a subplot that can be occupied at subplot center, can safely be visited, and meets the criteria for forest land (see: forest land).

Accessible other forest land—Land that meets the definition of accessible forest land, but is incapable of producing 20 cubic feet per acre per year of industrial wood under natural conditions because of adverse site conditions. Adverse conditions include sterile soils,

dry climate, poor drainage, high elevation, steepness and soil rockiness.

Agricultural land—Land managed for crops, pasture, or other agricultural use. The area must be at least 1.0 acre in size and 120 feet wide (with the exception of windbreak/shelterbelt, which has no minimum width). This land use includes cropland, pasture (improved through cultural practices), idle farmland, orchard, Christmas tree plantation, maintained wildlife opening, and windbreak/shelterbelt.

Rangeland—Land primarily composed of grasses, forbs, or shrubs. This includes lands vegetated naturally or artificially to provide a plant cover managed like native vegetation and does not meet the definition of pasture. The area must be at least ≥ 1.0 acre in size and ≤ 120 feet wide.

Developed—Land used primarily by humans for purposes other than forestry or agriculture. This land use includes cultural (business, industrial/commercial, residential, and other places of intense human activity), rights-of-way (improved roads, railway, power lines, maintained canal), recreation (parks, skiing, golf courses), and mining.

Other—Land parcels ≥ 1.0 acre in size and ≥ 120 feet wide, which do not fall into one of the uses described above. Examples include undeveloped beaches, barren land (rock, sand), marshes, bogs, ice, and snow. This land use includes nonvegetated, wetland, beach, and nonforest-chaparral.

Census water—Rivers and streams that are >200 feet wide and bodies of water >4.5 acres in size.

Noncensus water—Rivers, streams and other bodies of water that do not meet the requirements for census water.

Nonsampled—Not sampled due to denied access, hazardous conditions, being outside the U.S. or other reasons.

Large-diameter trees—Softwoods ≥ 9.0 inches d.b.h. and hardwoods ≥ 11.0 inches d.b.h. These trees were called sawtimber-sized trees in prior surveys. See: Stand-size class.

Litter—Undecomposed or only partially decomposed organic material that can be readily identified (e.g., plant leaves, twigs, etc.).

Main stem—The central portion of the tree extending from the ground level to the tip for timber species. For woodland species the main stem extends from the ground level to the tips of all branches of qualifying stems. For timber species trees that fork, the main stem follows the fork that would yield the most merchantable volume.

Measurement quality objective

(MQO)—A data user's estimate of the precision, bias, and completeness of data necessary to satisfy a prescribed application (e.g., Resource Planning Act, assessments by State foresters, forest planning, forest health analyses). Describes the acceptable tolerance for each data element. MQOs consist of two parts: a statement of the tolerance and a percentage of time when the collected data are required to be within tolerance. MQOs can only be assigned where standard methods of sampling or field measurements exist, or where experience has established upper or lower bounds on precision or bias. MQOs can be set for measured data elements, observed data elements, and derived data elements.

Medium-diameter tree—Softwood timber species 5.0 to 8.9 inches d.b.h. and hardwood timber species 5.0 to 10.9 inches d.b.h. These trees were called poletimber-sized trees in prior surveys. See: Stand-size class.

Microplot—A circular, fixed-radius plot with a radius of 6.8 feet (0.003 acre) that is used to sample trees <5.0 inches d.b.h./d.r.c., as well as other vegetation. Point center is 90 degrees and 12 feet offset from point center of each subplot.

Mortality—See: Components of change.

National forest land—See: Ownership.

Noncensus water—See: Land use.

Nonforest land—Land that does not support or has never supported, forests, and lands formerly forested where use for timber management is precluded by development for other uses. Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining rights-of-way, power line clearings of any width, and noncensus water. If intermingled in forest areas, unimproved roads and nonforest strips must be ≥ 120 feet wide, and clearings, etc., ≥ 1.0 acre in size, to qualify as nonforest land.

Nonindustrial private forest land—See: Ownership.

Other forest land—Forest land other than timberland and reserved forest land. It includes available and reserved forest land that is incapable of producing 20 cubic feet per acre per year of wood under natural conditions because of adverse site conditions such as sterile soils, dry climate, poor drainage, high elevation, steepness, or rockiness.

Other public land—See: Ownership.

Other removals—The volume of trees removed from the inventory by cultural operations such as timber stand improvement, land clearing, and other changes in land use, resulting in the removal of the trees from timberland.

Ownership—A legal entity having control of a parcel or group of parcels of land. An ownership may be an individual; a combination of persons; a legal entity such as corporation, partnership, club, or trust; or a public agency.

National forest land—Federal land that has been legally designated as national forests or purchase units, and other land under the administration of the Forest Service, including

experimental areas and Bankhead-Jones Title III land.

Forest industry land—An ownership class of private lands owned by a company or an individual(s) operating a primary wood-processing plant.

Nonindustrial private forest (NIPF) land—Privately owned land excluding forest industry land.

Corporate—Owned by corporations, including incorporated farm ownerships.

Individual—All lands owned by individuals, including farm operators.

Other public—An ownership class that includes all public lands except national forests.

Miscellaneous Federal land—Federal land other than national forests.

State, county, and municipal land—Land owned by States, counties, and local public agencies or municipalities, or land leased to these governmental units for 50 years or more.

Phase 1 (P1)—FIA activities related to remote sensing, the primary purpose of which is to label plots and obtain stratum weights for population estimates.

Phase 2 (P2)—FIA activities conducted on the network of ground plots. The primary purpose is to obtain field data that enable classification and summarization of area, tree, and other attributes associated with forest land uses.

Phase 2+ [Phase 3 (P3)]—A subset of Phase 2 plots where additional attributes related to forest health are measured.

Plantation—Stands that currently show evidence of being planted or artificially seeded.

Poletimber-sized tree—Softwood timber species 5.0 to 8.9 inches d.b.h. and hardwood timber species 5.0 to 10.9 inches d.b.h. Now referred to as medium-diameter trees.

Private land—See: Ownership.

Productivity class—A classification of forest land in terms of potential annual cubic-foot volume growth per acre at culmination of mean annual increment (MAI) in fully stocked natural stands.

Quality assurance (QA)—The total integrated program for ensuring that the uncertainties inherent in FIA data are known and do not exceed acceptable magnitudes, within a stated level of confidence. Quality assurance encompasses the plans, specifications, and policies affecting the collection, processing, and reporting of data. It is the system of activities designed to provide program managers and project leaders with independent assurance that total system quality control is being effectively implemented.

Quality control (QC)—The routine application of prescribed field and laboratory procedures (e.g., random check cruising, periodic calibration, instrument maintenance, use of certified standards, etc.) in order to reduce random and systematic errors and ensure that data are generated within known and acceptable performance limits. Quality control also ensures the use of qualified personnel; reliable equipment and supplies; training of personnel; good field and laboratory practices; and strict adherence to standard operating procedures.

Reserved forest land—Forest land where management for the production of wood products is prohibited through statute or administrative designation. Examples include national forest wilderness areas and national parks and monuments.

Reversion—Land that reverts from a nonforest land use to a forest land use. See: Components of change.

Sapling—Live trees 1.0 to 4.9 inches d.b.h./d.r.c.

Seedling—Live trees <1.0 inch d.b.h./d.r.c. that are ≥6.0 inches in height for softwoods and ≥12.0 inches in height for hardwoods and >0.5 inch d.b.h./d.r.c. at ground level for longleaf pine.

Small-diameter trees—Trees 1.0 to 4.9 inches in d.b.h./d.r.c. These were called sapling-seedling sized trees in prior surveys. See: Stand-size class.

Softwoods—Tree species belonging to the botanical division Coniferophyta, usually evergreen having needles or scale-like leaves.

Species group—A collection of species used for reporting purposes.

Stand—Vegetation or a group of plants occupying a specific area and sufficiently uniform in species composition, age arrangement, structure, and condition as to be distinguished from the vegetation on adjoining areas.

Stand age—A stand descriptor that indicates the average age of the live dominant and codominant trees in the predominant stand-size class of a condition.

Standing dead tree—A dead tree ≥5.0 inches d.b.h. that has a bole which has an unbroken actual length of at least 4.5 feet, and lean <45 degrees from vertical as measured from the base of the tree to 4.5 feet.

Stand origin—A classification of forest stands describing their means of origin.

Planted—Planted or artificially seeded.

Natural—No evidence of artificial regeneration.

Stand-size class—A classification of forest land based on the diameter-class distribution of live trees in the stand. See definitions of large-, medium-, and small-diameter trees.

Large-diameter stands—Stands at least 10 percent stocked with live trees, with one-half or more of total stocking in large- and medium-diameter trees, and with large-diameter tree stocking at least equal to medium-diameter tree stocking.

Medium-diameter stands—Stands at least 10 percent stocked with live trees, with one-half or more of total stocking in medium- and large-diameter trees, and with medium-diameter tree stocking exceeding large-diameter tree stocking.

Small-diameter stands—Stands at least 10 percent stocked with live trees, in which small-diameter trees account for more than one-half of total stocking.

Nonstocked stands—Stands <10 percent stocked with live trees.

Stand structure—The predominant canopy structure for the condition, only considering the vertical position of the dominant and codominant trees in the stand and not considering trees that are intermediate or overtopped. As a general rule, a different story should comprise 25 percent of the stand.

Nonstocked—The condition is <10 percent stocked.

Single-storied—Most of the dominant/codominant tree crowns form a single canopy (i.e., most of the trees are approximately the same height).

Multistoried—Two or more recognizable levels characterize the crown canopy. Dominant/codominant trees of many sizes (diameters and heights) for a multilevel canopy.

State, county, and municipal land—See: Ownership.

Stocking—1) At the tree level, stocking is the density value assigned to a sampled tree (usually in terms of numbers of trees or basal area per acre), expressed as a percent of the total tree

density required to fully utilize the growth potential of the land. 2) At the stand level, stocking refers to the sum of the stocking values of all trees sampled.

Subplot—A circular area with a fixed horizontal radius of 24.0 feet (1/24 acre), primarily used to sample trees ≥ 5.0 inches at d.b.h./d.r.c.

Survivor tree—A sample tree alive at both the current and previous inventories.

Timberland—Forest land that is producing or capable of producing 20 cubic feet per acre or more per year of wood at culmination of MAI. Timberland excludes reserved forest lands.

Treatment—Forestry treatments are a form of human disturbance. The term treatment further implies that a silvicultural application has been prescribed. This does not include occasional stumps of unknown origin or sparse removals for firewood, Christmas trees, or other miscellaneous purposes. The area affected by any treatment must be at least 1.0 acre in size.

None—No observable treatment.

Cutting—The removal of one or more trees from a stand. SRS FIA categories are the following:

Clearcut harvest—The removal of the majority of the merchantable trees in a stand; residual stand stocking is under 50 percent.

Partial harvest—Removal primarily consisting of highest quality trees. Residual consists of lower quality trees because of high grading or selection harvest (e.g. 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 seed tree. Also includes the final harvest of the seed trees.

Commercial thinning—The removal of trees (usually of medium-diameter) from medium-diameter stands leaving sufficient stocking of growing-stock trees to feature in future stand development. Also included are thinning in large-diameter stands where medium-diameter trees have been removed to improve quality of those trees featured in a final harvest.

Timber stand improvement (cut trees only)—The cleaning, release, or other stand improvement involving noncommercial cutting applied to an immature stand that leaves sufficient stocking.

Salvage 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.

Site preparation—Clearing, slash burning, chopping, disking, bedding, or other practices clearly intended to prepare a site for either natural or artificial regeneration.

Artificial regeneration—Following a disturbance or treatment (usually cutting), a new stand where at least 50 percent of the live trees present resulted from planting or direct seeding.

Natural regeneration—Following a disturbance or treatment (usually cutting), a new stand where at least 50 percent of the live trees present (of any size) were established through the growth of existing trees and/or natural seeding or sprouting.

Other silvicultural treatment—The use of fertilizers, herbicides, girdling, pruning, or other activities designed to improve the commercial value of the residual stand, or chaining, which is a practice used on woodlands to encourage wildlife forage.

Tree—A woody perennial plant, typically large, with a single well-defined stem carrying a more or less definite crown; sometimes defined as attaining a minimum diameter of 3 inches and a minimum height of 15 feet at maturity. For FIA, any plant on the tree list in the current field manual is measured as a tree.

Volume—A measure of the solid content of the tree stem used to measure wood quantity.

Gross board-foot volume—Total board-foot volume of wood inside bark without deductions for total board-foot cull.

Gross cubic-foot volume—Total cubic-foot volume of wood inside bark without deductions for rotten, missing, or broken-top cull.

Net board-foot volume—Gross board-foot volume minus deductions for total board-foot cull.

Net cubic-foot volume—Gross cubic-foot volume minus deductions for rotten, missing, and broken-top cull.

APPENDIX 1—INVENTORY METHODS

The Kentucky 2019 inventory was a three-phase, fixed-plot design conducted on an annual basis. Phase 1 (P1) provides the area estimates for the inventory. Phase 2 (P2) involves on-the-ground measurements of sample plots by field personnel. Phase 2+ or what was formerly known as Phase 3 (P3) is a subset of the P2 plot system, where additional measurements are made by field personnel to aid in the assessment of forest health. The three phases of the sampling method are based on a hexagonal grid design, with successive phases being sampled with less intensity. There are 16 P2 hexagons for every P3 hexagon. P2 and P3 hexagons represent about 6,000 and 96,000 acres, respectively.

Under the annual inventory system, 20 percent (1 panel) of the total number of plots in a State are measured every year over a 5-year period (1 cycle). Each panel of plots is selected on a subgrid that is slightly offset from the previous panel so that each panel covers essentially the same sample area (both spatially and in intensity) as the prior panel. In the sixth year, the plots that were measured in the first panel are remeasured. This marks the beginning of the next cycle of data collection. After field measurements are completed, a cycle of data is available for the 5-year report.

The Kentucky 2019 estimates were made using data from a total of 4,288 points sampled over the course of 5 years. Of these sampled points, 2,438 were found to have forest and a forest inventory plot measured. Of the forested plots, 2,413 were pre-existing plots that were remeasured and used for the estimates of change.

Phase 1

For the 2019 inventory of Kentucky, the P1 forest area estimate was based on classifying National Land Cover Database points collected in 2011. Stratification of forest and nonforest was performed at the unit level. Area estimation of all lands and ownerships was based on the probability of selection of P2 plot locations. As a

result, the known forest land area (for specific ownerships) does not always agree with area estimates based on probability of selection. For example, the acreage of national forests, published by the National Forest System, will not agree exactly with the statistical estimate of national forest land derived by Forest Inventory and Analysis. These numbers could differ substantially for very small areas.

Phase 2

Bechtold and Patterson (2005) describe P2 and P2+ ground plots and explain their use. These plots are clusters of four points arranged so that one point is central and the other three lie 120 feet from it at azimuths of 0, 120, and 240 degrees (fig. A1.1). Each point is the center of a circular subplot with a fixed 24-foot radius. Trees ≥ 5.0 inches diameter at breast height (d.b.h.) are measured in these subplots. Each subplot in turn contains a circular microplot with a fixed 6.8-foot radius. Trees 1.0 to 4.9 inches d.b.h. and seedlings (<1.0 inch d.b.h.) are measured in these microplots (USDA Forest Service 2014).

Sometimes, a plot cluster straddles two or more land use or forest condition classes (Bechtold and Patterson 2005). There are seven condition-class variables that require mapping of a unique condition on a plot: land use, forest type, stand size, ownership, stand density, regeneration status, and reserved status. A new condition is defined and mapped each time one of these variables changes during plot measurement.

Phase 2+

Data on forest health variables (P2+) are collected on about 1/16th of the P2 sample plots. P2+ data are coarse descriptions and are meant to be used as general indicators of overall forest health over large geographic areas. P2+ data collection has included variables pertaining to tree crown health, down woody material, and foliar ozone injury in the past. In recent years, however, the forest health monitoring data collection has evolved with some of the protocols changing and others being put on hiatus pending renovation. Down woody materials data were collected

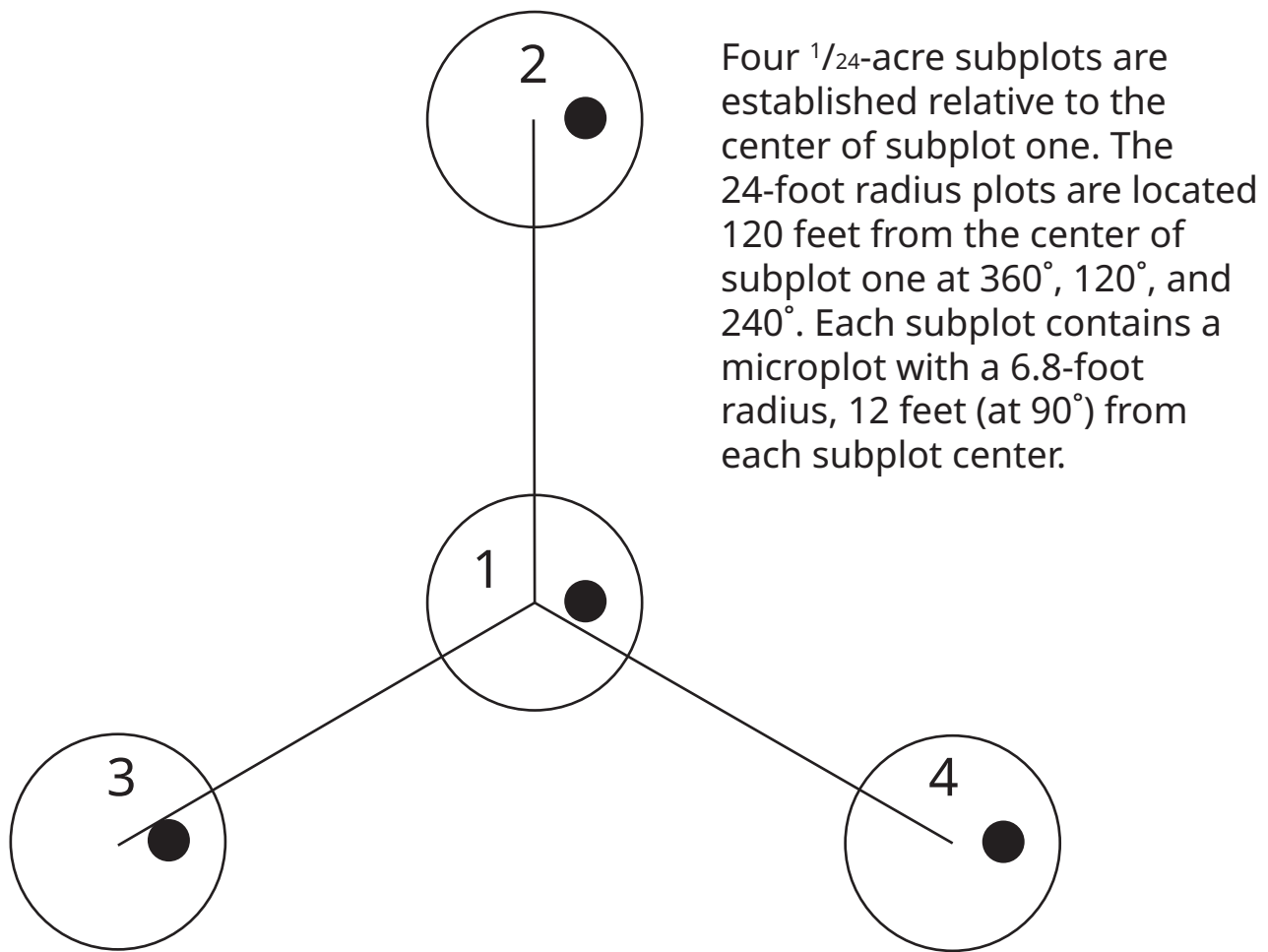


Figure A.1.1—Layout of annual fixed-radius plot design.

for the past cycle of Kentucky forest health monitoring. That data collection took place under a more simplified set of field protocols that can be implemented on a greater number of plots to improve the sample size. This and other forest health monitoring data collection will continue to evolve as these protocols are refined.

Summary

Users wishing to make rigorous comparisons of data between surveys should be aware of any changes in methodologies between measurements and the evolving nature of the FIA program. The most valuable and powerful trend information is obtained when the same plots are revisited

from one survey to the next and measured in the same way. Determining the strength of a trend or determining the level of confidence associated with a trend, is difficult or impossible when sampling methods change over time.

Literature Cited

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APPENDIX 2—DATA RELIABILITY

A relative standard of accuracy has been incorporated into the forest inventory. This standard satisfies user demands, minimizes human and instrumental sources of error, and keeps costs within prescribed limits. The two primary types of error are measurement error and sampling error.

Measurement Error

There are three elements of measurement error: (1) biased error, caused by instruments that are not properly calibrated; (2) compensating error, caused by instruments of moderate precision; and (3) accidental error, caused by human error in measuring and compiling. All of these are held to a minimum by the Forest Inventory and Analysis (FIA) quality assurance (QA) program. The goal of the QA program is to provide a framework of quality control procedures to assure the production of complete, accurate, and unbiased forest assessments for given standards. These methods include the use of nationally standardized field manuals, the use of portable data recorders, thorough entry-level training, periodic review training, supervision, and the use of check plots, editing checks, and an emphasis on careful work. Additionally, data quality is assessed and documented using performance measurements and post-survey assessments. These assessments are then used to identify areas of the data collection process that need improvement or refinement in order to meet the program's quality objectives.

Each variable collected by FIA is assigned a measurement quality objective (MQO) and a measurement tolerance level. The MQOs are documented in the FIA National Field Manual (USDA Forest Service 2014). In some instances, the MQOs are a “best guess” of what experienced field crews should be able to consistently achieve. Tolerances are somewhat arbitrary and are based on the crews' ability to make repeatable measurements or observations within the assigned MQO.

Evaluation of field crew performance is accomplished by calculating the differences between data collected by the field crew and data collected by the QA crew on blind-check plots. Results of these calculations are compared to the established MQOs. In the analysis of blind-check data, an observation is within tolerance when the difference between the field crew observation and the QA crew observation does not exceed the assigned tolerance for that variable. For many categorical variables, the tolerance is “no error” allowed, so only observations that are identical are within the tolerance level.

Sampling Error

Sampling error is associated with the natural and expected deviation of the sample from the true population mean. This deviation is susceptible to a mathematical evaluation of the probability of error. Sampling errors for State totals are based on one standard deviation. That is, there is a 68.27 percent probability that the confidence interval given for each sample estimate will cover the true population mean.

The size of the sampling error generally increases as the size of the area examined decreases. In addition, as area or volume totals are stratified by forest type, species, diameter class, ownership, or other subunits, the sampling error may increase and be greatest for the smallest divisions. However, there may be instances where a smaller component does not have a proportionately larger sampling error. This can happen when the post-defined strata are more homogeneous than the larger strata, thereby having a smaller variance. For specific post-defined strata, the sampling error can be calculated using the following formula. Sampling errors obtained by this method are only approximations of reliability, because this process assumes constant variance across all subdivisions of totals.

$$SE_s = SE_t \frac{\sqrt{X_t}}{\sqrt{X_s}}$$

where

SE_s = sampling error for subdivision of survey unit or State total

SE_t = sampling error for survey unit or State total

X_s = sum of values for the variable of interest (area or volume) for subdivision of survey unit or State

X_t = total area or volume for survey unit or State

For example, the estimate of sampling error for the area of forest land in the Bluegrass survey unit is computed as:

$$SEs = 0.74 \left[\frac{\sqrt{12,382,356}}{\sqrt{1,762,398}} \right] = 1.95$$

where there are 12,382,356 acres of forest land in Kentucky with a sampling error of 0.74 percent and 1,762,398 acres of forest land in the Bluegrass survey unit. Thus, the estimated sampling error for area of forest land in the Bluegrass survey unit is 1.95 percent, and the resulting estimate with 68.27 percent confidence interval for Bluegrass forest land area is 1,762,398 acres $\pm$ 34,367 acres.

Literature Cited

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This resource bulletin consolidates data from the eighth complete survey of Kentucky's forest resources which was conducted during the period 2014–2019 by the U.S. Department of Agriculture (USDA) Forest Service, Forest Inventory and Analysis (FIA) program in cooperation with the Kentucky Division of Forestry (KDF) of the Kentucky Energy and Environment Cabinet. Data on the extent, condition, and classification of forest land and associated timber volumes, as well as growth, removals, and mortality rates are described and interpreted. Data on forest health and forest landowner characteristics are also evaluated. Estimates of forest resources are reported at multiple scales.

Keywords: Forest inventory, timber volume, forest health monitoring, disturbance, resource use, FIA, forest trends, Kentucky.



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