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Kentucky's

Forests, 2009

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Front cover: top left, hardwood forest. (photo by Angie Rowe, U.S. Forest Service); top right, view from Tater Knob in the Daniel Boone National Forest. (photo courtesy of Wikimedia.org); bottom, Kentucky Warbler (*Oporornis formosus*) feeding chicks. (photo courtesy of Steve Maslowski, U.S. Fish and Wildlife Service/Wikimedia.org). Back cover: top left, Bee Lick Creek, Jefferson Memorial Forest. (photo courtesy of John Knouse/ Wikimedia.org); top right, hardwood forest. (photo by Angie Rowe, U.S. Forest Service); bottom, Carolina buckthorn (*Rhamnus caroliniana*), Logan County Glade State Nature Preserve. (photo courtesy of Mason Brock/Wikimedia.org).

Wavyleaf purple coneflower (*Echinacea simulata*) in a prairie near Pennyrile Forest State Resort Park. (photo courtesy of Mason Brock/Wikimedia.org)

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Jefferson Memorial Forest, Tuliptree Trail. (photo courtesy of John Knouse/Wikimedia.org)


A trail winds through Mammoth Cave National Park. (photo courtesy of Huw Williams/Wikimedia.org)

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Positive Developments

• Forests covered an estimated 12.4 million acres across Kentucky in 2009, or about 48 percent of the land base. Kentucky has experienced a slight increase in forest land cover since the late 1950s, when one of the first forest surveys found 11.5 million acres of forest land covering approximately 45 percent of the land base.

• More than 100 (107 to be exact) distinct tree species were sampled across the State. The 20 most numerous species account for about 74 percent of all-live trees. In addition to having large populations in Kentucky, red maple, sugar maple, and yellow-poplar are some of the most widely distributed tree species in the State.

• Statewide, yellow-poplar (Kentucky's State tree) accounts for an estimated 12 percent of all-live volume and accounts for a greater proportion of total live-tree volume than any other single species.

• According to the 2009 inventory, an estimated 88 percent (11.0 million acres) of the forest land in Kentucky is in private ownership. Twelve percent of the forest land in Kentucky is publicly administered by local, State, or Federal agencies.

• In 2009, timberland covered an estimated 12.2 million acres across the State. Timberland in Kentucky has consistently remained approximately 50 percent of all land and 99 percent of all forest land in the State.

Bee Lick Creek, Jefferson Memorial Forest. (photo courtesy of John Knouse/Wikimedia.org)

• The diverse forest products industry in Kentucky is made up of a variety of mills, ranging from small- to medium-sized softwood and hardwood sawmills, pole mills, and post mills to the very large pulpmills. In 2009, there were about 217 sawmills, pulpwood mills, and other primary wood-processing plants distributed across the State.

• Volume harvested and delivered for products (including residential fuelwood) from all sources totaled 194.8 million cubic feet (7.5 million green tons), or 43 percent, of total removals. The merchantable portion of all-live removals accounted for 181.8 million cubic feet (7.0 million green tons), or 93 percent of timber product harvest volume.

• Forest products and the forest industry play a significant role in Kentucky's economy. In 2005, the wood products and paper manufacturing subsectors combined (North American Industry Classification System [NAICS] subsectors 321 and 322, respectively) accounted for 6.8 percent of the State's manufacturing gross domestic product (GDP), a share that increased to 9.5 percent in 2009.

• During 2009, the forest sector provided 23,848 jobs with $1.20 billion in payroll, and contributed $1.91 billion of direct value added to Kentucky's economy. The State's forest sector activity resulted in total employment (direct, indirect, and induced) of 46,137 jobs and labor income close to $2.11 billion. Further, the sector generated $3.45 billion in total value added.

Interesting Trends

• Between 2004 and 2009 an estimated 42,000 acres of forests were lost to a mining land use. Previously 35,000 acres of forests were classified as mining land. Although mining leads to changes on the landscape, the FIA Program observed very little total change in forests resulting from mining activity for the period 2004–09.

• Statewide, 46 different genera were recorded on forested plots. *Quercus* dominated with 19 different species recorded. *Acer* (eight species), *Carya* (eight species), *Ulmus* (six species), *Pinus* (five species), and *Magnolia* (four species) were the other dominant genera found in forests across the State.

• Hardwood forest types have dominated the Kentucky landscape in every FIA inventory of the State, including the 2009 inventory. In fact, between 2004 and 2009, softwood forest-type acreage declined an estimated 61,000 acres.

• In 2009, there were an estimated 79,000 acres in planted forests across Kentucky. Planted acres declined in Kentucky from an estimate of 157,000 acres in 1988 to their lowest point in 2009. The area of planted land dropped from 1.2 percent of all forest land in 1988 to 0.6 percent in 2009.

• Standing volume of all-live trees (≥5 inches d.b.h.) on timberland was nearly 24 billion cubic feet in 2009 an increase from the estimated 22 billion cubic feet of volume on Kentucky timberlands in 2004. Greater than 18 billion cubic feet (77 percent) of all-live standing-tree volume was classified as the oak-hickory forest-type group.

Hundreds of trees destroyed by an F4 tornado that touched down on November 15, 2005 surround a solitary home which was demolished by flying limbs and tree trunks, Madisonville. (photo courtesy of Win Henderson, FEMA/Wikimedia.org)

• The average annual volume harvested for softwood products declined 48 percent from the previous survey period, totaling 66.3 million cubic feet (2.3 million green tons) between 2005 and 2009.

• Land use removals (land clearing or set-aside forest land), or removal volume attributed to land use change, accounted for 23 percent of total removals with 102.7 million cubic feet (3.9 million green tons).

• Kentucky's forests are heavily influenced by many disturbance events. An estimated 2.3 million acres exhibited signs of some type of disturbance during the 2009 inventory. That estimate is the equivalent of about 452,000 acres disturbed annually between 2004 and 2009. Thus, at current rates, an area equivalent to the entire forest land area in Kentucky is disturbed about every 27 years.

Issues and Trends to Watch

• Estimates of the exotic hardwoods forest type increased 181 percent between 2004 and 2009.

• Kentucky's forests are, for the most part, getting older. On average, the age class distribution between 2004 and 2009 shifted to older stands; the area of forests declined in some younger age classes and increased in some older age classes.

• Young forests in Kentucky have been declining. From 1988 to 2009, the area of small diameter stands declined from 16 percent to 10 percent of all forested area. The fact that Kentucky's forests are aging with very few acres of young forest land is concerning. Young forests play a vital role in sustaining healthy, productive forests over the long term.

• In 2009, an estimated 12 percent (8.3 billion board feet) of all sawtimber volume was within grade 1 trees. Sawtimber volume within grade 1 trees has been steadily declining from a peak of 12.8 billion board feet in 2004, when grade 1 material represented approximately 21 percent of all sawtimber volume.

• Nonnative invasive plants were detected on 1,723 plots across the State, or 71 percent of all forested plots measured. Invasive plant presence seems to be lowest in the more heavily forested eastern part of the State. Disturbance (such as harvests and tornadoes) and proximity to agricultural land may account for the larger proportion of plots containing invasive plants in the west-central and western regions.

• Positive collections of emerald ash borer, an invasive beetle, have been made in every State bordering Kentucky, including Tennessee. Therefore, the entire population of ash trees in Kentucky is at risk.

• The recent observation of thousand cankers disease in east Tennessee is the first within the native range of black walnut and poses a serious threat to the species in Kentucky and the Eastern United States.

Introduction

This resource bulletin consolidates data from the sixth complete survey of Kentucky's forest resources, which was conducted during the period 2005–09 by the Forest Service, U.S. Department of Agriculture (USDA) Forest Inventory Analysis (FIA) Program in coordination with the Kentucky Department for Natural Resources Division of Forestry (KDF). 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-scale. The State of Kentucky is divided into seven FIA units (fig. 1) that approximate broad physiographic (see glossary) 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 approximately 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 years. This analysis focuses primarily on changes and trends in recent years and their implications for Kentucky's forests, forest land owners, and citizens (see appendix A—Data Sources and Techniques for further information on data collection methods).

The inventory dates of 2009 and 2004 are repeated throughout this report. The inventory year of 2009 represents data that were collected between 2005 and 2009. The inventory year 2004 represents data that were collected between 2000 and 2004. Estimates of components of change (i.e., growth, removals, and mortality) are calculated from plot measurements collected between 2000 and 2004, and remeasurements of the same plots between 2005 and 2009.

The 2009 inventory accounted for 2,439 forested plots across the State. There were 321, 342, 400, 408, 452, 373, and 143 plots measured in the Eastern, Northern Cumberland, Southern Cumberland,

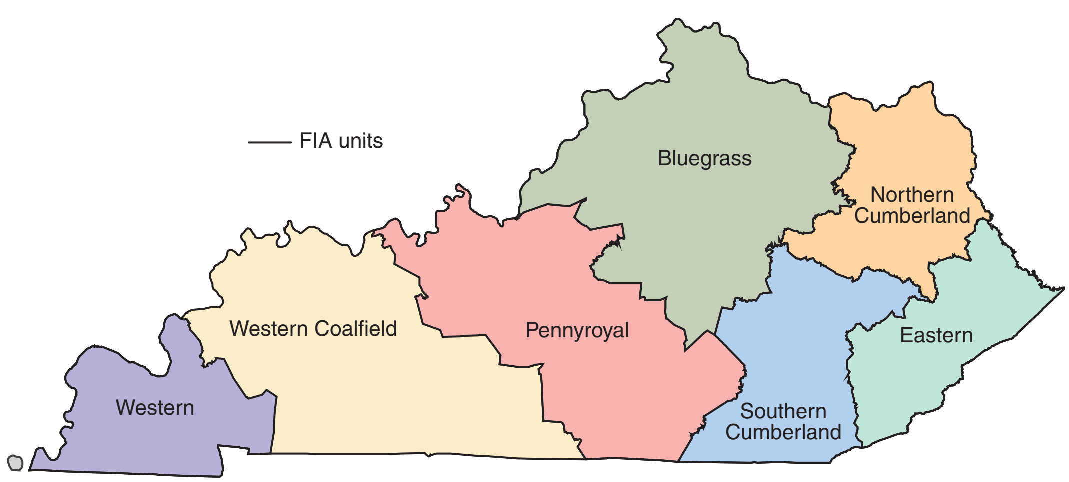


Figure 1—Forest Inventory and Analysis unit boundaries for Kentucky.

Bluegrass, Pennyroyal, Western Coalfield, and Western units, respectively. A total of 2,388 plots measured for the 2004 inventory were remeasured during the 2009 inventory.

Note: Data were accessed and compiled from the Forest Inventory and Analysis Database (FIADB) in November and December 2011 and January 2012. Publicly available data from the FIADB are regularly updated when data collection 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

Five previous inventories have been completed in Kentucky. The inventories of 1949, 1963, 1975, 1988, and 2004 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 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.

State Contributions to Kentucky's Forest Inventory

Concurrent with the implementation of the annual survey design in Kentucky, a strong partnership between FIA and KDF was forged. Working together with shared responsibilities to the annual inventory has helped create solid assessments of Kentucky's forest resources. Currently, KDF implements the daily functions of data collection and has contributed resources that allow for a shorter remeasurement period (5 years as opposed to 7). The FIA Program of the Forest Service provides base funding for the Program along with data collection support through a data quality assurance and training program, data processing, analysis, reporting, database management, and data archiving.

Updates of Past Estimates

In 2010, the SRS FIA Program began the adoption of version 4.0 of the National Information Management System (NIMS) to meet National FIA Program standards. The 2004 Kentucky forest resources report (Turner and others 2008) was based on data processed through version 2.2 of the NIMS. The NIMS version 4.0 processing system included programmatic changes that at times altered standard definitions and estimate derivation. For example, some forest types were retired, some forest types were consolidated, and others included 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) was reprocessed through version 4.0 of the NIMS. The data and estimates available to the public and the estimates presented in this report 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 historical data in electronic form in the FIADB version 4.0. Historical data were converted to the current format of the FIADB. For Kentucky, electronic data are now available for all inventories from 1988 to present.

Forest Extent

Kentucky Forest Land

Forests are an important characteristic of the Kentucky landscape. They play a vital role in Kentucky's economic, cultural, and biological landscape. The dependence of Kentuckians on the State's forests requires that attention be paid to their extent and condition, and regular assessments are necessary. Today in Kentucky, forests are abundant and productive.

Forests covered an estimated 12.4 million acres across Kentucky in 2009 (table 1) or about 48 percent of the land base. By far, the greatest concentrations of forest land are in the east within the Eastern, Northern Cumberland, and Southern Cumberland units (fig. 2). Kentucky has experienced a slight increase in forest land cover since the late 1950s, when one of the first forest surveys found 11.5 million acres of forest land covering approximately 45 percent of the land base (table 1). Since the inception of the annual survey in Kentucky, very little change has occurred in any unit within the State (fig. 3).

Table 1—Forest land area and percent forest land for forest surveys, Kentucky

	Forest land	
Year	Area	Percent[a]
	thousand acres	
1959	11,497	44.5
1963	11,700	45.2
1975	11,900	46.0
1988	12,675	49.0
2004	12,283	47.5
2009	12,401	47.9

[a] Based on the current U.S. Census Bureau estimate of 25.9 million acres of land in Kentucky.

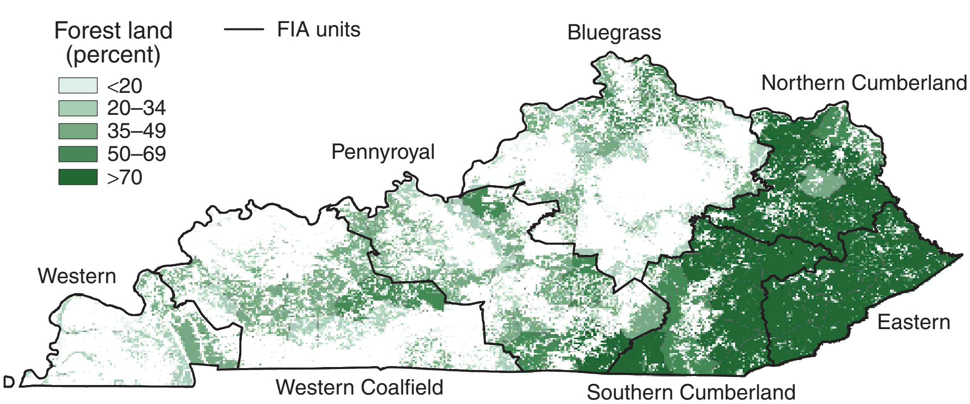


Figure 2—Forest land area as a percentage of total land area for counties, Kentucky, 2009. (Plot locations are approximate.)

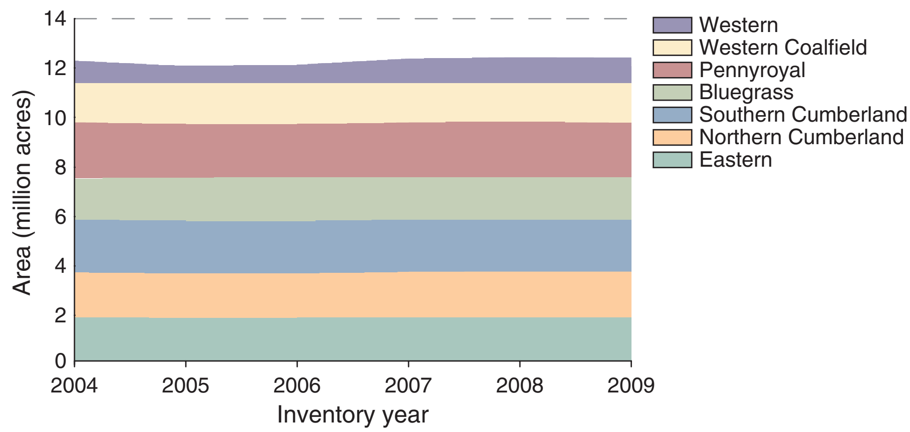


Figure 3—Forest land area by FIA unit, Kentucky, 2004–09.

Land Use and Land Use Change

According to the land use (for example, forest, urban, or agriculture) at the center of each plot, 48 percent of the plots (excluding water) were found in a forested condition (fig. 4). Agricultural land use accounted for 38 percent of plots, while developed land use accounted for 12 percent. Although current land use estimates indicate that a near majority of land in Kentucky is forested, it is important to understand recent land use changes. For example, each year forest land is converted to agricultural land or to urban conditions, and abandoned agricultural lands revert to forest.

Between 2004 and 2009, Kentucky lost an estimated 412,000 acres of forest land to nonforest land uses (table 2). During that same period, however, an estimated 533,000 acres reverted to forest. Overall, Kentucky gained forest land between 2004 and 2009. (Note: the estimated net change in table 2 is not the same as the difference of the 2004 and 2009 estimates of forest land area, and is a result of a lack of complete overlap in plots used for each estimate. The estimates in table 2 use only plots measured during both inventories whereas the 2009 estimate presented earlier includes new forested plots. As a result, slight discrepancies exist among

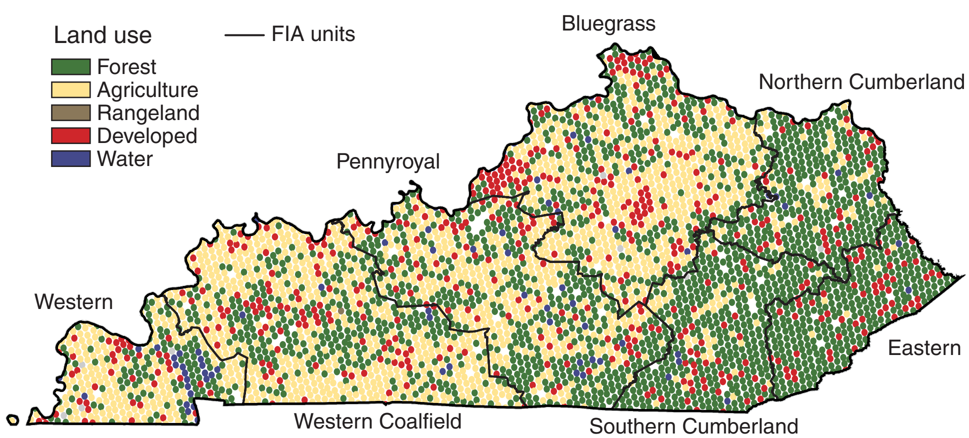


Figure 4—Assigned land use for each phase 2 hexagon of the 2009 annual inventory for Kentucky. Each phase 2 hexagon contains one plot. Land use at plot center was assigned to corresponding hexagon. (Plot locations are approximate.)

Table 2—Land use change, Kentucky, 2004–09

Previous land use	Current land use: Agricultural land	Developed	Forest land	Other	Rangeland	Water	Total
	acres						
Agricultural land	9,237,432	211,711	332,877	11,869	—	22,264	9,816,153
Developed	263,406	2,134,208	174,187	1,510	4,189	7,617	2,585,117
Forest land	195,250	203,087	11,830,106	6,752	1,598	4,868	12,241,661
Other	—	—	1,598	10,303	—	—	11,901
Rangeland	1,794	—	—	—	6,306	—	8,100
Water	18,001	14,194	23,933	8,859	—	496,230	561,217
Total	9,715,883	2,563,200	12,362,701	39,293	12,093	530,979	25,224,149

— = no sample for the cell.

the different estimates.) Mining is an important land use in Kentucky and was therefore isolated to evaluate the activity as a significant driver of forest land loss or gain within the State. For the period 2004–09, an estimated 42,000 acres of forests (timberland and other forest land in table 3) were lost to a mining land use. In 2004, 35,000 acres of forests were classified as mining land. Although mining leads to changes on the landscape, the FIA Program observed very little total change in forests resulting from mining activity for the period 2004–09.

Table 3—Change from and to a mining land use, Kentucky, 2004–09

Land use: Previous	Current	Acres
		thousand
Mining	Timberland	21,131
	Other forest land	13,899
	Cropland	5,882
	Pasture	4,189
	Developed	11,239
	Cultural	5,357
	Rights-of-way	5,631
	Mining	145,900
	Noncensus water	131
Total		213,359
Timberland	Mining	41,572
Developed		57,140
Cultural		4,766
Mining		145,900
Total		249,378

A former farm turned to wildlife habitat in southwestern Marshall County. (photo courtesy of USDA Farm Service Agency/Wikimedia.org)

Forest Composition

Tree Species Diversity and Distribution

The species composition of a forested stand defines its character, likely future development, ecosystem function, and dynamics, as well as providing insight into its historical evolution. For this reason, analyses of current and past species composition aid in understanding the existing forest character and potential developmental pathways of the future.

A wide variety of tree species are found in Kentucky, including hardwoods such as yellow-poplar, oak, hickory, maple, beech, birch, and black locust. Softwood species occurring in the State are shortleaf pine, Virginia pine, loblolly pine, eastern redcedar, and others. Overall, 107 separate tree species were recorded during the 2009 forest inventory (table B.1).

Tree species richness—Biological diversity can be quantified in a myriad of ways. Here, species diversity is primarily addressed through quantifying the number of unique tree genera or species observed on FIA plots in Kentucky as species richness. (Note: for a detailed discussion of using FIA data for assessing tree species diversity, see Rosson and Rose 2010.) Statewide, 46 different genera were recorded on forested plots (table B.1). *Quercus* dominated with 19 different species recorded. *Acer* (eight species), *Carya* (eight species), *Ulmus* (six species), *Pinus* (five species), and *Magnolia* (four species) were the other dominant genera found in forests across the State.

The greatest species richness was observed in the eastern part of the State. In general, there was a moderate relationship between the area of forest land within a given county and the number of distinct tree species sampled within that county (fig. 5). As forest land area increased, the number of distinct tree species recorded also increased.

Red maple was the most abundant species in terms of number of individual stems recorded on forest land and was estimated to account for >12 percent of the statewide population of all-live stems (fig. 6). It is important to note, however, that all

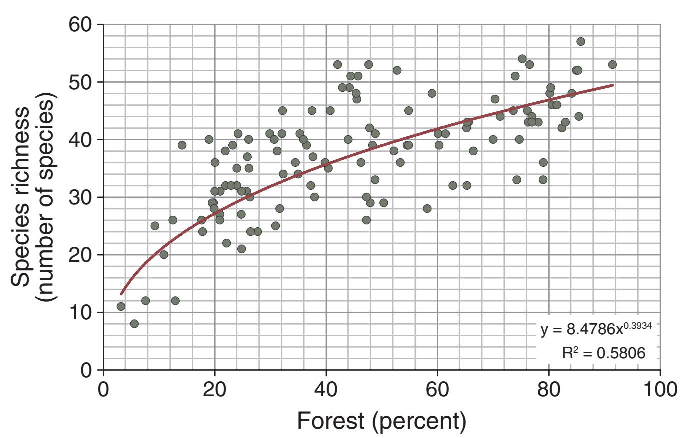


Figure 5—Relationship between the proportion of a county that is in forest and the number of distinct species codes recorded in that county, Kentucky, 2009.

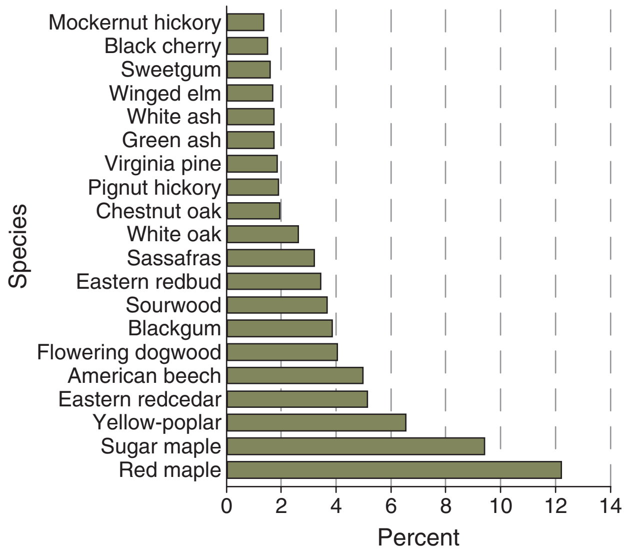


Figure 6—Proportion of all-live trees accounted for by the 20 most numerous tree species, Kentucky, 2009.

oak species combined make up a very substantial proportion of the total estimated number of stems. Although 107 distinct species were sampled across the State, the top 20 species (fig. 6) account for about 74 percent of all-live trees (fig. 7). In addition to having large populations in Kentucky, red maple, sugar maple, and yellow-poplar are some of the most widely distributed tree species in the State (fig. 8). Softwood species (particularly of the *Pinus* genus), though distributed throughout the State (fig. 9), are much less common than hardwood species. The most common pine sampled in Kentucky during the period 2004–09 was Virginia pine (fig. 9).

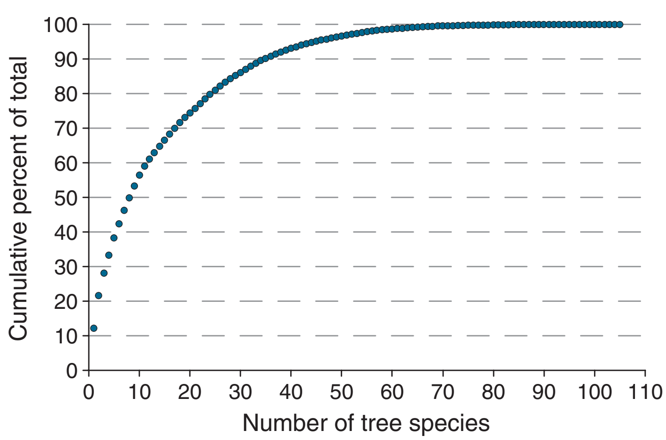


Figure 7—Cumulative percent of all-live trees accounted for by adding individual tree species in rank order from most numerous to least, Kentucky, 2009.

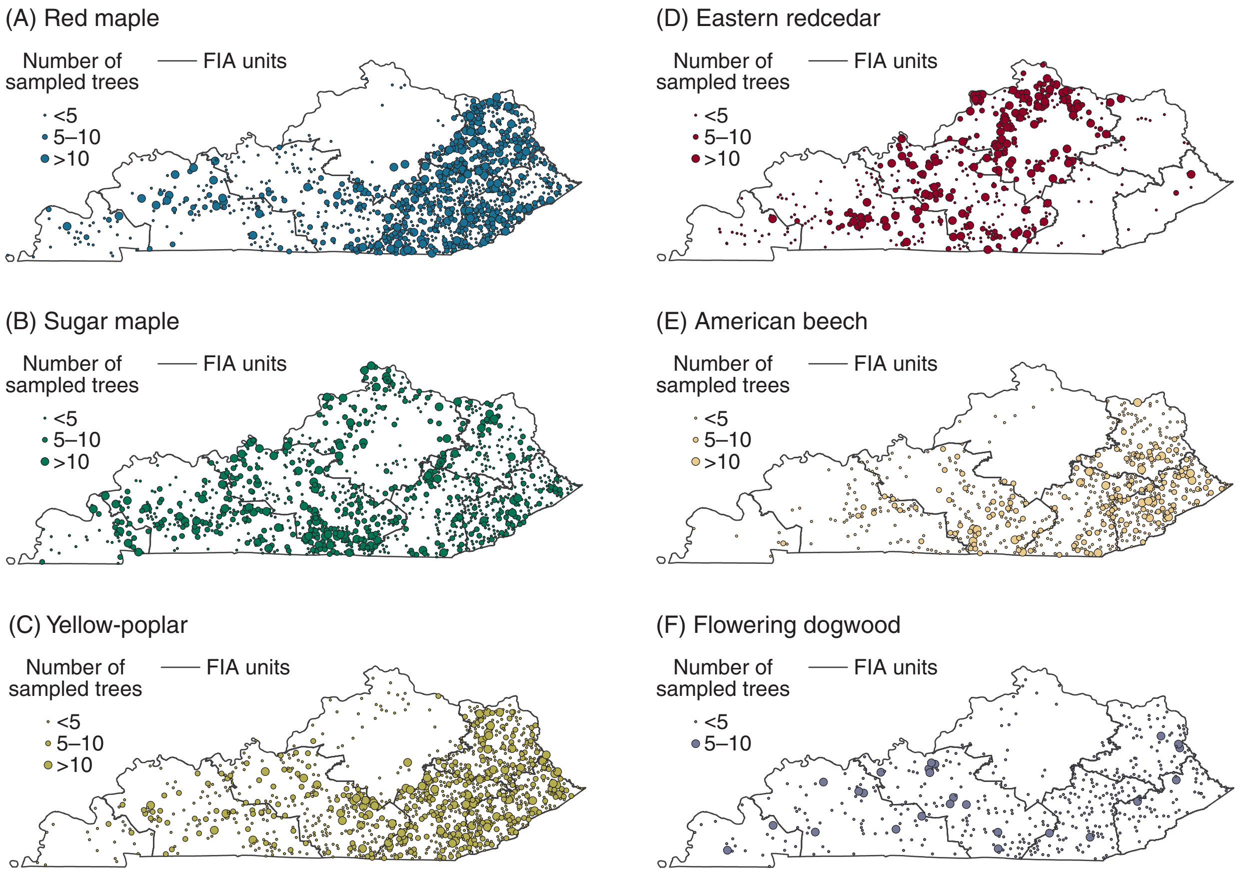


Figure 8—Sampled distribution of the six most numerous tree species, Kentucky, 2009: (A) red maple, (B) sugar maple, (C) yellow-poplar, (D) eastern redcedar, (E) American beech, and (F) flowering dogwood. (Plot locations are approximate.)

A common Kentucky hardwood forest. (photo by Angie Rowe, U.S. Forest Service)

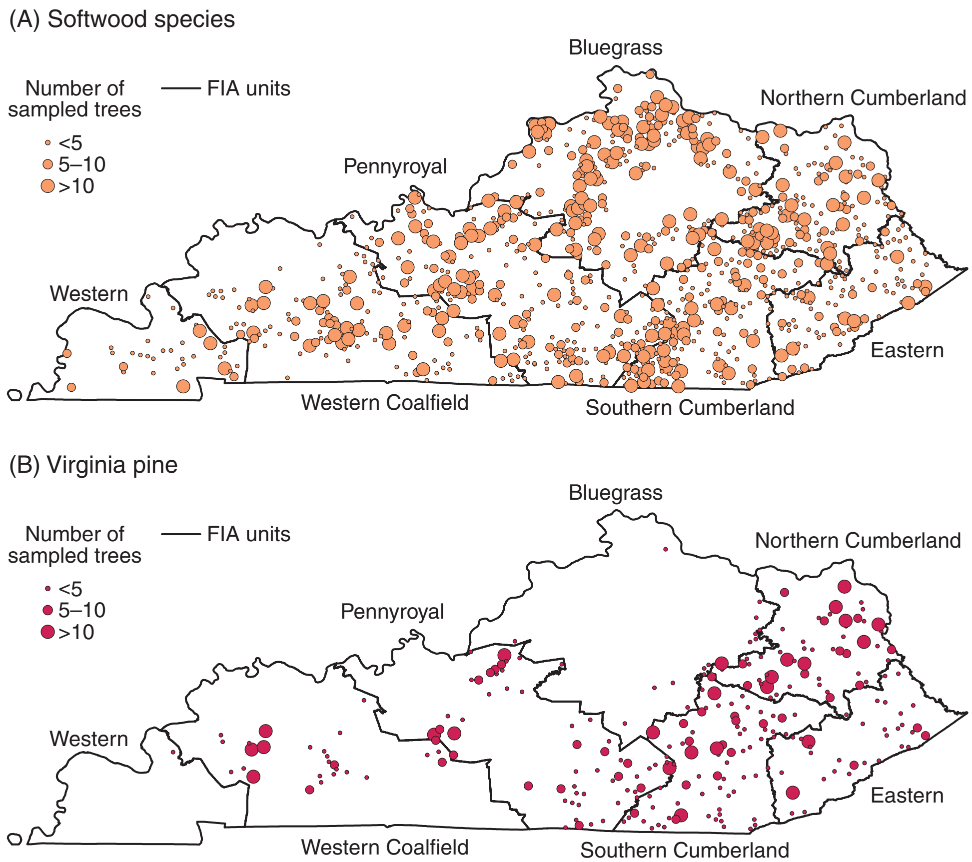


Figure 9—Sampled distribution of (A) all softwood species and (B) Virginia pine in Kentucky, 2009. (Plot locations are approximate.)

Tree species dominance—Ecological dominance can be defined as the degree to which a species is more numerous than its competitors in an ecological community, or a dominant species may account for a greater proportion of the biomass, basal area, or volume. Here, dominance is defined in terms of total volume.

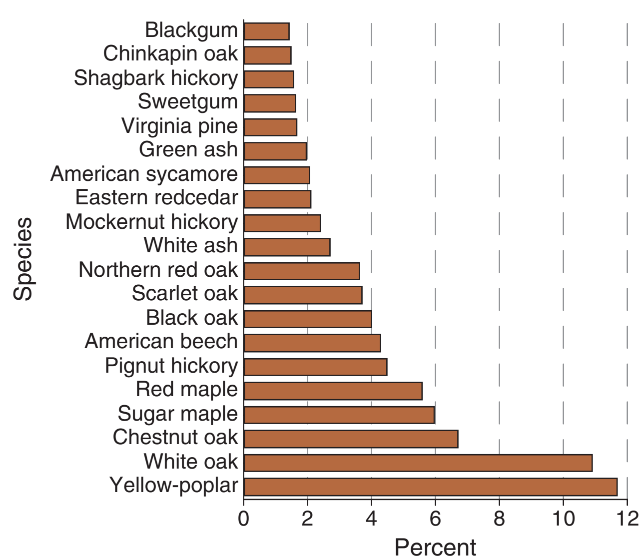


Figure 10—Proportion of all-live tree (≥5 inches d.b.h.) volume accounted for by the 20 most voluminous tree species, Kentucky, 2009.

Statewide, yellow-poplar (Kentucky's State tree) accounts for a greater proportion (an estimated 12 percent) of total live-tree volume (fig. 10) than any other single species. Six oak species (white oak, chestnut oak, black oak, scarlet oak, northern red oak, and chinkapin oak), however, rank in the top 20 voluminous tree species and account for a combined 30 percent of all-live-tree volume across the State. The top 20 tree species accounted for about 80 percent of all-live volume across the State's forest land (fig. 11). Yellow-poplar and

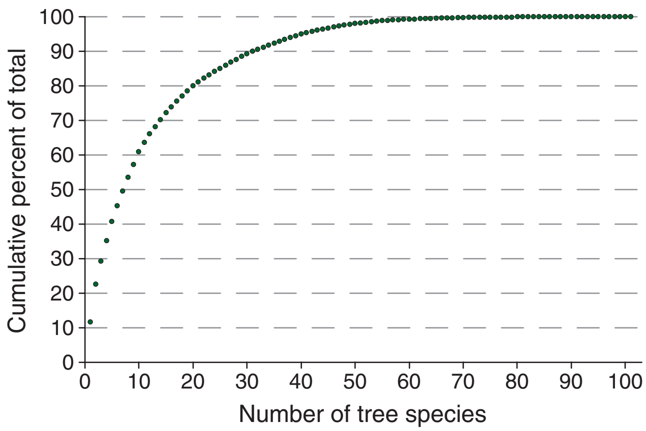


Figure 11—Cumulative percent of all-live tree (≥5 inches d.b.h.) volume accounted for by adding individual tree species in rank order from the species representing the most volume to the least, Kentucky, 2009.

white oak volume was widely distributed throughout the State, but basal area concentrations reached the highest levels in the eastern portion of the State for both species (fig. 12).

No one tree species dominates Kentucky's forest land in terms of both number of live trees and volume. The statistics reflect the ecological niches and silvical characteristics of the common species found in the State. Species such as yellow-poplar, white oak, and many in the red oak group make up the larger canopy species in much of the forest. Some of the more numerous species, such as red maple, flowering dogwood, and eastern redbud are smaller, but generally occupy the midstory and understory in greater numbers.

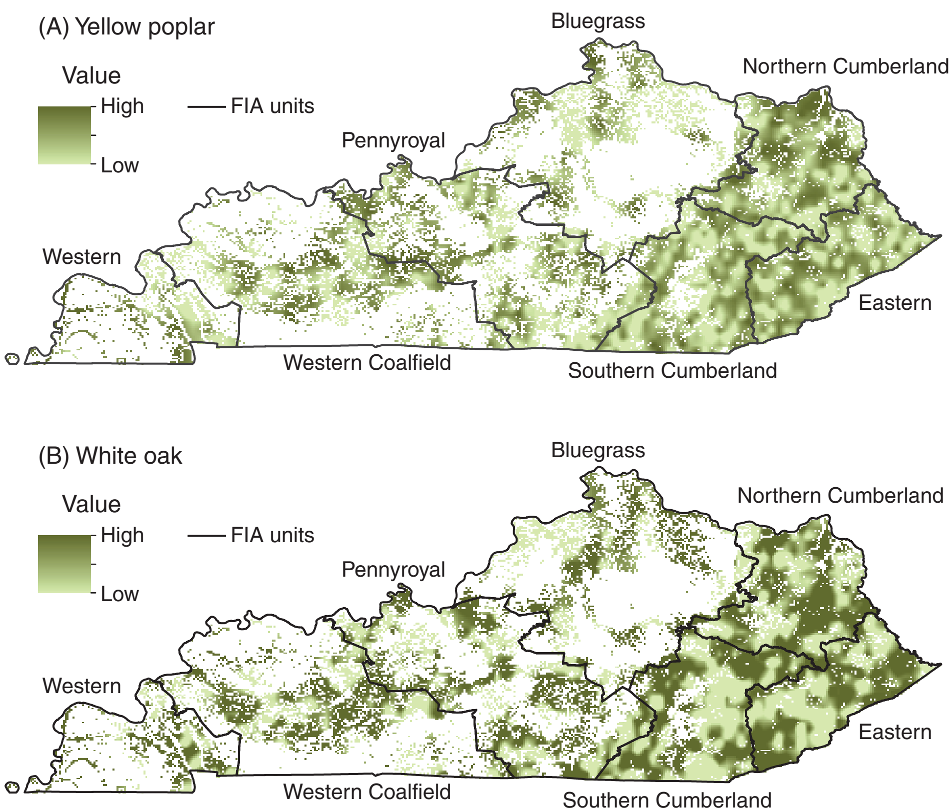


Figure 12—Concentration of basal area sampled for (A) yellow-poplar and (B) white oak, Kentucky, 2009. (Plot locations are approximate.)

Forest Types in Kentucky

Hardwood forest types have dominated the Kentucky landscape in every FIA inventory of the State (Turner and others 2008), including the 2009 inventory (fig. 13). In fact, between 2004 and 2009, softwood forest-type acreage declined an estimated 61,000 acres. Stands of softwood forest types have been mostly limited to mid- and high-elevation communities of the Appalachian Mountains, and the Cumberland Plateau in the east.

In 2009, the oak-hickory forest-type group accounted for 75 percent (9.3 million acres) of the 12.4 million acres of Kentucky forest land (fig. 13). The oak-hickory forest-type group was also the most widely distributed forest-type group in the State. The maple-beech-birch, elm-ash-cottonwood, and oak-pine forest-type groups accounted for 1.073 million, 724,000 and 556,000 acres, respectively. Both the loblolly-shortleaf pine and white-red-jack pine forest-type groups realized declines in acreage from 2004 to 2009 (fig. 14).

In 2009, the least extensive forest-type group within the State (with the exception of the other hardwoods group) was exotic hardwoods (nonnative species such as tree-of-heaven, paulownia, and mimosa) with an estimated 33,000 acres across the State. Although exotic hardwoods increased in acreage by 181 percent between 2004 and 2009 (fig. 14), acreage estimates for forest-type groups with such rarity are accompanied by significant error rates (fig. 15).

In 2009, the white oak/red oak/hickory forest type was the most extensive type distributed across the State (fig. 16).

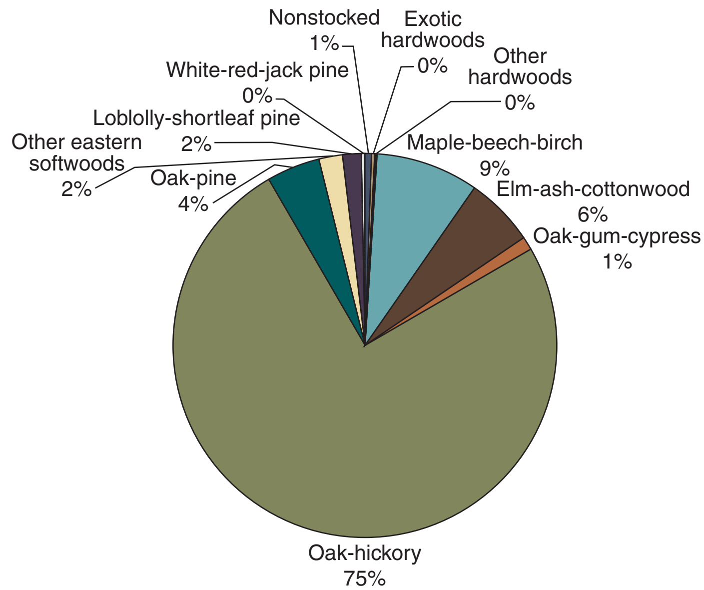


Figure 13—Proportion of forest land area by forest-type group, Kentucky, 2009.

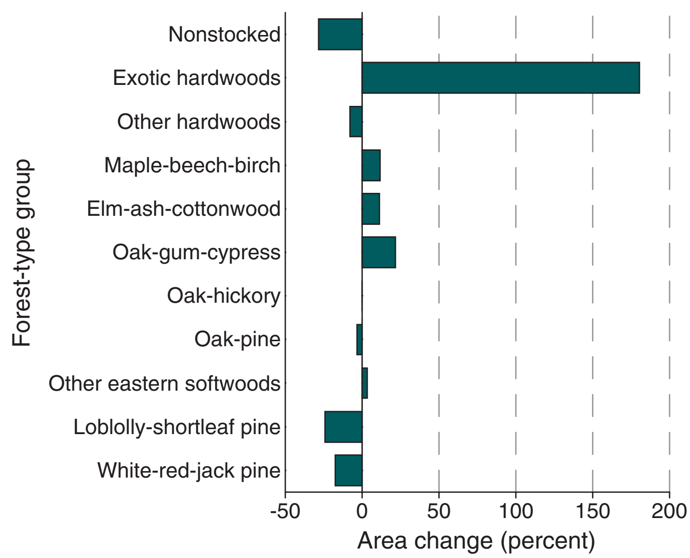


Figure 14—Area change (percent) of forest land by forest-type group, Kentucky, 2004–09.

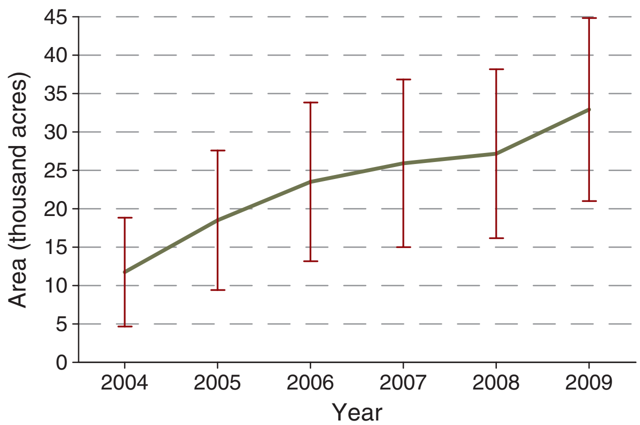


Figure 15—Area of forest land classified as "exotic hardwoods" forest-type group, Kentucky, 2004–09. Error bars represent one standard error

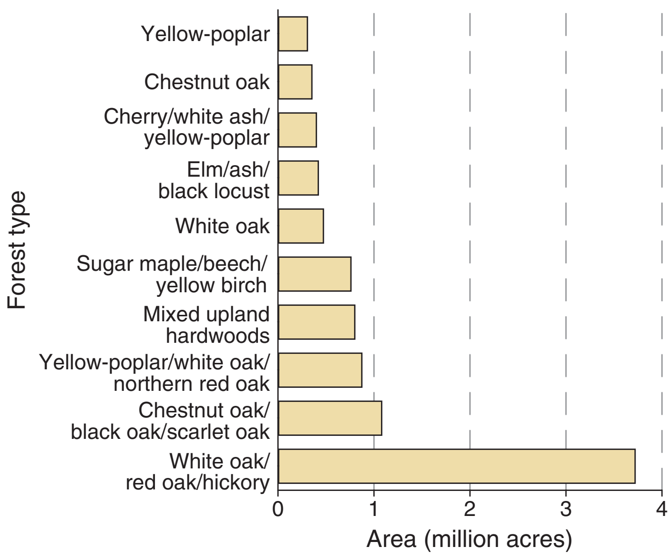


Figure 16—Area of forest land occupied by the 10 most common detailed forest types, Kentucky, 2009.

Supporting the idea that Kentucky is a "hardwood State" was the fact that all 10 of the most common forest types were hardwood forest types. While the white oak/red oak/hickory forest type can be found across the State (fig. 17A), the second and third most common forest types, chestnut oak/black oak/scarlet oak, and yellow-poplar/white oak/northern red oak, respectively, are found primarily in the east (fig. 17B-C). The white oak/red oak/hickory forest type covered approximately 30 percent of all forest land in the State (table 4). In each of the seven FIA units, the white oak/red oak/hickory forest type accounted for the most forest land acres and ranged from 21 percent of forests in the Eastern unit to 36 percent of forests in the Pennyroyal unit. The forest type composition of each of the units was similar for the top three forest types; however, considerable differences were expressed in the fourth and fifth most common forest types for each unit (table 4).

To gain a better understanding of changes in detailed forest types across the State, comparisons between 2004 and 2009 were made for each forest type sampled during that period. Forest type changes were ranked according to acres changed. The transition from yellow-poplar/white oak/northern red oak to white oak/red oak/hickory was the most common and accounted for nearly 100,000 acres (table 5). The majority of the most common forest type transitions was insignificant and represented only slight compositional changes. However, an estimated 75,000 acres transitioned from the white oak/red oak/hickory type to sugar maple/beech/yellow birch type. The transition from an oak-dominated forest to the maple/beech/yellow birch forest type is interesting but may be only an artifact of the forest-type algorithm used by the FIA Program.

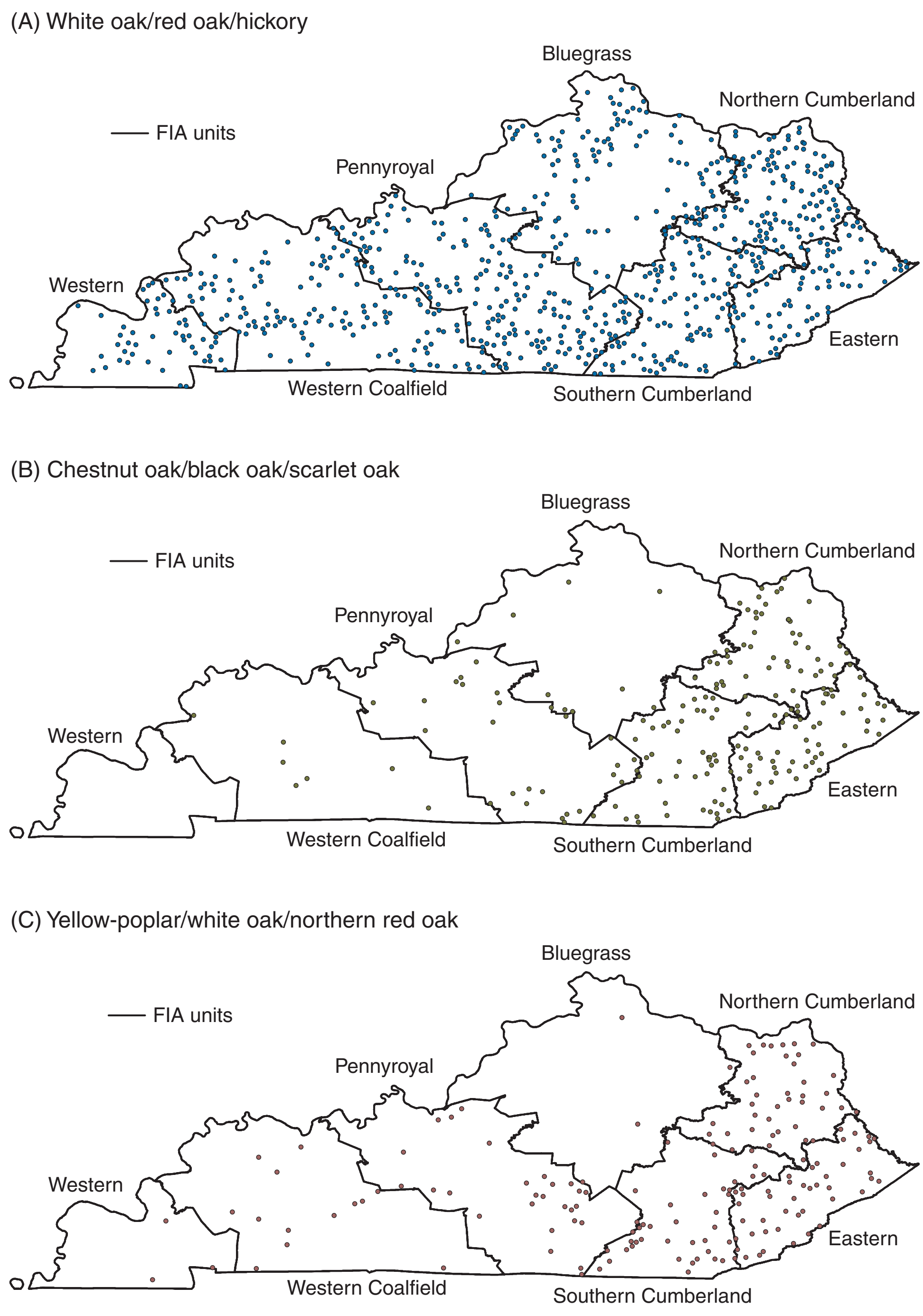


Figure 17—Sampled distribution of (A) white oak/red oak/hickory, (B) chestnut oak/black oak/scarlet oak, and (C) yellow-poplar/white oak/northern red oak forest types, Kentucky, 2009. (Plot locations are approximate.)

Table 4—The five most common, detailed forest types for each FIA unit on forest land by rank status, and percent of forest land occupied by each, Kentucky, 2009

FIA unit	Rank status 1	2	3	4	5
	Forest type				
Statewide	White oak/ red oak/hickory	Chestnut oak/ black oak/ scarlet oak	Yellow-poplar/ white oak/ northern red oak	Mixed upland hardwoods	Sugar maple/ beech/ yellow birch
Eastern	White oak/ red oak/hickory	Chestnut oak/ black oak/ scarlet oak	Yellow-poplar/ white oak/ northern red oak	Sugar maple beech/ yellow birch	Mixed upland hardwoods
Northern Cumberland	White oak/ red oak/hickory	Chestnut oak/ black oak/ scarlet oak	Yellow-poplar/ white oak/ northern red oak	White oak	Cherry/white ash/ yellow-poplar
Southern Cumberland	White oak/ red oak/hickory	Chestnut oak/ black oak/ scarlet oak	Yellow-poplar/ white oak/ northern red oak	White oak	Sugar maple/ beech/ yellow birch
Bluegrass	White oak/ red oak/hickory	Mixed upland hardwoods	Elm/ash/black locust	Eastern redcedar	Eastern redcedar/ hardwood
Pennyroyal	White oak/ red oak/hickory	Sugar maple/ beech/yellow birch	Mixed upland hardwoods	Yellow-poplar/ white oak/ northern red oak	Chestnut oak/ black oak/ scarlet oak
Western Coalfield	White oak/ red oak/hickory	Sugar maple/ beech/yellow birch	Mixed upland hardwoods	Elm/ash/black locust	Sugarberry/ hackberry/elm/ green ash
Western	White oak/ red oak/hickory	Sugarberry/ hackberry/ elm/green ash	Mixed upland hardwoods	Post oak/ blackjack oak	White oak
	percent				
Statewide	30	9	7	6	6
Eastern	21	17	13	11	6
Northern Cumberland	33	15	10	5	4
Southern Cumberland	26	12	10	7	7
Bluegrass	27	10	10	8	8
Pennyroyal	36	8	6	6	6
Western Coalfield	35	8	7	4	4
Western	34	8	7	6	5

FIA = Forest Inventory and Analysis.

Mountain maple (*Acer spicatum*) near cave on Buck Creek, Pulaski County. (photo courtesy of Mason Brock/Wikimedia.org)

Table 5—Most common forest type changes on forest land, Kentucky, 2004–09

Forest type		
Previous	Current	Acres
Yellow poplar/white oak/northern red oak	White oak/red oak/hickory	98,027
White oak	White oak/red oak/hickory	95,581
White oak/red oak/hickory	Chestnut oak/black oak/scarlet oak	93,605
Mixed upland hardwood	White oak/red oak/hickory	89,658
Chestnut oak/black oak/scarlet oak	White oak/red oak/hickory	89,317
Chestnut oak/black oak/scarlet oak	Chestnut oak	84,975
White oak/red oak/hickory	Sugar maple/beech/yellow birch	74,686
White oak/red oak/hickory	Yellow-poplar/white oak/northern red oak	65,814
White oak/red oak/hickory	Mixed upland hardwood	64,661
Yellow poplar/white oak/northern red oak	Mixed upland hardwood	57,149

Forest Stand Structure

Forests can be described by their composition, function, and structure (Franklin and others 1981). Most descriptions of forest stand structure are based on measurements easily obtainable from the ground level (e.g., diameter at breast height [d.b.h.]). Oliver and Larson (1990) define forest stand structure as the physical and temporal distribution of trees in a stand and include within the description the distribution of species, vertical and horizontal spatial patterns, size of trees or tree parts, and tree or stand age. Here we use four common FIA metrics (stand age, stand size, basal area, and origin) to explore the structure of Kentucky's forests.

Stand Age

Stand age is the average age of the majority of live trees in the predominant stand-size class. Kentucky's forests are, for the most part, getting older. The age class distribution during the 2004–09 period shifted to older stands on average (fig. 18). While the peak of the age class distribution remained unchanged between 2004 and 2009, the area of forests declined in some younger age classes and increased in some older age classes. The result has been a slight shift in the distribution toward older age classes, providing evidence that Kentucky's forests are aging.

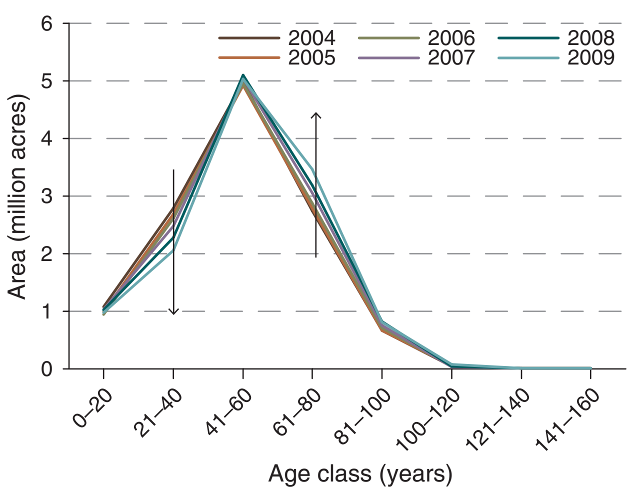


Figure 18—Age class (20-year classes) distribution for all forest land area, Kentucky, 2004–09. Arrows show direction of change in area for the period.

Stand Size

It is important to know the size of the trees that make up the forests in Kentucky. Armed with this knowledge, resource managers are better able to understand the structure of the forested stands and the habitat that exists on the landscape. In addition, trend analysis of stand size (a classification based on stocking and the diameter of the majority of the live trees in a stand) facilitates understanding of the successional status and potential future development of the forest and the populations of its inhabitants.

The stand-size classes used 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 inches d.b.h. Medium-diameter stands are ≥5 inches d.b.h. but are not large enough to be considered large diameter. In order to be large-diameter size, a softwood species must be ≥9 inches, while hardwood species must be ≥11 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. These are generally 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 2009, the majority of stands were in the large-diameter size class (fig. 19). The area of forest land classified as large diameter has been increasing in recent years. In 1988, an estimated 58 percent of all forest land in Kentucky was in large-diameter stands. In 2004, the proportion of large-diameter stands had increased to 65 percent, and by 2009 had increased to 68 percent. Concurrently, stands classified as medium diameter declined from 26 percent in 1988 to 24 and 21 percent in 2004 and 2009, respectively. Between 1988 and 2009, the area of small-diameter stands declined from 16 percent to 10 percent. The fact that Kentucky's forests are aging with very few acres of young forest land is concerning. Young forests play a vital role in sustaining healthy, productive forests over the long term.

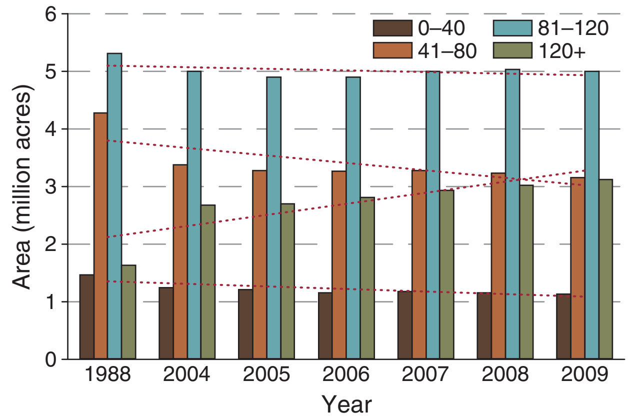


Figure 20—Stand basal area class distribution for all forest land area, Kentucky, 1988–2009. Dotted lines represent general direction of change for each stand basal area class across the seven inventories.

Stand Basal Area

The FIA Program classifies each measured stand into 1 of 4 all-live basal area classes (typically 0–40, 41–80, 81–120, and ≥120 square feet per acre). In 2009, the 81–120 square feet of live basal area class contained the greatest acreage across all Kentucky forest land (fig. 20), with an estimated 5.0 million acres. The second largest class across all forest land was both the 41–80 and ≥120 square feet of basal area classes with an estimated 3.1 million acres in each.

The common pattern of an aging forest resource is apparent in the temporal dynamics of the basal area class distribution as well. Since 1988, the ≥120 square feet of basal area class has been increasing while the 0–40 and 41–80 square feet of basal area classes have been declining (fig. 20).

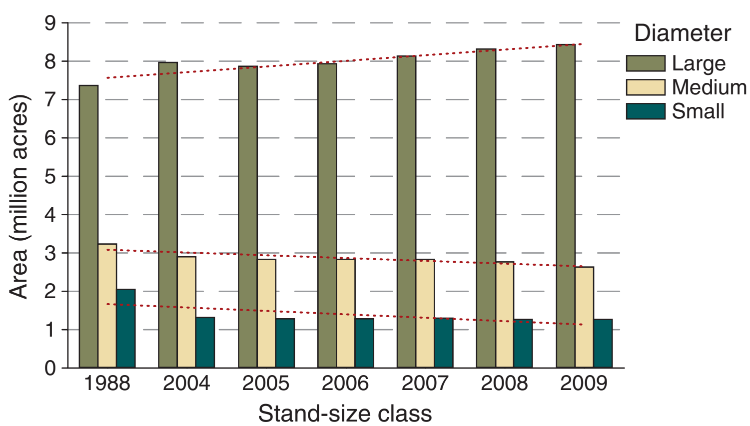


Figure 19—Stand-size class distribution by year for forest land area, Kentucky, 1988–2009. Dotted lines represent general direction of change for each stand-size class across the seven inventories.

Sally Brown waterfall, Sally Brown Nature Preserve, Garrard County. (photo courtesy of Mason Brock/ Wikimedia.org)

Stand Origin

The area of planted forests across Kentucky declined from an estimated 157,000 acres in 1988 to their lowest point, 79,000 acres, in 2009 (table 6). The area of planted land has dropped from 1.2 percent of all forest land in 1988 to 0.6 percent in 2009 (fig. 21). The small number of acres planted in Kentucky is not much of a surprise because southern pine plantations are not common in the State.

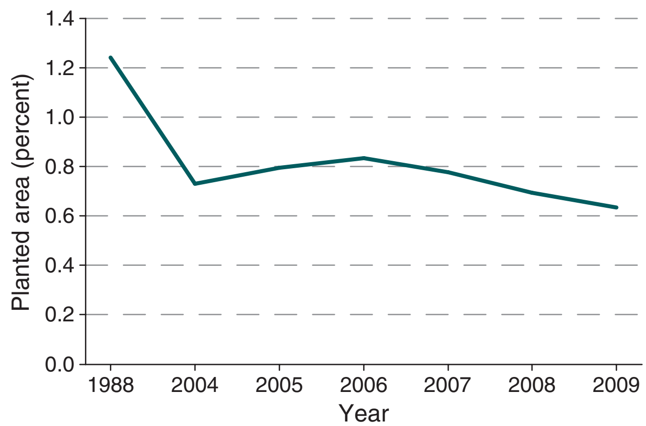


Figure 21—Area of forest land in planted stands, Kentucky, 1988–2009.

Table 6—Area of forest land in natural and planted stands, Kentucky, 1988–2009

Inventory year	Total	Natural	Planted
		acres	
1988	12,674,752	12,517,466	157,288
2004	12,283,434	12,193,858	89,577
2005	12,071,007	11,975,043	95,965
2006	12,121,334	12,020,215	101,119
2007	12,369,226	12,273,043	96,184
2008	12,425,529	12,339,360	86,171
2009	12,400,650	12,321,984	78,663

Totals may not sum due to rounding.

Forest Land Ownership

The FIA Program collects information about ownership of forested land in each State. Ownership at each forested phase 2 (see glossary) ground plot is determined from publicly available records at local county courthouses. Area, density, and volume estimates are displayed by ownership classes such as nonindustrial private forest land, public (including the Forest Service), and forest industry (defined as forest landowners who also own a wood-processing facility).

View from Tater Knob in the Daniel Boone National Forest. (photo courtesy of Wikimedia.org)

According to the 2009 inventory, an estimated 88 percent (11.0 million acres) of the forest land in Kentucky is in private ownership (table 7). Twelve percent of the forest land in Kentucky is publicly administered by local, State, or Federal agencies. About one-half of the public forest land (6 percent of all forest land) and another 30 percent is also in Federal hands. The remaining public Kentucky forest land (2 percent of all forest land) is owned and administered by various State and local governments. The majority of the forest land owned and administered by the Forest Service is within the Daniel Boone National Forest (DBNF) in the Northern and Southern Cumberland units and the Land Between the Lakes National Recreation Area, primarily in the Western unit. The highest density of publicly administered forest land is in the Southern Cumberland unit (fig. 22).

Table 7—Area of forest land by ownership class and FIA unit, Kentucky, 2009

		FIA unit						
Ownership class	Total	Eastern	Northern Cumberland	Southern Cumberland	Bluegrass	Pennyroyal	Western Coalfield	Western
				acres				
National forest	730,212	69,066	165,265	435,294	21,131	39,455	—	—
Other Forest Service	86,427	—	—	—	—	—	—	86,427
National Park Service	84,744	—	—	25,486	—	12,425	46,832	—
U.S. Fish and Wildlife Service	11,483	—	—	—	586	4,659	—	6,238
Dept. of Defense	215,875	12,557	29,074	—	14,209	136,035	11,524	12,475
Other Federal	39,001	6,279	3,503	2,722	1,546	—	—	24,951
State	200,794	44,166	30,266	27,103	14,880	21,680	56,461	6,238
County and municipal	65,290	—	6,723	9,232	25,770	6,212	11,708	5,645
Other local government	13,011	—	6,723	6,288	—	—	—	—
Private	10,953,812	1,629,096	1,663,877	1,693,165	1,717,181	2,045,457	1,634,660	570,377
Total	12,400,648	1,761,164	1,905,431	2,199,290	1,795,304	2,265,924	1,761,186	712,351

FIA = Forest Inventory and Analysis; — = no sample for the cell.

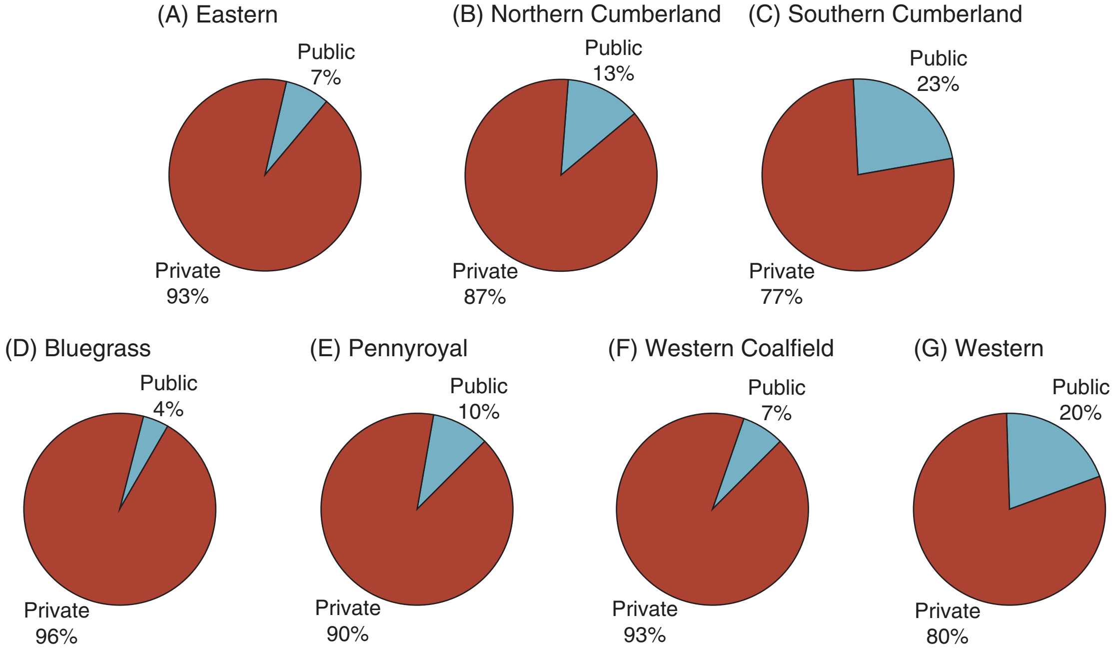
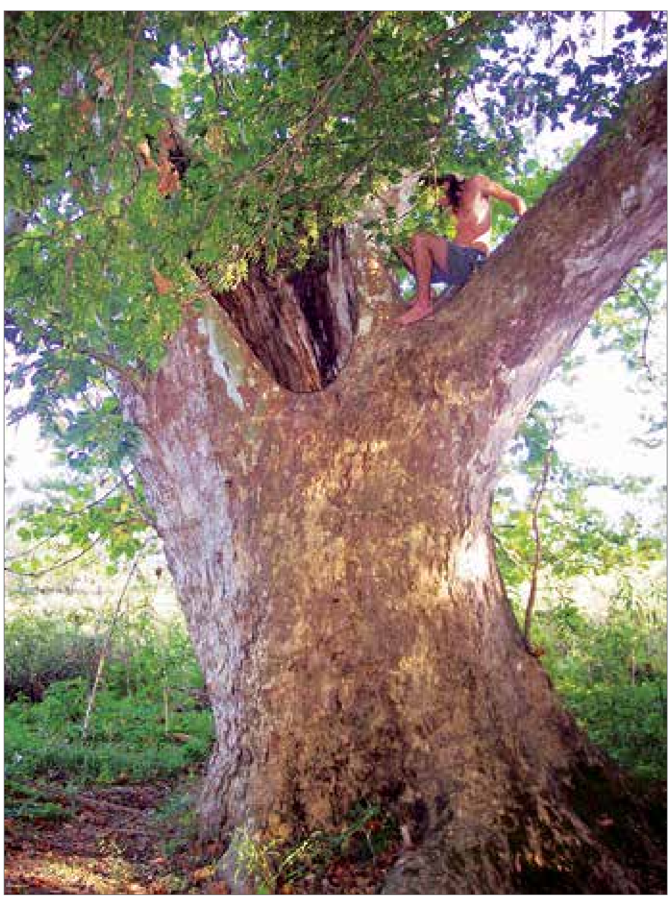


Figure 22—Proportion of forest land area in public (blue) and private (red) ownership for each FIA Unit in Kentucky, 2009 (A) Eastern, (B) Northern Cumberland, (C) Southern Cumberland, (D) Bluegrass, (E) Pennyroyal, (F) Western Coalfield, and (F) Western.



Massive American sycamore (Platanus occidentalis) on the bank of Townsend Creek, Bourbon County. (photo courtesy of Mason Brock/Wikimedia.org)

Special Section: Daniel Boone National Forest

The DBNF includes some of the most rugged terrain west of the Appalachian Mountains. The forest lies within the Cumberland Plateau, where steep forested slopes, sandstone cliffs, and narrow ravines characterize the land. Spread across 21 counties of southern and eastern Kentucky, >708,000 acres of National Forest system lands are managed within a 2.1 million-acre proclamation boundary (fig. 23). The forest is divided into four ranger districts: (1) Cumberland, (2) London, (3) Redbird, and (4) Stearns (see http://www.fs.usda.gov/dbnf/).

Sample-based estimates of forest land within the DBNF were an estimated 730,212 acres (table 8). The DBNF contains 19 different forest types according to FIA data (table 8). The most common forest type found (nearly 229,000 acres) on the DBNF was the white oak/red oak/hickory forest type.

Table 8—Area of forest land by detailed forest type for the Daniel Boone National Forest, Kentucky, 2009

Detailed forest type	Area
	acres
Eastern white pine	11,454
Eastern white pine/northern red oak/white ash	14,417
Shortleaf pine/oak	6,288
Virginia pine/southern red oak	19,299
Post oak/blackjack oak	2,292
Chestnut oak	25,840
White oak/red oak/hickory	228,942
White oak	63,835
Northern red oak	1,681
Yellow-poplar/white oak/northern red oak	106,176
Scarlet oak	7,969
Yellow-poplar	14,157
Chestnut oak/black oak/scarlet oak	137,517
Cherry/white ash/yellow-poplar	17,859
Red maple/oak	15,588
Mixed upland hardwoods	14,365
River birch/sycamore	1,268
Sugar maple/beech/yellow birch	31,266
Hard maple/basswood	9,999
Total	730,212

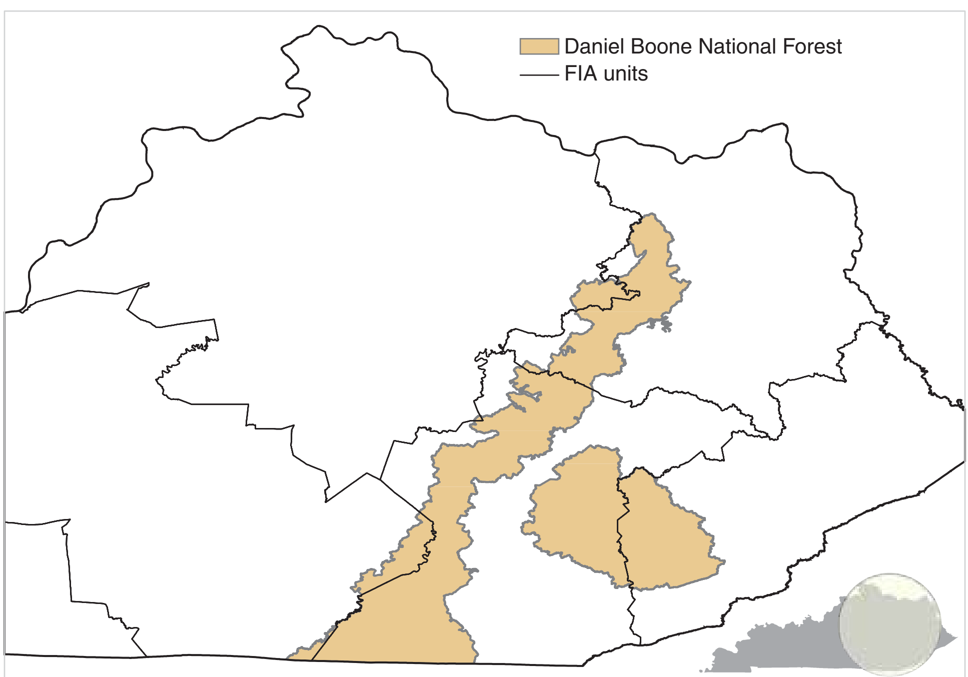


Figure 23—Location of the Daniel Boone National Forest in Kentucky.

The FIA Program classifies sampled plots into physiographic classes (see glossary) that help describe the local ecology of the sampled forests. Physiographic class accounts for the general effect of land form, topographical position, and soil moisture available to the trees. In 2009, the DBNF largely consisted of moist slopes and coves and rolling uplands with 46 and 24 percent of all DBNF forest land area, respectively (table 9). An estimated 17 percent of DBNF forest land area was classified as dry slopes and 13 percent classified as dry tops. Very little area was within the flatwoods physiographic class.

When stand-size class is used as a proxy for successional status, there is a lack of early successional forests on the DBNF. Approximately 79 percent of all forest land on the DBNF is within the large-diameter class while only 7 percent is within the small-diameter class or early successional forests (fig. 24). In contrast, across all of Kentucky's forests, 68 percent of forested stands are classified as large-diameter stands and 10 percent are classified as small-diameter stands. Stand size class is imbalanced across the State, but the imbalance appears to be larger on the DBNF.

Table 9—Area of forest land by physiographic class for the Daniel Boone National Forest, Kentucky, 2009

Physiographic class	Area
	acres
Dry tops	91,416
Dry slopes	126,341
Other xeric	1,572
Flatwoods	4,479
Rolling uplands	171,733
Moist slopes and coves	333,101
Narrow floodplains/bottomlands	1,570
Total	730,212

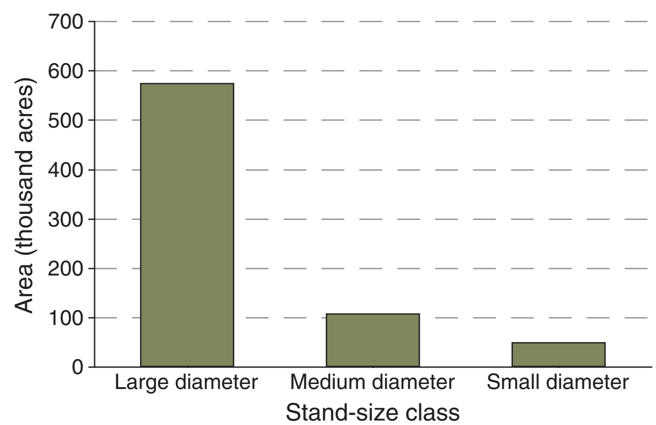


Figure 24—Area of forest land by stand-size class for the Daniel Boone National Forest, Kentucky, 2009.

Productive Capacity of Kentucky's Forests

Productive capacity refers to the ability of forests to produce goods and services for humans (U.S. Department of Agriculture Forest Service 2004). This definition incorporates aspects of both the environmental and economic sustainability of Kentucky's forest systems. Maintaining the productive capacity of the State's forests is essential because people and wildlife in Kentucky rely on a productive, healthy forest to supply livelihoods, wood, wood products, food, fuel, cover, habitat, recreation, and many other goods and services year after year.

FIA defines timberland as any forested land that is available for timber production, that is, forested land not withdrawn from timber harvesting by law. An example of forest land withdrawn from timber harvesting by law in Kentucky is the Mammoth Cave National Park. Thus, timberland is the land base from which Kentucky citizens can obtain multiple timber and nontimber products and services. The timberland base in Kentucky should remain productive.

Because few changes occur in the acreage of reserved forest land, the area of timberland in Kentucky tracks closely to that of forest land (table 10). In 2009, timberland covered an estimated 12.2 million acres across the State. This estimate was slightly higher than in 2004 (12.0 million acres), but it should not be interpreted as a significant change. The interpretation of reserve status has been inconsistent in past surveys and therefore has necessitated the correction of past data. Real change is confounded or masked by misapplied definitions. Timberland in Kentucky has consistently remained near 50 percent of all land and approximately 98–99 percent of all forest land in the State. The counties with large proportions of timberland relative to total land base are distributed across the State (fig. 25). All Kentucky FIA units, except the Western Coalfield unit, have counties with 71 percent of timberland or more (fig. 26).

Table 10—Area of timberland by forest-type group and FIA unit, Kentucky, 2009

		FIA unit						
Forest-type group	Total	Eastern	Northern Cumberland	Southern Cumberland	Bluegrass	Pennyroyal	Western Coalfield	Western
				acres				
White-red-jack pine	36,762	—	21,643	9,144	—	5,976	—	—
Loblolly-shortleaf pine	185,635	9,171	42,943	45,329	1,546	32,102	33,473	21,072
Other eastern softwoods	241,217	—	5,042	—	147,769	55,506	32,900	—
Oak-pine	544,908	26,329	73,481	73,737	138,733	151,249	66,378	15,002
Oak-hickory	9,162,459	1,387,512	1,611,492	1,771,947	1,118,420	1,618,978	1,186,014	468,095
Oak-gum-cypress	139,245	1,374	—	11,361	29,559	28,088	44,356	24,506
Elm-ash-cottonwood	724,220	43,289	46,097	34,275	184,105	94,548	175,804	146,104
Maple-beech-birch	1,050,036	238,588	52,561	189,235	159,987	231,355	154,905	23,403
Other hardwoods	24,744	6,279	1,489	3,144	5,534	6,738	—	1,559
Exotic hardwoods	32,884	9,418	6,723	1,287	1,546	4,659	9,251	—
Nonstocked	58,346	13,433	17,069	5,989	3,362	5,661	11,273	1,559
Total	12,200,455	1,735,392	1,878,540	2,145,447	1,790,561	2,234,861	1,714,353	701,300

FIA = Forest Inventory and Analysis; — = no sample for the cell.

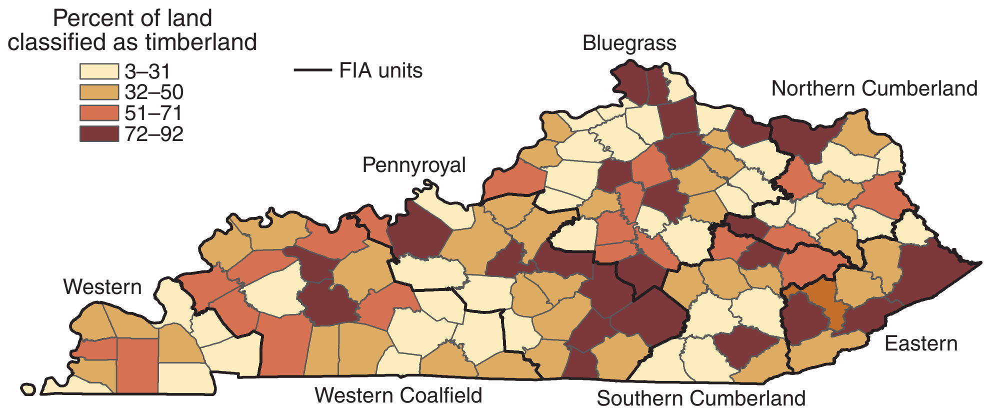


Figure 25—Percent of all land classified as timberland, Kentucky, 2009.

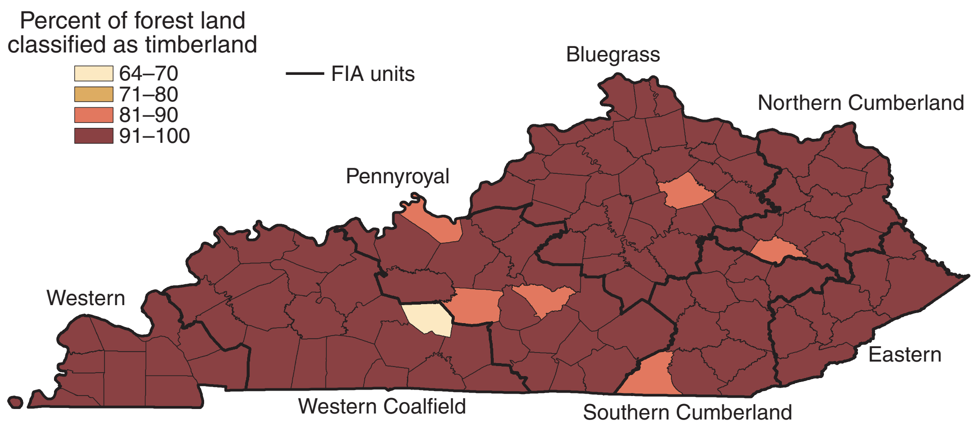


Figure 26—Percent of forest land classified as timberland, Kentucky, 2009.

Composition of Timberlands

The oak-hickory forest-type group accounted for an estimated 75 percent (9.2 million acres) of the timberland in Kentucky in 2009 (table 10). The loblolly-shortleaf pine type group accounted for only 2 percent, of which only 6 percent was in the Eastern and Bluegrass units. Mixed stands of the oak-pine forest-type group accounted for an estimated 4 percent of timberland in Kentucky. Bottomland hardwoods (elm-ash-cottonwood and oak-gum-cypress forest-type groups), largely in northern and southwestern Kentucky, accounted for approximately 7 percent of the timberland.

In 2009, the single most common forest type across Kentucky timberland was white oak/red oak/hickory (table 11) and is found within each unit in the State. The scarcest forest type found on timberland within the State was the baldcypress/water tupelo type, which was found only in the Western unit.

Table 11—Area of timberland by FIA unit and detailed forest type, Kentucky, 2009

		FIA unit						
Forest type	Total	Eastern	Northern Cumberland	Southern Cumberland	Bluegrass	Pennyroyal	Western Coalfield	Western
				acres				
Eastern white pine	27,497	—	15,521	6,000	—	5,976	—	—
Eastern hemlock	9,266	—	6,122	3,144	—	—	—	—
Loblolly pine	47,823	—	—	—	—	1,465	25,287	21,072
Shortleaf pine	16,657	—	1,395	9,462	—	5,800	—	—
Virginia pine	91,804	9,171	30,640	23,636	1,546	18,625	8,186	—
Pitch pine	29,351	—	10,908	12,231	—	6,212	—	—
Eastern redcedar	241,217	—	5,042	—	147,769	55,506	32,900	—
Eastern white pine/ northern red oak/ white ash	32,266	—	15,659	16,607	—	—	—	—
Eastern redcedar/ hardwood	280,445	1,374	5,580	—	138,733	101,879	26,640	6,238
Shortleaf pine/oak	23,790	13,031	4,471	6,288	—	—	—	—
Virginia pine/ southern red oak	184,656	9,912	46,090	49,574	—	49,370	28,299	1,411
Loblolly pine/hardwood	12,937	—	—	—	—	—	5,584	7,353
Other pine/hardwood	10,815	2,012	1,681	1,268	—	—	5,854	—
Post oak/blackjack oak	127,272	1,570	—	3,869	3,048	28,635	45,753	44,398
Chestnut oak	351,321	77,221	63,151	112,293	9,216	59,018	11,708	18,713
White oak/red oak/ hickory	3,681,741	366,746	634,540	562,820	482,453	795,449	594,117	245,616
White oak	447,048	33,493	99,320	149,714	31,501	72,647	32,391	27,980
Northern red oak	52,293	7,042	16,051	4,716	14,650	8,311	1,524	—
Yellow-poplar/white oak/ northern red oak	849,438	230,075	188,506	197,738	17,394	137,263	61,901	16,561
Sassafras/persimmon	162,197	10,988	33,267	20,456	14,277	28,462	32,760	21,987
Sweetgum/yellow-poplar	178,104	17,093	—	41,651	16,104	27,226	69,679	6,351
Bur oak	6,183	—	—	—	6,183	—	—	—
Scarlet oak	112,706	23,545	45,851	35,574	6,183	1,553	—	—
Yellow poplar	300,056	83,139	52,157	94,770	3,092	46,153	19,186	1,559
Black walnut	36,412	—	—	—	27,978	7,426	1,008	—
Black locust	92,018	26,097	1,489	9,607	20,804	6,326	27,694	—
Chestnut oak/black oak/ scarlet oak	1,059,297	300,217	273,438	267,206	56,551	135,865	26,020	—
Cherry/white ash/ yellow-poplar	389,272	52,699	82,819	80,584	52,182	74,738	37,232	9,018
Elm/ash/black locust	418,131	37,787	23,931	48,766	170,604	42,168	71,445	23,430
Red maple/oak	113,731	19,855	18,370	34,009	2,992	10,197	23,884	4,424
Mixed upland hardwoods	785,238	99,945	78,603	108,173	183,208	137,538	129,712	48,058
Swamp chestnut oak/ cherrybark oak	52,989	—	—	3,805	28,013	—	14,933	6,238

continued

Table 11—Area of timberland by FIA unit and detailed forest type, Kentucky, 2009 (continued)

Forest type	Total	Eastern	Northern Cumberland	Southern Cumberland	Bluegrass	Pennyroyal	Western Coalfield	Western
	FIA unit							
	acres							
Sweetgum/Nuttall oak/ willow oak	12,055	—	—	—	—	1,685	10,369	—
Overcup oak/ water hickory	26,503	—	—	—	1,546	7,766	12,958	4,234
Baldcypress/water tupelo	1,559	—	—	—	—	—	—	1,559
Sweetbay/swamp tupelo/ red maple	46,139	1,374	—	7,556	—	18,637	6,096	12,475
River birch/sycamore	146,467	15,851	15,823	14,526	38,718	32,553	5,000	23,996
Cottonwood	14,914	—	—	—	—	—	5,854	9,060
Willow	11,435	—	—	1,129	6,183	—	—	4,122
Sycamore/pecan/ American elm	157,363	24,521	3,361	4,109	26,035	15,657	51,838	31,841
Sugarberry/hackberry/elm/ green ash	303,712	2,917	16,542	14,511	108,631	33,460	71,445	56,207
Silver maple/American elm	72,318	—	10,370	—	—	12,878	28,192	20,877
Red maple/lowland	8,924	—	—	—	1,546	—	7,378	—
Cottonwood/willow	9,087	—	—	—	2,991	—	6,096	—
Sugar maple/beech/ yellow birch	737,478	187,355	44,905	140,626	51,897	169,202	123,612	19,881
Black cherry	16,265	5,071	—	7,880	—	1,553	—	1,761
Hard maple/basswood	290,620	43,795	7,656	37,424	108,090	60,600	31,293	1,761
Red maple/upland	5,672	2,367	—	3,305	—	—	—	—
Other hardwoods	24,744	6,279	1,489	3,144	5,534	6,738	—	1,559
Paulownia	4,402	1,570	—	1,287	—	—	1,545	—
Other exotic hardwoods	28,482	7,848	6,723	—	1,546	4,659	7,706	—
Nonstocked	58,346	13,433	17,069	5,989	3,362	5,661	11,273	1,559
Total	12,200,455	1,735,392	1,878,540	2,145,447	1,790,561	2,234,861	1,714,353	701,300

FIA = Forest Inventory and Analysis; — = no sample for the cell.

Standing Volume

Standing volume of all-live trees (≥5 inches d.b.h.) on timberland was nearly 24 billion cubic feet in 2009 (table 12), an increase from the estimated 22 billion cubic feet of volume on Kentucky timberlands in 2004. Greater than 18 billion cubic feet (77 percent) of all-live standing-tree volume was classified as the oak-hickory forest-type group. With the exception of the Eastern unit, oak-gum-cypress standing tree volume increased statewide while loblolly-shortleaf standing tree volume declined in every unit, except the Western, illustrating the physiographic differences among the different regions within the State. Approximately 49 percent of all-live standing-tree volume in 2009 was located in the Eastern, Northern Cumberland, and Southern Cumberland units.

All-live standing-tree volume on timberland has increased since 1988 in all seven FIA units (fig. 27). Although all units have increased in all-live tree volume since the beginning of the annual inventory in 2000, the Western unit exhibited little change between 2004 and 2009.

Table 12—Standing volume of live trees by FIA unit and forest-type group on timberland, Kentucky, 2009

Forest-type group	Total	FIA unit: Eastern	Northern Cumberland	Southern Cumberland	Bluegrass	Pennyroyal	Western Coalfield	Western
	cubic feet							
White-red-jack pine	95,095,562	—	50,225,636	32,105,031	—	12,764,896	—	—
Loblolly-shortleaf pine	329,984,931	6,502,790	51,624,677	76,944,152	1,777,531	85,502,878	78,855,475	28,777,429
Other eastern softwoods	178,820,546	—	5,025,054	—	93,918,353	45,264,870	34,612,269	—
Oak-pine	816,097,174	39,503,255	135,231,431	127,615,944	173,524,801	200,498,482	112,609,567	27,113,695
Oak-hickory	18,226,315,823	2,930,093,668	3,194,760,801	3,569,792,869	2,070,376,865	3,252,494,675	2,350,835,868	857,961,077
Oak-gum-cypress	351,866,856	546,715	—	23,128,072	66,591,614	74,143,400	79,590,052	107,867,002
Elm-ash-cottonwood	1,528,067,368	118,321,955	90,176,307	40,459,421	319,952,352	188,446,129	429,802,752	340,908,452
Maple-beech-birch	2,198,388,587	518,797,214	91,551,726	449,452,269	280,668,061	486,373,528	314,527,761	57,018,028
Other hardwoods	28,965,041	13,567,577	172,407	2,906,825	2,338,110	9,980,121	—	—
Exotic hardwoods	17,935,705	5,915,030	2,906,852	1,972,583	249,864	5,386,321	1,505,055	—
Nonstocked	3,442,148	1,168,233	267,044	97,588	—	1,046,279	863,005	—
Total	23,774,979,741	3,634,416,437	3,621,941,935	4,324,474,754	3,009,397,552	4,361,901,578	3,403,201,803	1,419,645,682

FIA = Forest Inventory and Analysis; — = no sample for the cell.

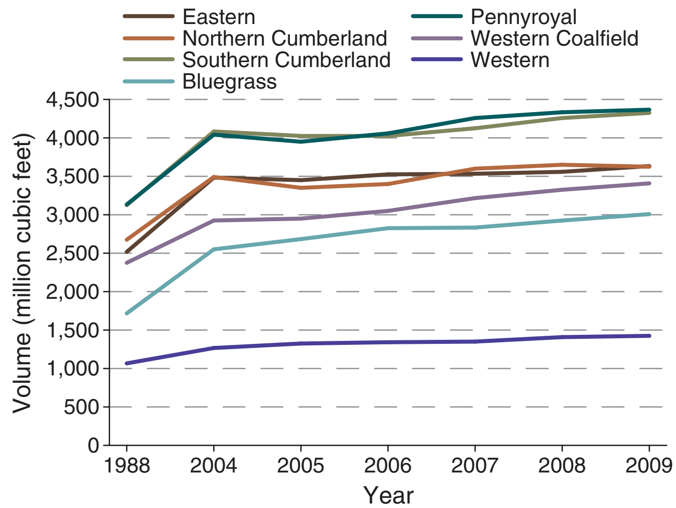


Figure 27—All-live volume of trees ≥5 inches d.b.h. on timberland, Kentucky, 1988–2009.

In 2009, the greatest concentrations of live standing tree volume were in the Eastern unit and in the southern regions of the remainder of the State (fig. 28). County-level standing tree volume density ranged from 830 cubic feet per acre to >4,800 cubic feet per acre of timberland. Relative to all-live standing-tree volume, concentrations of hardwood volume were greatest in the southern and western counties (fig. 29), while softwood volume concentrations were highest in northern counties (fig. 30). The biggest block of counties with large percentages of standing-tree volume on timberland in hardwood species was located in the Bluegrass unit. The biggest block of counties with large percentages of standing-tree volume on timberland in softwood species was located in northern Kentucky. The highest concentrations of sawtimber volume were located in the southeastern part of the State, primarily the Eastern and Southern Cumberland units (fig. 31).

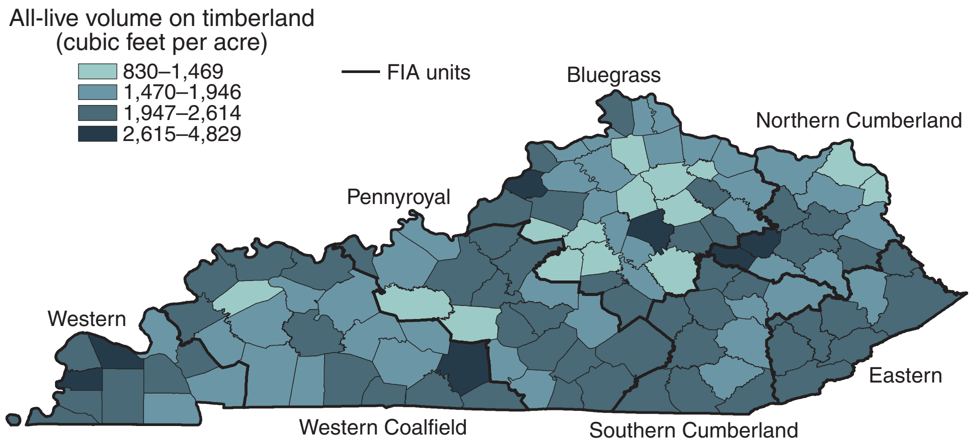


Figure 28—All-live volume on timberland, Kentucky, 2009.

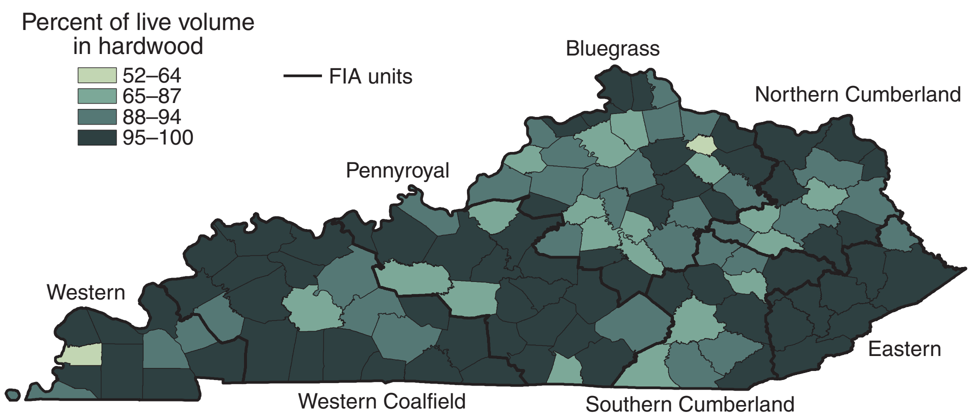


Figure 29—Percent of live volume on timberland that is from hardwood species, Kentucky, 2009.

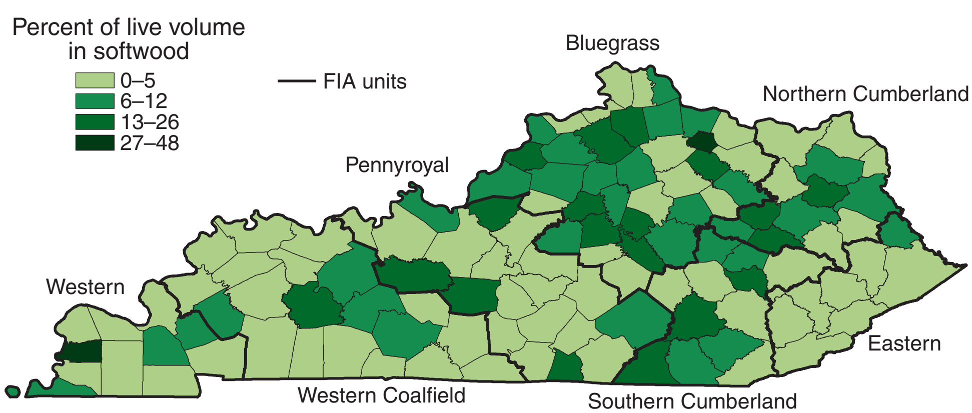


Figure 30—Percent of live volume on timberland that is from softwood species, Kentucky, 2009.

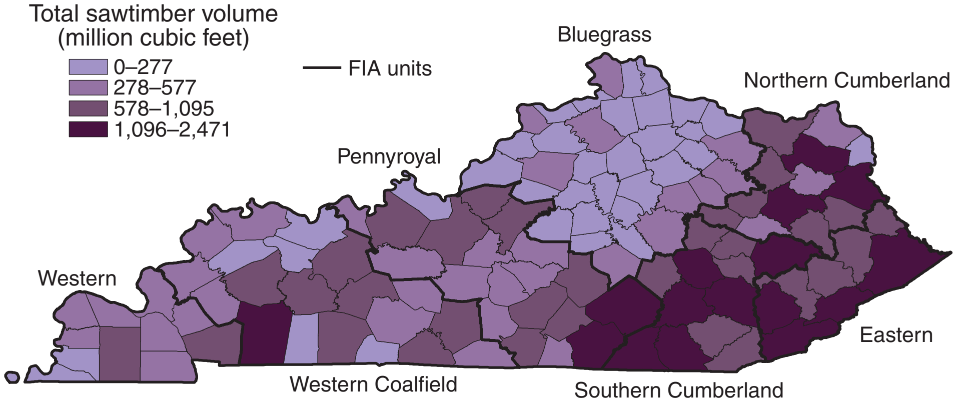


Figure 31—Total sawtimber volume on timberland, Kentucky, 2009.

Tree Quality

Tree grade is a classification that indicates the suitability of individual sawtimber-size trees to yield factory-grade lumber or construction-strength timbers. Factory-grade lumber is used in furniture, flooring, pallets, and other products. Unlike log grade, tree grade applies to the whole tree and is generally evaluated before the tree is felled. FIA adapted the hardwood tree grading system devised by Hanks (1976). The FIA system is based on the amount and distribution of surface defects, the amount of rotten wood, and the location of the utilizable log or logs within the tree.

In 2009, an estimated 12 percent (8.3 billion board feet) of all sawtimber volume was within grade 1 trees (fig. 32). Sawtimber volume within grade 1 trees has been steadily declining from a peak of 12.8 billion board feet in 2004, when grade 1 material represented approximately 21 percent of all sawtimber volume. Sawtimber volume within grade 2 trees decreased only slightly from 28 percent in 2004 to 25 percent in 2009. Conversely, total sawtimber volume within grade 3 trees and below-grade trees has been increasing over the same period (fig. 32). (Note: users are cautioned when comparing estimates derived from the annual inventory design [2004 to present] to estimates derived from the periodic inventory design [pre-2000 in Kentucky]. Numerous changes in the inventory can often result in a high noise-to-signal ratio and confound temporal trends.)

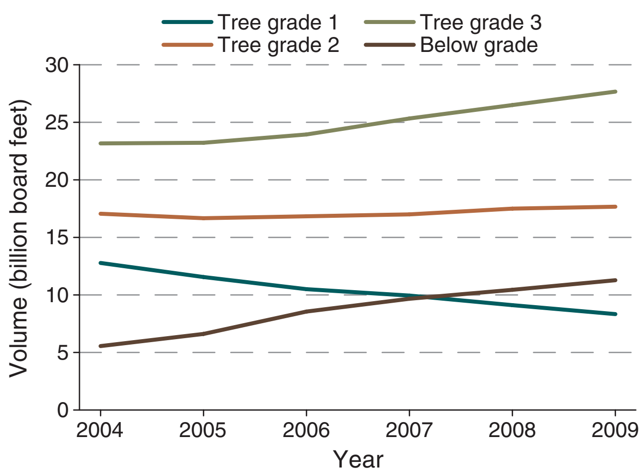


Figure 32—Sawtimber volume on timberland by tree grade for all species, Kentucky, 2004–09.

The trends for hardwood volume only mirrored those for total sawtimber volume (fig. 33) due to the high proportion of volume represented by hardwood species in Kentucky. The proportion of hardwood sawtimber volume found in grade 1 trees has declined from an estimated 21 percent to 12 percent between 2004 and 2009. During the same period, below-grade volume has increased from 9 percent to 17 percent of all hardwood sawtimber volume. These estimates support the general notion, based on anecdotal evidence, that

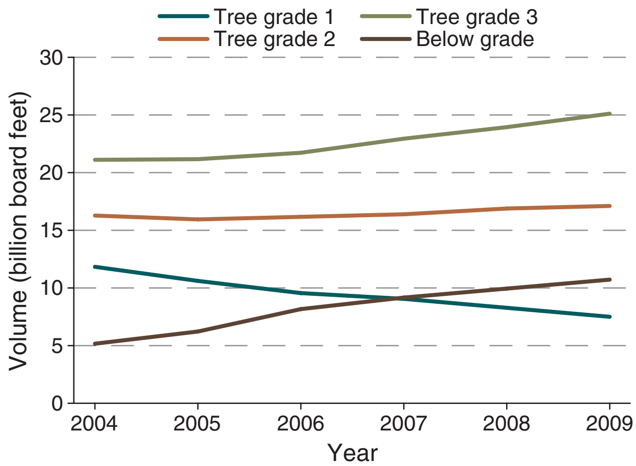


Figure 33—Sawtimber volume on timberland by tree grade for hardwood species, Kentucky, 2004–09.

Felled hardwood tree being measured by field foresters. (photo by Tony Johnson (retired), U.S. Forest Service)

forests in Kentucky are experiencing a decline in sawtimber quality, particularly hardwood sawtimber quality.

Softwood sawtimber tree grade trends are similar to those for hardwood sawtimber over the same time period (2004–09). The sawtimber volume found within grade 1 trees has decreased from 22 percent to 18 percent from 2004 to 2009 (fig. 34). Conversely, sawtimber volume found in grade 3 trees has increased from 50 percent (2.1 billion board feet) of all softwood volume in 2004 to 57 percent (2.6 billion board feet) in 2009.

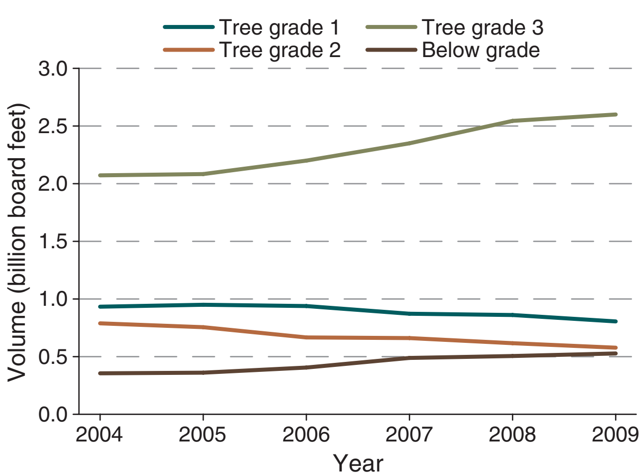


Figure 34—Sawtimber volume on timberland by tree grade for softwood species, Kentucky, 2004–09.

Growth

Average annual net growth (gross growth minus mortality, in cubic feet) of all-live trees on timberland in Kentucky was an estimated 730 million cubic feet per year in 2009 (fig. 35). The majority of that growth was accounted for by growth on hardwood species (94 percent or 686 million cubic feet). While average annual growth for hardwood species has been declining since 2007, growth for softwood species has been nearly unchanged since a low in 1999.

Average annual net growth differed among the seven FIA units in Kentucky (fig. 35). In the Southern Cumberland unit, average annual net growth increased for hardwood and decreased for softwood species between 1999 and 2009. Temporal trends in the other units mimic statewide trends. Estimates of average annual growth for softwood species were negative in 2009 for the Northern Cumberland and Pennyroyal units for the first time since the periodic inventories. At the same time, average annual growth for hardwood species increased steadily during every measurement period for the Southern Cumberland unit.

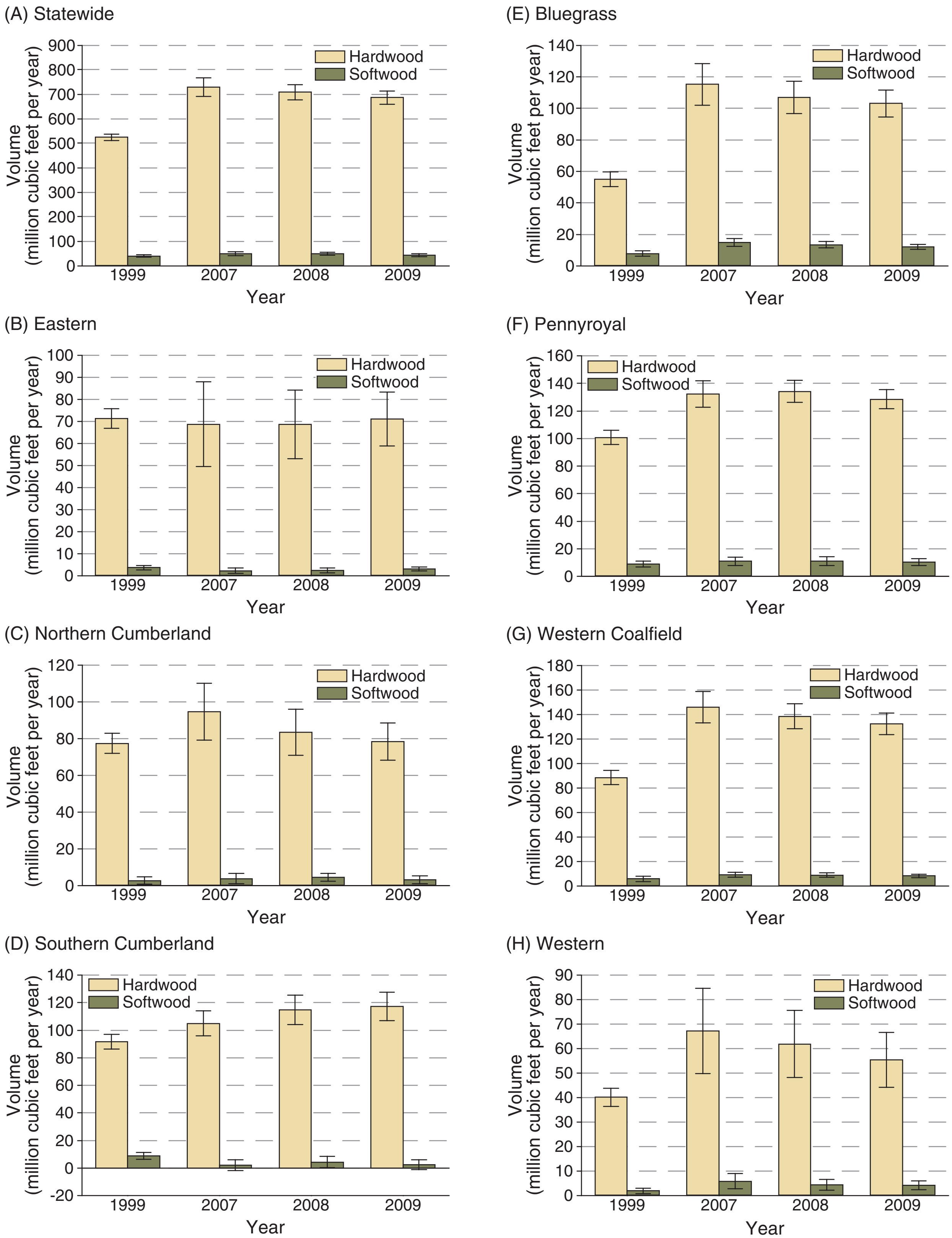


Figure 35—Average annual net growth of live trees on timberland by major species group statewide and for each FIA Unit, Kentucky, 1999–2009: (A) Statewide, (B) Eastern, (C) Northern Cumberland, (D) Southern Cumberland, (E) Bluegrass, (F) Pennyroyal, (G) Western Coalfield, and (H) Western.

Socioeconomic Benefits of Kentucky's Forests

Timber Removals and Utilization

Average annual timber removals from timberland include the merchantable and nonmerchantable volume of trees harvested for products and whole trees, or portions of trees cut and left behind, as logging residue. Average annual removals volume also includes trees removed due to land clearing for agriculture or urban development and timberland set aside by statute prohibiting tree harvesting. The latter removals are considered land use change removals. Total removals include harvested products, logging residues, and land use removals and are reported by broad species group at the regional, State, FIA survey unit, or county level for ownership, forest type, diameter class, stand origin, and other variables.

Most FIA removal tables report only the merchantable portion or volume from a 1-foot stump to the 4-inch top in cubic feet for trees ≥5 inches d.b.h. For the sawtimber portion of sawtimber-size trees, removal volume is reported in board feet (International ¼-inch log rule) as well.

Removal estimates are generated for the sawtimber portion of growing-stock trees, all other growing-stock trees ≥5 inches d.b.h., and all-live trees ≥5 inches d.b.h., which include rough and rotten cull trees. It is best to think of these categories for removals as subsets; sawtimber removals are a subset of growing-stock removals, growing-stock removals are a subset of all-live tree removals, and all of these are a subset of total aboveground tree removals, which include the volume of the stumps, tops, and limbs to 1 inch in diameter. Volume of removal trees <5 inches d.b.h. has been considered noncommercial and has not been reported on a routine basis.

Reporting removals in this fashion served FIA and its users well for many decades when dealing with the traditional timber products such as saw logs, veneer logs, poles, and other solid-wood forest products. However, the traditional fiber products industries (pulpwood, composite panel, and mulch) along with the emerging bioenergy industry have increased and are expected to further increase the utilization of rough and cull trees, tops, and limbs, a portion of trees <5 inches d.b.h., and in some cases, understory vegetation.

Draft horses skidding a hardwood log to the logging deck. (photo by Tony Johnson (retired), U.S. Forest Service)

Timber bought and sold commercially has been scaled by weight at many destination mills for numerous years. The forestry community has become familiar with weight as a unit of measure for timber products and has requested FIA to include weight as a reporting unit for removals. The cubic foot volumes have been converted to green tons throughout this section by using 71.10 pounds of wood and bark per cubic foot of solid wood for softwoods and 77.07 pounds of wood and bark per cubic foot of solid wood for hardwoods. It is important to keep in mind that this is fresh green weight of wood and bark per cubic foot immediately after harvest.

This section focuses on total average annual removals for all-live tree volume for trees >5 inches d.b.h. expressed in cubic feet and green tons. It will also include an estimate of removals for stumps, tops, and limbs and will be expressed as average annual harvest removals from nonmerchantable sources. In addition, an estimate of removals for trees <5 inches d.b.h. is discussed under the section for logging residue and is not included in total annual removals. Figure 36 shows the total annual removals by the subcategories previously discussed.

Between 2004 and 2009, total removals from all sources in Kentucky, for both softwoods and hardwoods, totaled 453.4 million cubic feet, or 17.4 million green tons (tables 13 and 14). Hardwoods accounted for 94 percent of total removals, or 424.2 million cubic feet (16.3 million green tons). Volume of removals attributed to the merchantable portion of all-live tree removals accounted for 330.5 million cubic feet (12.7 million green tons), while nonmerchantable sources accounted for 123.0 million cubic feet (4.7 million green tons).

The following sections present an average annual estimate for the merchantable and nonmerchantable portions of annual timber product output (TPO) (timber harvested and delivered to mills), land use removals, and an estimate of logging residue in Kentucky for the period 2005–09.

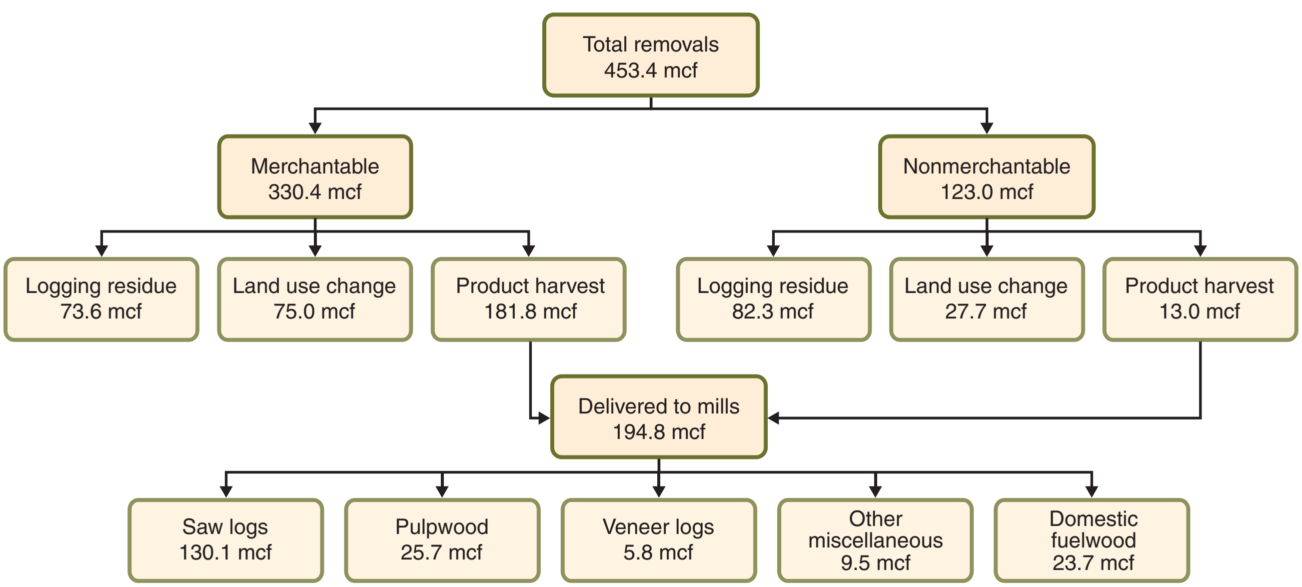


Figure 36—Total removals by merchantability and category, Kentucky, 2009.

Table 13—Volume of timber removals by removals class, species group, and source, Kentucky, 2004–09

Removals class and species group	All sources	Source: All-live removals: Merchantable	Source: All-live removals: Non-merchantable
	thousand cubic feet		
Timber products			
Softwood	11,499	11,269	230
Hardwood	183,316	170,553	12,763
Total	194,815	181,822	12,993
Logging residues			
Softwood	6,500	2,558	3,942
Hardwood	149,463	71,062	78,401
Total	155,963	73,620	82,343
Land use removals			
Softwood	11,202	8,606	2,596
Hardwood	91,461	66,405	25,056
Total	102,663	75,011	27,652
Total removals			
Softwood	29,201	22,433	6,768
Hardwood	424,240	308,020	116,220
Total	453,441	330,453	122,988

Totals may not sum due to rounding.

Table 14—Weight of timber removals by removals class, species group, and source, Kentucky, 2004–09

Removals class and species group	All sources	Source: All-live removals: Merchantable	Source: All-live removals: Non-merchantable
	green tons		
Timber products			
Softwood	408,784	400,608	8,176
Hardwood	7,064,403	6,572,557	491,846
Total	7,473,187	6,973,165	500,022
Logging residues			
Softwood	231,071	90,936	140,135
Hardwood	5,759,828	2,738,498	3,021,330
Total	5,990,899	2,829,434	3,161,465
Land use removals			
Softwood	398,226	305,940	92,286
Hardwood	3,524,612	2,559,032	965,580
Total	3,922,838	2,864,972	1,057,866
Total removals			
Softwood	1,038,081	797,484	240,597
Hardwood	16,348,843	11,870,087	4,478,756
Total	17,386,924	12,667,571	4,719,353

Totals may not sum due to rounding.

Timber Products

The diverse forest products industry in Kentucky comprises a variety of mills, ranging from small to medium-sized softwood and hardwood sawmills, pole mills, and post mills to the very large pulpmills. In 2009, there were about 217 sawmills, pulpwood mills, and other primary wood-processing plants distributed across the State (fig. 37). This section presents estimates of average annual timber product harvest volume for the period 2005 through 2009.

Estimates of TPO and plant residues were obtained from canvasses (questionnaires) sent to all major primary wood-using mills in the State. The canvasses are used to determine the types and amount of roundwood or timber (for example, saw logs, pulpwood, plywood and veneer, poles) received by each mill, the county of origin, the species used, and how the mills disposed of the bark and wood residues produced. The canvasses were conducted every 2 years by SRS and KDF personnel. These data are used to augment the FIA annual inventory of all-live timber removals by providing 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.

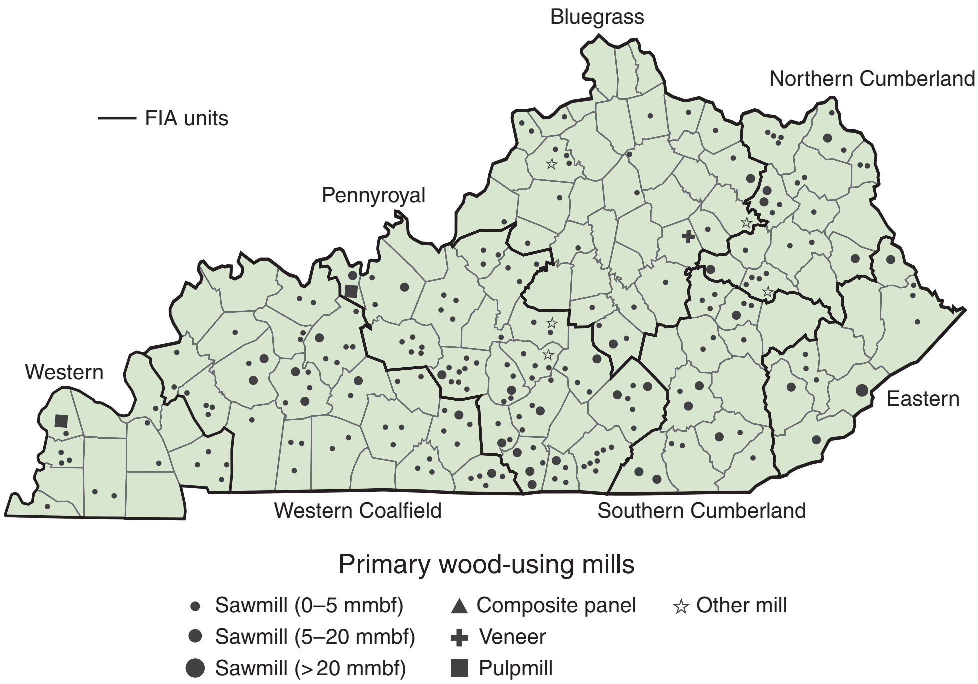


Figure 37—Location of primary wood-using mills by region, Kentucky, 2009.

Industry surveys conducted in 2005 and 2007 and preliminary findings for 2009 were used to determine average annual output for timber products and plant byproducts for the latest FIA cycle (Bentley and Lowe 2007, Cooper and others 2011, Mathison and Nevins 2009). Therefore, the average volumes reported in this section for individual products will not match specific year values reported in TPO publications or online query tools.

Volume harvested and delivered for products (including residential fuelwood) from all sources totaled 194.8 million cubic feet (7.5 million green tons), or 43 percent, of total removals. The merchantable portion of all-live removals accounted for 181.8 million cubic feet (7.0 million green tons), or 93 percent of timber product harvest volume. Nonmerchantable sources from all-live removals accounted for 13.0 million cubic feet (500,000 tons), or 7 percent of product output levels. Average annual volume harvested for hardwood products totaled 183.3 million cubic feet (7.1 million green tons) and accounted for 94 percent of the total product volume. The average annual volume harvested for softwood products declined 48 percent from the previous survey period, totaling 66.3 million cubic feet (2.3 million green tons) between 2005 and 2009.

Trends in average annual harvest volume by product type for the survey periods from 2004 through 2009. Harvest volume for every major industrial product type was down from the previous survey period except for veneer and residential fuelwood production. As stated earlier, most of these declines by individual products were driven by the dramatic drop in softwood product output.

Table 15 depicts the average annual TPO by survey years or the survey period, species group, the hardwood proportion for each category, and the proportion of total products represented by that category.

Table 15—Average annual volume of timber products by product type, survey years, and species group, Kentucky, 1939–2009

Product type and survey years	Species group: Softwood	Hardwood	Total
	- - - - *thousand cubic feet* - - - -		
Saw logs			
1939–48	7,100	180,746	187,846
1949–62	4,651	67,708	72,359
1963–74	5,771	66,658	72,429
1975–87	7,258	109,380	116,638
1988–2004	5,625	154,999	160,624
2005–09	3,783	126,328	130,111
Veneer logs			
1939–48	0	7,452	7,452
1949–62	0	4,901	4,901
1963–74	0	853	853
1975–87	14	1,930	1,944
1988–2004	78	5,455	5,533
2005–09	93	5,729	5,822
Pulpwood			
1939–48	0	3,366	3,366
1949–62	2,594	3,483	6,077
1963–74	2,820	29,557	32,377
1975–87	2,920	31,741	34,661
1988–2004	2,820	49,817	52,637
2005–09	4,712	20,983	25,695
Other industrial			
1939–48	3,000	10,551	13,551
1949–62	1,953	5,612	7,565
1963–74	5,451	12,673	18,124
1975–87	3,249	10,263	13,512
1988–2004	4,877	46,008	50,885
2005–09	2,729	6,714	9,443
Residential fuelwood			
1939–48	0	95,907	95,907
1949–62	769	45,722	46,491
1963–74	359	11,078	11,437
1975–87	720	43,728	44,448
1988–2004	98	17,064	17,162
2005–09	182	23,562	23,744
All products			
1939–48	10,100	198,022	208,122
1949–62	9,967	127,426	137,393
1963–74	14,401	120,819	135,220
1975–87	14,161	197,042	211,203
1988–2004	13,498	273,343	286,841
2005–09	11,499	183,316	194,815

Volume harvested for saw-log products, used mainly for dimension lumber, was the leading product in Kentucky, averaging 130.1 million cubic feet (5.0 million green tons), and accounted for 67 percent of total product output. This volume was down 19 percent from the 160.6 million cubic feet reported for the previous survey period (table 15). The total number of sawmills has varied between 277 in 2005 and the current number of 217 in 2009. At 126.3 million cubic feet (4.9 million green tons) hardwoods accounted for 97 percent of saw-log harvest volume (tables 16 and 17).

The two pulpmills operating in Kentucky over the time period made pulpwood the second leading wood product produced during the latest survey period. Pulpwood output as a proportion of total product output increased from 16 percent during the 1975–87 survey period, to 18 percent during the 1988–2004 survey period.

Table 16—Average annual timber removals from all sources on timberland by removal type and species group, Kentucky, 2005–09

Removal type	All species	Species group: Softwood	Hardwood
	thousand cubic feet		
Timber products			
Saw logs	130,111	3,783	126,328
Veneer logs and bolts	5,822	93	5,729
Pulpwood	25,695	4,712	20,983
Composite panels	7,658	1,322	6,336
Other miscellaneous	1,785	1,407	378
Residential fuelwood	23,744	182	23,562
All products	194,815	11,499	183,316
Logging residues	155,963	6,500	149,463
Land use removals	102,663	11,202	91,461
Total removals	453,441	29,201	424,240

Totals may not sum due to rounding.

Table 17—Average annual timber removals from all sources on timberland by removal type and species group, Kentucky, 2005–09

Removal type	All species	Species group: Softwood	Species group: Hardwood
		green tons	
Timber products			
Saw logs	5,002,755	134,484	4,868,271
Veneer logs and bolts	224,083	3,306	220,777
Pulpwood	976,126	167,509	808,617
Composite panels	291,165	46,996	244,169
Other miscellaneous	64,585	50,018	14,567
Residential fuelwood	914,473	6,470	908,003
All products	7,473,187	408,784	7,064,403
Logging residues	5,990,899	231,071	5,759,828
Land use removals	3,922,838	398,226	3,524,612
Total removals	17,386,924	1,038,081	16,348,843

Totals may not sum due to rounding.

Pulpwood output during the latest remeasurement period decreased and accounted for 13 percent of total product output for the State. Average annual harvest for pulpwood (softwood and hardwood combined) was down 51 percent from the previous survey period but still totaled 25.7 million cubic feet (976,100 green tons). Hardwood pulpwood production was down 58 percent from the previous survey period and totaled 21.0 million cubic feet (808,600 green tons) and accounted for 82 percent of total pulpwood harvest volume. Softwood pulpwood production was up 67 percent to 4.7 million cubic feet (167,500 green tons) (tables 16 and 17).

Volume harvested for veneer products totaled 5.8 million cubic feet (224,100 green tons). Volume harvested for veneer was up 5 percent from the previous survey period and accounted for only 3 percent of TPO for the State.

Volume harvested for other industrial products such as poles, posts, composite panels, and mulch totaled 9.4 million cubic feet (355,800 green tons), or 5 percent of the State's TPO. Hardwoods accounted for 71 percent of the volume harvested for other industrial products and totaled 6.7 million cubic feet (258,700 green tons).

Volume used for residential fuelwood totaled 23.7 million cubic feet (914,500 green tons) and accounted for 5 percent of total product output. At 23.6 million cubic feet (908,003 green tons), hardwoods accounted for 99 percent of the residential fuelwood harvest.

Hardwood saw logs stacked on barge for transport. (photo courtesy of Larry Lowe, Kentucky Division of Forestry)

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 or in secondary products such as mulch and animal bedding, or as fuel at wood product mills.

Table 18 depicts the average annual disposal of mill residue and how it was utilized. Data on mill residue production and disposal generated from the averaged forest products industry surveys over the time period indicated 83.5 million cubic feet of wood and bark residue was generated from primary processors. Sawmills generated most of the mill residue produced. Bark accounted for 20.8 million cubic feet (25 percent), coarse residues accounted for 36.2 million cubic feet (43 percent), and sawdust and shavings accounted for 26.5 million cubic feet (32 percent) of mill residue produced.

Nearly 25.8 million cubic feet, or 31 percent, of mill residue produced was used for industrial fuel either at pulpmills for boiler fuel or at sawmills for dry kiln operations. Bark and sawdust, at 8.9 and 12.4 million cubic feet, respectively, accounted for 82 percent of mill residue utilized for industrial fuel. Forty-three percent of bark residue produced was utilized for fuel, with the remainder of the utilized bark going for mulch or miscellaneous products. Fiber products were by far the largest uses of mill residue produced in Kentucky. Fifty-one percent of the coarse residue produced, 18.4 million cubic feet, was utilized for pulp or fiber products. Bark and wood residue not utilized totaled 2.0 million cubic feet, or 2 percent of all residues produced.

Table 18—Disposal of average annual volume of residue at primary wood-using plants by product, species group, and type of residue, Kentucky, 2004–09

Product and species group	All types	Type of residue: Bark	Coarse	Sawdust	Shavings
	thousand cubic feet				
Fiber products					
Softwood	152	0	152	0	0
Hardwood	18,252	0	18,235	17	0
Total	18,404	0	18,386	17	0
Particleboard					
Softwood	51	0	27	24	0
Hardwood	2,620	133	2,306	164	16
Total	2,671	133	2,333	188	16
Charcoal/ chemical wood					
Softwood	135	4	42	88	1
Hardwood	14,369	1,743	5,544	7,047	36
Total	14,504	1,747	5,586	7,134	37
Sawn products					
Softwood	1	0	1	0	0
Hardwood	377	0	377	0	0
Total	378	0	378	0	0
Industrial fuelwood					
Softwood	734	440	178	117	0
Hardwood	25,064	8,446	4,241	12,235	142
Total	25,798	8,886	4,418	12,352	142
Miscellaneous					
Softwood	1,538	285	765	480	8
Hardwood	18,279	9,476	3,465	5,148	190
Total	19,817	9,761	4,230	5,628	198
Not used					
Softwood	181	22	92	66	0
Hardwood	1,788	297	737	754	0
Total	1,969	319	829	820	1
All products					
Softwood	2,792	751	1,257	775	9
Hardwood	80,749	20,095	34,905	25,364	385
Total	83,541	20,846	36,161	26,139	394

Totals may not sum due to rounding.

Land use removals—Land use removals (land clearing or set-aside forest land), or removal volume attributed to land use change, accounted for 23 percent of total removals with 102.7 million cubic feet (3.9 million green tons) (table 13). The merchantable portion of live trees accounted for 75.0 million cubic feet (2.9 million green tons), while nonmerchantable sources accounted for 27.7 million cubic feet (1.1 million green tons). The hardwood species group accounted for 89 percent of the land use change removals.

Logging residue—The merchantable portions of trees cut and left on-site are underutilized removals by FIA merchantability standards, while the nonmerchantable portions of trees (part of the 1-foot stump or volume in tops <4 inches) used for products are considered overutilized removals by FIA merchantability standards. With this in mind, underutilization and overutilization factors used to estimate average annual logging residue for this section were derived from preliminary estimates from the 2009 Kentucky Harvest and Utilization Study (Cooper and Bentley 2013). Logging residue has been considered a possible source for bioenergy and other timber products during recent years. It is important to keep in mind that logging residue has not traditionally 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.

Most loggers are set up to merchandise the main bole of the tree or the merchantable portion of the tree (from a 1-foot stump to a 4-inch top). The current conventional logging system in Kentucky is a feller buncher, working with one or two rubber-tired grapple skidders, a delimbing gate or pull-through delimber at the deck, a knuckleboom loader, and the appropriate number of tractor trailers to haul the volume harvested. Improved mechanization and equipment capabilities have dramatically increased productivity and utilization across the South. These systems are typically capable of producing on average about 10 loads of tree-length wood per day.

Wood 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).

This wood material left on the 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 is 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. For instance, felled-tree utilization studies conducted for Kentucky showed that only 6.81 percent of the merchantable softwood bole was not utilized for products, whereas 14 percent of the merchantable hardwood bole was not utilized.

Residual logging residue after harvest activity is complete. (photo by James Bentley, U.S. Forest Service)

The reader must remember that total removal volume is made up of volume from the merchantable and nonmerchantable portions of removal trees. Overutilization 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. After the nonmerchantable portion of timber products and land use change values is calculated and subtracted from total nonmerchantable removals volume, the remainder is the volume of nonmerchantable logging residues.

With this in mind, the annual logging residue volume in Kentucky from 2005 to 2009 averaged 156.0 million cubic feet per year, or 6.0 million green tons (table 13). This volume accounted for 34 percent of total timber removals. Nearly 149.5 million cubic feet (5.8 million green tons), or 96 percent, of the logging residues generated came from hardwoods, and 6.5 million cubic feet (231,100 green tons) came from softwood species. Logging residue from the merchantable portion of all-live removals totaled 73.6 million cubic feet per year (2.8 million green tons), or 47 percent of total logging residue. It is interesting to note that while total logging residue accounted for 34 percent of total removals, the merchantable portion of logging residue for softwood and hardwood combined, accounted for about 16 percent of total-live removals. For softwoods, the merchantable portion of logging residue accounted for 11 percent of the total softwood all-live tree removals, which totaled 22.4 million cubic feet. The merchantable portion of hardwood logging residue accounted for 23 percent of all-live hardwood removals, which amounted to 308.0 million cubic foot. Nonmerchantable sources (such as the residual stump, forks, tops, and limbs) accounted for 82.3 million cubic feet (3.2 million green tons), or 53 percent of total logging residue. Trees <5 inches d.b.h. contributed another 748,000 green tons of possible logging residue.

Over the same time period, the area of timber harvested annually in Kentucky amounted to 216,500 acres. Of this area, 13,600 acres (6 percent) underwent a final harvest, while 186,200 acres (86 percent) had a partial harvest and 6,200 acres (3 percent) had commercial thinning. Other silvicultural treatments accounted for 10,200 acres or 5 percent of all treatments. The removals volume attributed to timber products and logging residues are directly related to these treated acres. Based on these estimates, nearly 62.2 tons per acre in the merchantable and nonmerchantable portion of trees >5 inches d.b.h. were removed annually from Kentucky timberland. Of this, nearly 34.5 tons per acre were utilized for products, while 24.5 tons per acre were left as logging residue after discounting the residual stump volume. Adding in 3.4 tons per acre for trees <5 inches, the total logging residue amounts to 27.9 tons per acre. This volume would be the equivalent of a tree-length trailer load of wood for every acre treated in Kentucky.

Potential recoverable logging residue— Conventional logging operations are designed to haul tree-length wood that fits between the stanchions of the trailer. A more effective way to handle the nonmerchantable portion of removals trees—rough trees with crooked boles, tops, and limbs—is to chip this material at the site and transport the material in chip vans. Some Kentucky loggers have begun to add whole-tree chippers and chip vans to their inventory of equipment. Current markets for chipped wood captured from logging residue are limited to facilities with wood-fired boiler systems or production of mulch. Where bioenergy or mulch markets are available, chipping this material on-site is a cost-efficient way of handling and transporting rough and rotten trees, the nonmerchantable portions of cut trees, and small trees <5 inches d.b.h.

What is a realistic recovery rate of logging residue in Kentucky? Current literature and personal communications with loggers and others in the forestry field suggest that conventional logging operations described earlier could capture 60 percent of what is currently being left behind as logging residue. This recovery rate excludes residual stump volume and would seem to be a realistic goal for possible extraction of formerly unutilized material (Perlack and others 2005).

For this assessment, the nonmerchantable portion of logging residue (3.2 million green tons) has been reduced by 59 percent to 1.3 million green tons (table 19) to account for residual stump (691,300 green tons) and tops and limb volume (1.2 million green tons) that are not immediately recoverable. This amount combined with the merchantable logging residue of 1.8 million green tons leaves 3.1 million green tons available from trees ≥5 inches d.b.h., or 14.5 tons per acre. Residual volume following harvest operations for trees <5 inches d.b.h. accounts for another 748,000 green tons. This report assumes only 20 percent could realistically be extracted, or 149,600 green tons.[1] This volume adds another 0.7 ton per acre. Combined, the average annual recovery of logging residue at a 60-percent recovery rate from all sources could have amounted to an additional 15.2 tons per acre added to the product stream.

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[1]Personal communication. 2012. H.M. (Mac) Lupold, Lupold Consulting, Inc., 228 Chestnut Ferry RD., Camden, SC 29020.

Table 19—Average annual weight of logging residue by size class and recovery potential, Kentucky, 2004–09

			Non-recoverable		Total available			Potentially recoverable at 60% recovery rate[a]	
Logging residue in harvested trees by size class	Total		Discounted stump volume	Discounted <5" volume	Base total volume	Total	Discounted ≥5" volume	Total volume	Total
	green tons	*tons/acre*	*- - - - - - - - - green tons - - - - - - - - -*			*tons/acre*	*- - - - green tons - - - -*		*tons/acre*
Merchantable volume ≥5"	2,829,434	13.1	0	0	2,829,434	13.1	993,030	1,836,404	8.5
Nonmerchantable volume ≥5"	3,161,465	14.6	691,319	0	2,470,146	11.4	1,162,103	1,308,043	6.0
Subtotal	5,990,899	27.7	0	0	5,299,580	24.5	2,155,133	3,144,447	14.5
Nonmerchantable volume <5"	748,017	3.4	0	598,414	149,603	0.7	0	149,603	0.7
Total	6,738,916	31.1	691,319	598,414	5,449,183	25.2	2,155,133	3,294,050	15.2

Totals may not sum due to rounding.
[a] This value is calculated from the base total volume of 5,449,183 tons.

Summary

Traditional markets for paper and construction materials still dominate the wood products industry. However, timber removals and utilization continue to change as increased demand for wood as a source for energy creates new market opportunities.

FIA and TPO data show substantial sources of fiber that are currently underutilized and that could be used for bioenergy or other timber products if effectively captured. New facilities that utilize wood for energy may provide opportunities to capture logging residue and minimize any increase above current traditional harvest levels. This possibility will require further study.

New markets, such as bioenergy facilities, that plan to use logging residues as a primary source for fuel must carefully assess average annual volume available in a procurement area, and consider incentives to attract loggers to invest in operations that harvest wood residues at minimum costs.

With proper assessment, investment, and operation, industries utilizing logging residue could possibly offer opportunities for a renewable energy source while creating "green" jobs. Loggers would realize additional markets for fiber and additional sources of income from each logging site. Landowners may also receive additional income with increased utilization from harvested acres and lower site preparation costs for establishing new forests.

Forest Industry in Kentucky

Manufacturing sector and forest products industries—Forest products and the forest industry play a significant role in Kentucky's economy. In 2005, the wood products and paper manufacturing subsectors combined (North American Industry Classification System (NAICS) subsectors 321 and 322, respectively) accounted for 6.8 percent of the State's manufacturing GDP, a share that increased through the 2005–09 period, reaching 9.5 percent in 2009 (U.S. Department of Commerce Bureau of Economic Analysis 2012). As shown in figure 38, while the State's manufacturing sector displayed a continuous downward trend from 2006 forward, the paper manufacturing industry showed an upwards trend from 2008 to 2009, driving the forest industry's overall increase in GDP contribution.

Economic contribution of the forest industry—The following analyses were developed using IMpact analysis for PLANning (IMPLAN) version 3.0 economic modeling tools (Minnesota IMPLAN Group, Inc. 2009). IMPLAN models report on the direct, indirect, induced, and total effects of the forest products industry. For a sector analysis, IMPLAN direct effects represent total sales by the forest industry. Indirect effects capture total sales resulting from the forest industry's purchase of goods and services from other local industries, and the induced effects denote the impacts from changes in household expenditures resulting from the change in production. Total effects consist of direct, indirect, and induced effects. For each of these contribution effects, IMPLAN generates estimates for employment (includes full- and part-time jobs), labor income, output, and total value added. Output represents the sector's total value of production, and the total value added is the difference between the total output and the costs of intermediate inputs. In other words, total value added is the industry's gross contribution to the overall economy of an area (Minnesota IMPLAN Group 2011).

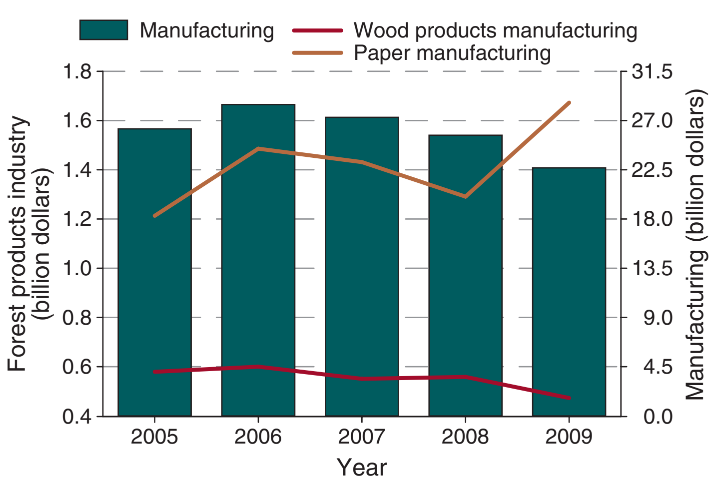


Figure 38—Kentucky's GDP from manufacturing and forest products industries (NAICS 321 and 322), 2005–09. Source: U.S. Department of Commerce, Bureau of Economic Analysis, 2012.

We assessed the forest sector's economic contribution by using IMPLAN's estimated total output for each industry as the model's initial effects. Forest industries were grouped into five categories: (1) timber-logging, (2) sawmill-panel, (3) pulp, (4) durable goods, and (5) nondurable goods. Within the manufacturing industries, the primary sector includes sawmill-panel and pulp industries, and the secondary sector comprises industries in the durable and nondurable goods categories. A complete list of the industries included under each category is provided in the appendix. Following, we provide direct and total effect figures for State models corresponding to IMPLAN datasets for 2006 through 2009. All estimated dollar values are shown in 2009 dollars.

During 2009, the forest sector provided 23,848 jobs with $1.20 billion in payroll, and contributed $1.91 billion of direct value added to Kentucky's economy. The State's forest sector activity resulted in total employment (direct, indirect, and induced) of 46,137 jobs and labor income close to $2.11 billion. Further, the sector generated an overall $3.45 billion in total value added.

Industries in the secondary sector category provided a significant portion of the forest sector employment (table 20). During 2009, the secondary sector accounted for 72 percent of the direct employment and 76 percent of the labor income. Durable goods industries provided 9,633 jobs, 56 percent of the secondary sector direct employment. The primary sector, on the other hand, supplied 19 percent of the forest sector's direct employment. Within the primary sector, sawmill-panel industries provided 3,019 jobs, 66 percent of the primary sector direct employment.

Between 2006 and 2009, direct employment from the forest products sector dropped by 23 percent (table 20). Although the sector's overall direct employment appears to decrease gradually through the 4-year period, the downwards trend varies across industry groups (fig. 39). Direct employment in the timber-logging and the secondary sector increased from 2006 to 2007 and decreased from 2007 to 2009. The primary sector, on the other hand, experienced a continuous decrease during the 4-year period. Industries in the sawmill-panel group faced the largest

Table 20—Effects of forest sector by impact type and category on employment and labor income, Kentucky, 2006–09

Impact type and category	Employment 2006	Employment 2007	Employment 2008	Employment 2009	Change	Labor income 2006	Labor income 2007	Labor income 2008	Labor income 2009
	number of jobs				*percent*	*millions of dollars*			
Direct effect									
Timber, logging	2,397	2,739	2,512	2,050	-14.5	$49.17	$56.42	$63.95	$46.22
Primary sector									
Sawmill, panel	6,025	4,272	4,210	3,019	-49.9	191.14	134.65	136.91	93.30
Pulp	1,629	1,603	1,600	1,549	-4.9	160.98	152.01	159.11	150.80
Total primary	7,655	5,875	5,810	4,569	-40.3	352.12	286.66	296.02	244.10
Secondary sector									
Durable goods	13,033	13,570	13,209	9,633	-26.1	630.00	598.00	582.00	444.00
Nondurable goods	7,847	8,497	8,361	7,596	-3.2	540.14	559.93	556.89	487.60
Total secondary	20,880	22,067	21,571	17,229	-17.5	1,132.25	1,122.34	1,100.06	905.16
Total direct effect	30,932	30,681	29,893	23,848	-22.9	1,533.54	1,465.41	1,460.03	1,195.48
Total effect									
Timber, logging	4,879	3,633	4,900	3,071	-37.1	126.49	85.95	140.32	80.54
Primary sector									
Sawmill, panel	9,322	6,719	6,356	4,874	-47.7	323.82	231.71	225.30	169.28
Pulp	5,169	5,646	5,104	5,579	7.9	314.07	323.30	315.19	325.83
Total primary	14,490	12,364	11,461	10,452	-27.9	637.89	555.01	540.49	495.11
Secondary sector									
Durable goods	21,049	22,515	20,632	15,876	-24.6	906.74	907.48	837.54	660.93
Nondurable goods	17,931	19,190	18,271	16,739	-6.6	965.38	1,001.61	984.25	872.09
Total secondary	38,980	41,705	38,903	32,614	-16.3	1,872.12	1,909.10	1,821.79	1,533.03
Total impact type	58,350	57,702	55,264	46,137	-20.9	2,636.51	2,550.06	2,502.60	2,108.68

Source: IMPLAN Version 3.0, 2006–09 data.
Note: Percent change corresponds to change between 2006 and 2009.

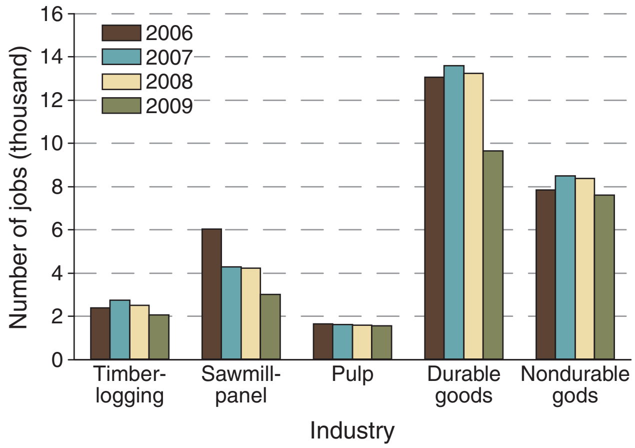


Figure 39—Direct effect of the forest sector on employment by major category, Kentucky, 2006–09.

percent drop in employment, with close to 50 percent fewer jobs in 2009 than in 2006 (a loss of 3,006 jobs). In terms of number of employees, the durable goods industries experienced the largest fall, with direct employment decreasing by 3,400 jobs between 2006 and 2009. In contrast, industries in the nondurable goods category observed a 3.2-percent decrease in employment with 251 fewer jobs in 2009 than in 2006.

Similarly, total direct value added from the forest sector decreased by 18 percent from 2006 to 2009 (table 21). Sawmill-panel industries sustained the largest

Table 21—Direct and total effect of forest sector on output, Kentucky, 2006–09

Impact type and category	Year				
	2006	2007	2008	2009	Change
	millions of dollars				*percent*
Direct effect					
Timber, logging	$81.22	$188.95	$110.29	$58.99	-27.4
Primary sector					
Sawmill, panel	297.88	200.40	179.02	121.69	-59.1
Pulp	300.22	229.47	271.72	337.63	12.5
Total primary	598.10	429.88	450.74	459.32	-23.2
Secondary sector					
Durable goods	852.87	729.49	665.99	625.54	-26.7
Nondurable goods	775.87	661.69	710.09	765.22	-1.4
Total secondary	1,628.74	1,391.18	1,376.09	1,390.76	-14.6
Total direct effect	2,308.06	2,010.01	1,937.12	1,909.07	-17.3
Total effect					
Timber, logging	189.54	234.94	215.58	111.64	-41.1
Primary sector					
Sawmill, panel	530.58	361.93	330.15	249.26	-53.0
Pulp	571.77	517.46	540.80	635.22	11.1
Total primary	1,102.35	879.39	870.95	884.48	-19.8
Secondary sector					
Durable goods	1,409.82	1,308.15	1,172.05	1,039.91	-26.2
Nondurable goods	1,507.48	1,392.82	1,436.49	1,415.76	-6.1
Total secondary	2,917.30	2,700.97	2,608.54	2,455.67	-15.8
Total impact type	4,209.19	3,815.29	3,695.07	3,451.79	-18.0

Source: IMPLAN Version 3.0, 2006–09 data.
Note: Percent change corresponds to change between 2006 and 2009.

Skidder pulling hardwood logs to the logging deck. (photo courtesy of Larry Lowe, Kentucky Division of Forestry)

fall with total value added decreasing by 59 percent. Conversely, the direct value added from pulp industries was 12 percent higher in 2009 than in 2006. Within the secondary sector, total direct value added from nondurable goods decreased from 2006 to 2007, and increased from 2007 to 2009. Pulp industries displayed a similar pattern (fig. 40). Durable goods industries, as well as sawmill-panel industries declined continuously in value added through the 2006–09 period.

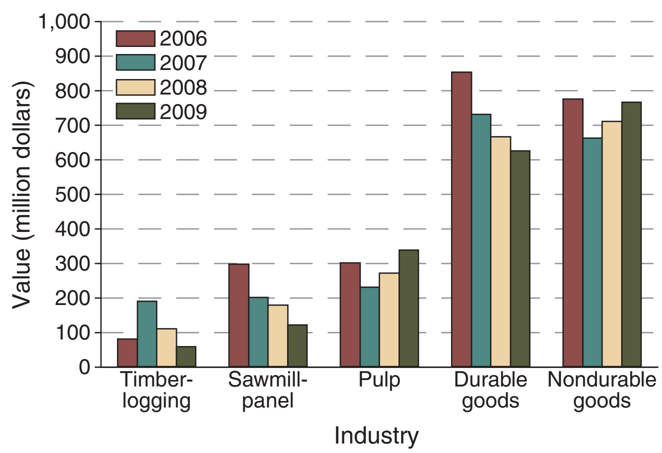


Figure 40—Direct effect of the forest sector output value by major category, Kentucky 2006–09.

Forest Health Indicators in Kentucky

What is a Healthy Forest?

From the Appalachian forests of eastern Kentucky to the bottomland hardwood forests of the Land Between the Lakes in southwestern Kentucky, Kentucky's forests are complex ecosystems and are essential to the State's overall well-being. Wildlife depends on them for habitat, and we humans depend on them for food, fiber, recreation, water quality, and economic stability. A variety of factors affect forest health.

Regardless of how the forests of Kentucky are viewed, the health of these forests is vital. But what is a healthy forest and how is it defined? There are many definitions and concepts depending on an individual's perspective on forest health. It may be difficult to explicitly define a "healthy forest," yet we can look at many indicators and synthesize the information into a larger picture of the health of the forests in the State. No single measurement or variable can summarize forest health. Instead, we must consider a wide set of indicators that together serve as a reflection of existing conditions. Repeated monitoring of these indicators over time allows identification of trends in forest conditions. For example, increased tree mortality can indicate a pest or disease issue, high levels of observed ozone damage may mean a problem with ozone pollution, or increasing observations of nonnative invasive species may warn of future ecological or economic problems.

Numerous forest health indicators must be viewed holistically in order to gain an appreciation for the overall health of our forests and the numerous threats they may be facing. We can use this information to help improve the condition of the State's forests over time.

An array of trees, herbaceous plants, animals, and microorganisms, as well as natural processes such as disturbances (for example, fire), help maintain a healthy forest ecosystem. Careful management and harvesting also play a vital role in sustaining the health of forested ecosystems. Some forces that have a negative impact on forest health are pests, diseases, and exotic invasive species (for example, the Hemlock woolly adelgid and the gypsy moth).

Forest Disturbance

Kentucky's forests are heavily influenced by many disturbance events. An estimated 2.3 million acres exhibited signs of some type of disturbance during the 2009 inventory (table 22). That estimate is the equivalent of about 452,000 acres disturbed annually between 2004 and 2009. Thus, at current rates, an area equivalent to the entire forest land area in Kentucky is disturbed about every 27 years. Disturbances are important in defining, shaping, and changing the forests within the State. There are areas within the State, such as deep coves on the escarpment of the Cumberland Plateau in eastern Kentucky, which can persist without external disturbances for longer periods of time.

Table 22—Area of forest land by year and primary disturbance, Kentucky, 2004–09

		Primary disturbance								
Year	Total	None	Insect	Disease	Fire	Animal	Weather	Other	Human	Not collected
					acres					
2004	12,283,434	10,118,449	134,177	15,443	428,172	497,314	579,933	37,933	472,015	0
2005	12,071,007	10,047,837	129,378	11,812	428,731	469,254	481,554	45,210	450,990	6,243
2006	12,121,334	10,247,238	99,038	6,210	401,453	454,468	504,519	42,411	353,578	12,419
2007	12,369,226	10,448,180	84,208	15,961	388,798	507,372	495,651	75,692	334,561	18,803
2008	12,425,529	10,314,408	56,530	15,936	348,701	502,972	819,864	103,617	244,647	18,851
2009	12,400,650	10,123,876	50,308	19,758	258,970	473,914	1,168,834	104,175	181,957	18,855

However, maturing forests without external disturbances are influenced by internal changes, particularly as trees age, senesce, and begin to break up and fall over. Many areas in Kentucky, such as the table lands of the Cumberland Plateau, can be affected by multiple disturbances over short periods.

Weather events and animals (for example, wild boar), as primary disturbance agents, have generally accounted for the largest acreage of disturbed forest land in Kentucky (fig. 41). Animal disturbances accounted for an estimated 474,000 acres of disturbed forest land (21 percent of all disturbed forest land) and weather-related disturbances accounted for an estimated 1.2 million acres (51 percent of all disturbed forest land). Disturbed acreage where the primary disturbance was associated with some type of weather event was significantly higher in 2009 than any other type of disturbance. Moreover, weather-disturbed acreage increased from 27 percent of all disturbed acreage in 2004 to 51 percent in 2009.

Weather-related forest disturbances occurred across all of the State, but exhibited a clear pattern that stretched from the southwest to the northeast (fig. 42). Damage associated with ice was common within this weather disturbance corridor and is closely associated with the pattern of ice accumulation recorded during an event on January 26-28, 2009 that affected large portions of Kentucky (fig. 43). It is reasonable to suspect that even though this event did not cause all of the increase in weather-disturbed acreage, it played a large role.

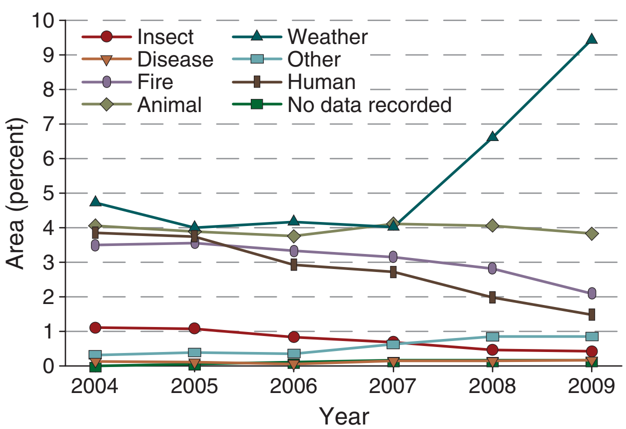


Figure 41—Proportion of area of forest land disturbed by primary disturbance agent, Kentucky, 2004–09.

Trees in Eddyville, KY damaged by an ice storm on January 27th, 2009. (photo courtesy of Liz Roll, FEMA/Wikimedia.org)

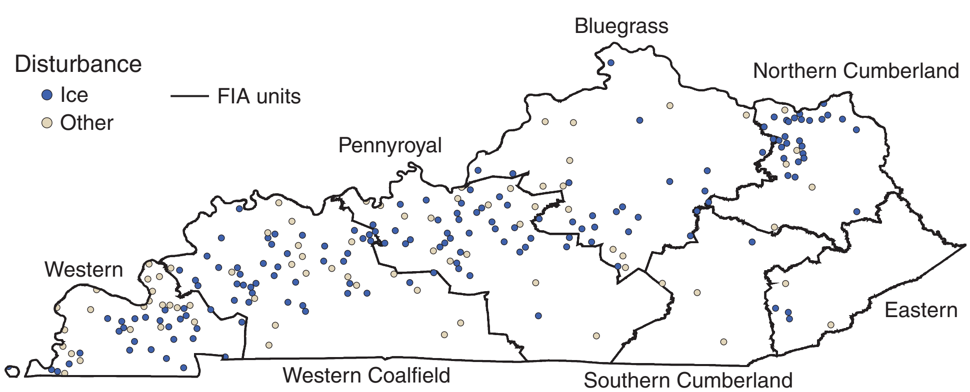


Figure 42—Weather-related disturbed plots sampled on Kentucky forest land for the period 2005–09. (Plot locations are approximate.)

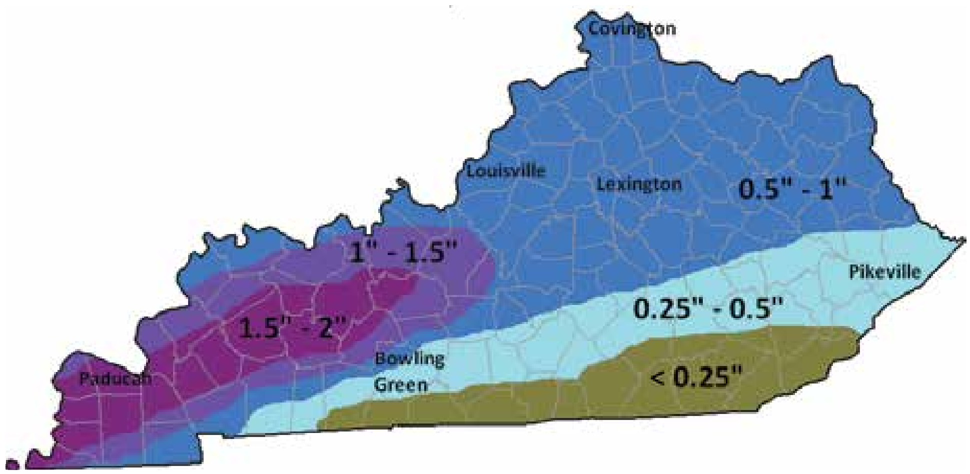


Figure 43—National Weather Service map of ice accumulation for the period of January 26–28, 2009.

Invasive Plants

Foresters and ecologists have noted the spread of nonnative invasive species onto U.S. forest land for decades. Despite soaring costs and inestimable environmental impacts, nonnative invasive species continue to spread across managed and natural forests. Nonnative invasive plants were detected on 1,723 plots across the State, or 71 percent of all forested plots measured (fig. 44). The maximum number of nonnative invasive species detected on an individual plot was eight, which occurred on <1 percent of forested plots (table 23). Invasive plant presence seems to be lowest in the more heavily forested eastern part of the State. Disturbance (for example, harvests, tornadoes) and proximity to agricultural land may account for the larger proportion of plots containing invasive plants in the west-central and western regions.

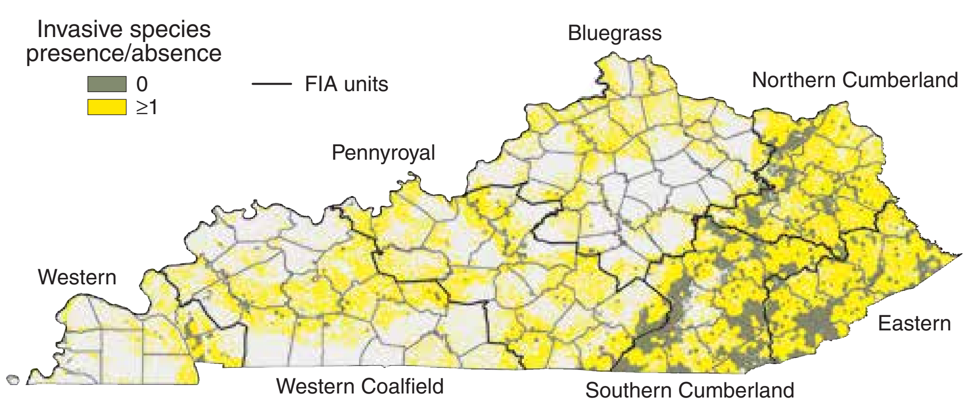


Figure 44—Presence/absence of invasive species on forest land, Kentucky, 2009. (Plot locations are approximate.)

Table 23—Area of forest land by count of unique species and primary disturbance, Kentucky, 2004–09

	Primary disturbance	
Count of unique species	Plots	Surveyed plots[a]
	number	*- percent -*
1	1,582	24
2	606	25
3	333	14
4	155	6
5	36	1
6	7	<1
7	2	<1
8	2	<1
Total	1,723	71

[a] Percent of surveyed plots out of 2,438.

Japanese honeysuckle was the most frequently detected nonnative species in Kentucky (table 24). The seemingly ubiquitous invasive vine was found on 52 percent of all forested plots surveyed, and 73 percent of all plots containing an invasive species. On average, Japanese honeysuckle foliage covered 22 percent of the subplots on which it was found. Nonnative roses were the second most frequently detected species, and were noted on 41 percent of measured plots, with an average percent cover of approximately 10 percent on subplots where it was detected. Tall fescue was the third most frequently observed nonnative invasive in forests of Kentucky. Nepalese browntop, a grass species whose introduction to the United States can be traced to east Tennessee, was the fourth most frequently

Table 24—Invasive species detected on forest land with frequency of plot detections and mean percent subplot cover, Kentucky, 2009

Common name	Scientific name	Plot detections[a]	Mean percent subplot cover[b]
		- number -	*- - percent - -*
Japanese honeysuckle	*Lonicera japonica*	1,258	22
Nonnative roses	*Rosa* spp.	994	10
Tall fescue	*Lolium arundinaceum*	330	28
Nepalese browntop	*Microstegium vimineum*	278	22
Bush honeysuckles	*Lonicera* spp.	230	20
Tree-of-heaven	*Ailanthus altissima*	143	14
Chinese lespedeza	*Lespedeza cuneata*	80	22
Autumn olive	*Elaeagnus umbellata*	59	14
Garlic mustard	*Alliaria petiolata*	59	9
Princesstree, royal paulownia	*Paulownia tomentosa*	34	14
Nonnative climbing yams-air yam/Chinese yam	*Dioscorea bulbifera/D. oppositifolia*	31	6
Chinese/European privet	*Ligustrum sinense/L. vulgare*	28	14
Silktree, mimosa	*Albizia julibrissin*	27	7
Wintercreeper	*Euonymus fortunei*	26	14
Winged burning bush	*Euonymus alata*	25	7
Shrubby lespedeza	*Lespedeza bicolor*	23	20
Nonnative vincas, periwinkles	*Vinca minor/V. major*	14	26
Chinese silvergrass	*Miscanthus sinensis*	11	25
Kudzu	*Pueraria Montana* var. *lobata*	5	24
Nonnative bamboos	*Phyllostachys* spp., *Bambus* spp.	4	32
Japanese/glossy privet	*Ligustrum japonicum/L. lucidum*	3	9
Russian olive	*Elaeagnus angustifolia*	3	0

[a] Plot refers to the forested portion of all subplots measured. If a species was detected on more than one subplot, it is only counted once here.

[b] Percent cover in this column is the average cover on an individual subplot, not the whole plot.

detected species, and was noted on 11 percent of measured plots, with an average percent cover of approximately 22 percent on subplots where it was detected. The above-mentioned species along with bush honeysuckles, tree-of-heaven, Chinese lespedeza, autumn olive, garlic mustard, and royal paulownia are the top 10 most frequently detected invasive plants surveyed for on forested plots in Kentucky (table 24).

Invasive vines, primarily Japanese honeysuckle, were the most frequently detected nonnative invasive plant life form (table 25) and were found on 53 percent of all forested plots. Invasive shrubs were found on 42 percent of all forested plots, while grasses were found on 24 percent, trees on 8 percent, and herbs on only 7 percent of all forested plots.

Invasive trees were noted throughout Kentucky (fig. 45). Tree-of-heaven was the most frequently detected invasive tree in every physiographic region in the State except the Western unit, where mimosa was observed with greater frequency. Tree-of-heaven detections were highest in the Eastern unit (fig. 46). Nonnative roses occupied a fairly high proportion of plots

Table 25—Invasive species on forest land, number of species detections, and number and percent of plots on which they occur by plant life form, Kentucky, 2009

Life form	Plots	Surveyed plots[a]
	- number -	*- percent -*
Trees	197	8
Shrubs	1,032	42
Herbs	160	7
Vines	1,283	53
Grass	576	24

[a] Percent of surveyed plots out of 2,438.

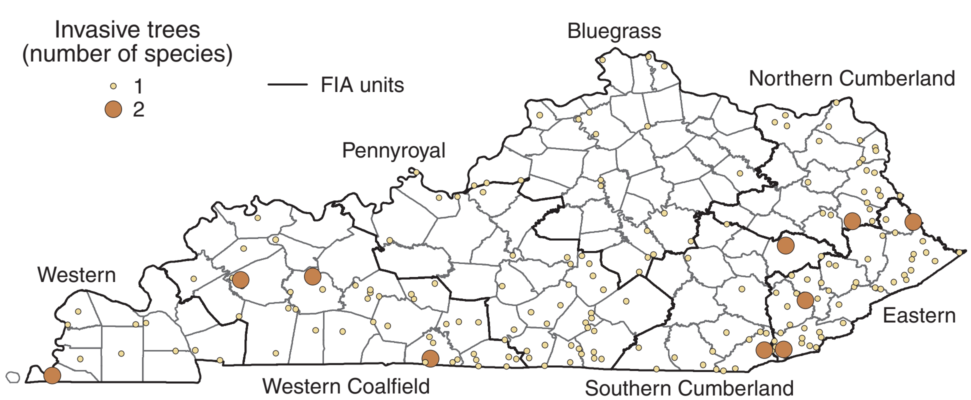


Figure 45—Number of invasive tree species on plots, Kentucky, 2009. (Plot locations are approximate.)

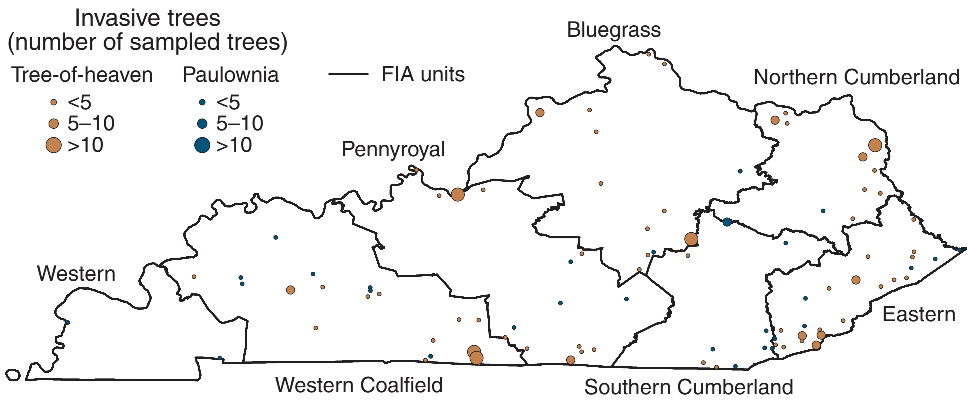


Figure 46—Number of tree-of-heaven and paulownia trees on plots, Kentucky, 2009. (Plot locations are approximate.)

in the Bluegrass (70 percent of forested plots) and Pennyroyal (52 percent) units. No other nonnative shrubs were detected on >7 percent of forested plots within any given unit (fig. 47). Japanese honeysuckle was the most commonly detected vine and was recorded on 24 percent of plots in the Eastern unit, 42 percent of plots in the Northern Cumberland unit, 30 percent of plots in the Southern Cumberland unit, 60 percent of plots in the Bluegrass unit, 67 percent of plots in the Pennyroyal unit, 72 percent of plots in the Western Coalfield unit, and 71 percent of plots in the Western unit (fig. 48). No other invasive vine was detected on >4 percent of plots in any region.

Tall fescue was the most frequently detected invasive grass in Kentucky (fig. 49), and it was detected on 6, 13, 3, 29, 9, 21, and 16 percent of plots in the Eastern, Northern Cumberland, Southern Cumberland, Bluegrass, Pennyroyal, Western Coalfield, and Western units, respectively. Invasive herbs were most common in the Bluegrass unit (fig. 50), and consisted primarily of garlic mustard.

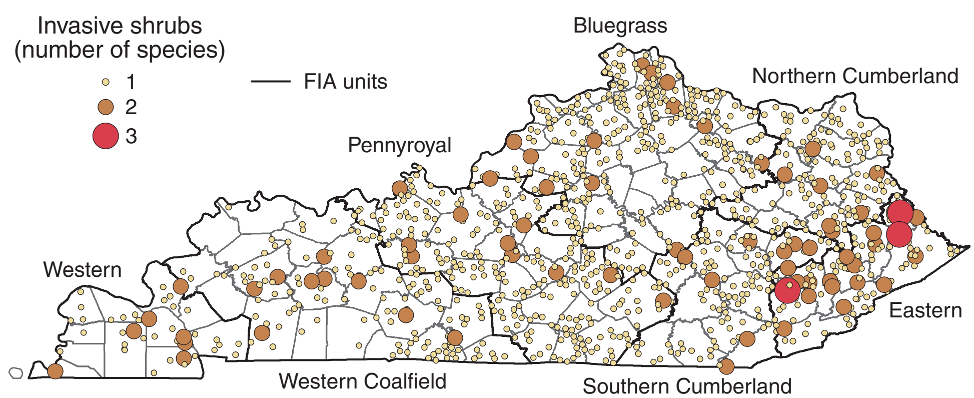


Figure 47—Number of invasive shrub species on plots, Kentucky, 2009. (Plot locations are approximate.)

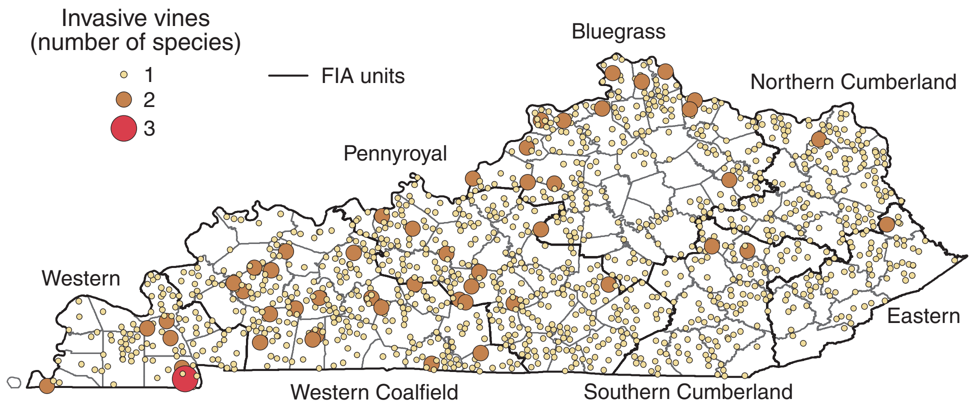


Figure 48—Number of invasive vine species on plots, Kentucky, 2009. (Plot locations are approximate.)

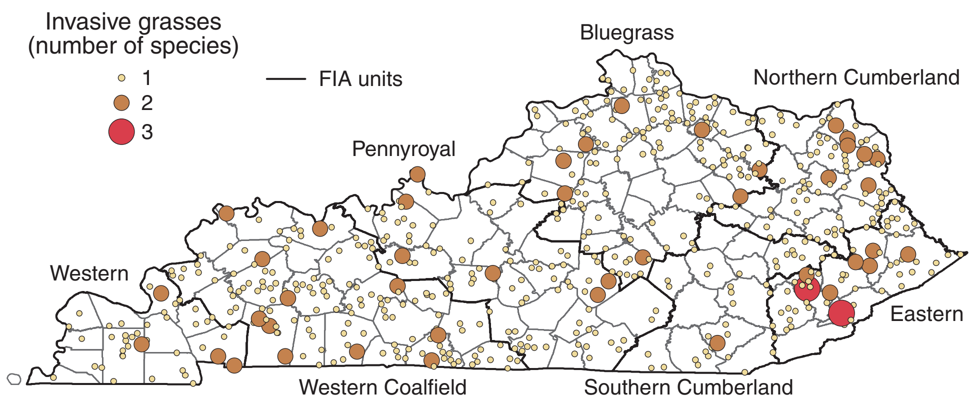


Figure 49—Number of invasive grass species on plots, Kentucky, 2009. (Plot locations are approximate.)

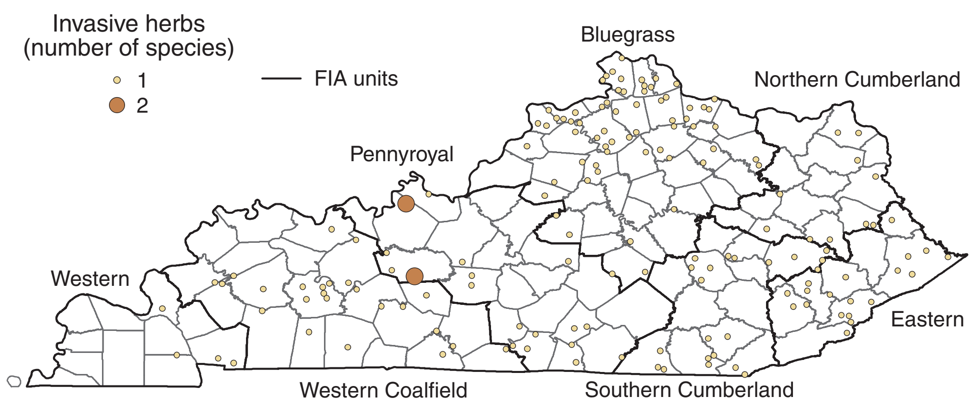


Figure 50—Number of invasive herb species on plots, Kentucky, 2009. (Plot locations are approximate.)

Deadwood on Kentucky Forest Land

Deadwood is extremely important to forest ecosystems because it performs a number of key ecological functions. For example, it serves as nurse logs for the growth of plants and moss, is critical to nutrient cycling and as an element of wildlife habitat, and is a major component of forest fuel loads (Bate and others 2004, Waddell 2002). A multitude of organisms rely on deadwood to provide structural or thermal protection, foraging sites, or travel corridors (Bate and others 2004). For example, Mannan and others (1996) describe 13 small mammal species that depend on coarse woody material for all three of their life-history requirements: food, shelter, and reproduction. However, too much deadwood in the forest can result in excessive fuel loads, sustaining damaging wildfires over large areas. Therefore, forest managers must strike a balance between maintaining enough deadwood to support wildlife, insect, and plant communities and avoiding unacceptably high fuel accumulations.

A major contributing factor to deadwood pools is standing-dead trees. In 2009, there were an estimated 129 million standing-dead trees (≥5 inches d.b.h.) within Kentucky's forests. Standing-dead tree populations were largest in the smallest and largest diameter classes (fig. 51). Plots with the greatest number of standing-dead trees were located in the Northern and Southern Cumberland units and the Eastern unit (fig. 52). Large numbers of standing-dead trees were also sampled in the ice-damage corridor described earlier (see Forest Disturbance section), which may help to explain why weather-disturbed acreage had the most standing-dead trees (table 26).

Black locust (14,093,242 trees), Virginia pine (10,624,025 trees), and sassafras (10,545,682 trees) had the largest absolute populations of standing-dead trees (table 27) across all of Kentucky's forests.

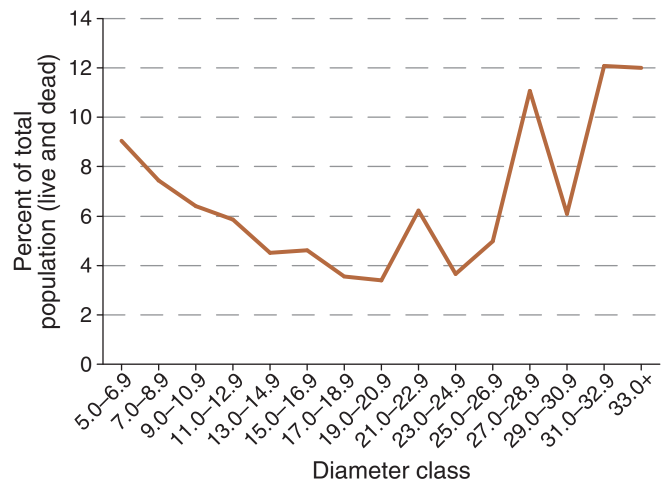


Figure 51—Standing dead trees (≥5 inches d.b.h.) on forest land as a proportion of the total standing tree population (live and dead) by diameter class, Kentucky, 2009.

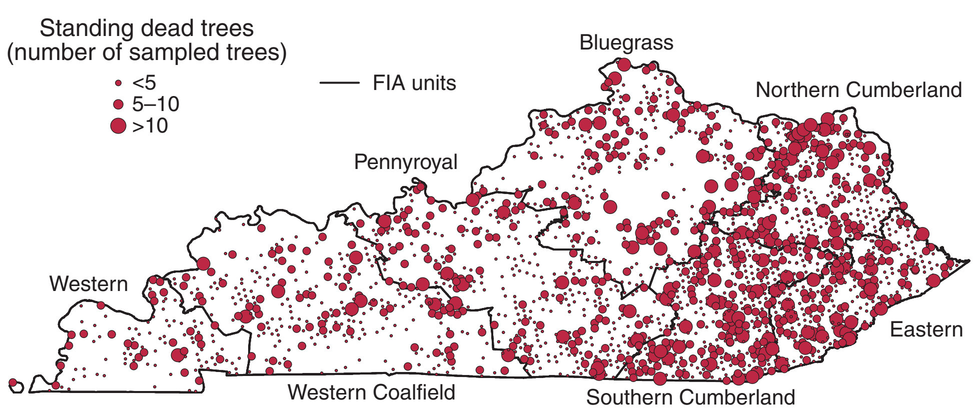


Figure 52—Distribution of sampled standing dead trees (≥5 inches d.b.h.) on forest land, Kentucky, 2009. (Plot locations are approximate.)

Table 26—Number of standing-dead trees (≥5 inches d.b.h.) on forest land by primary disturbance, Kentucky, 2009

Primary disturbance	Standing-dead trees
	number
None	98,218,216
Insects	1,676,543
Disease	335,248
Fire	4,523,276
Animal	6,001,946
Weather	14,822,164
Other	1,810,022
Human	1,101,494
Not collected	189,150
Total	128,678,059

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

Table 27—Number of standing-dead trees (≥5 inches d.b.h.) on forest land by species, Kentucky, 2009

Species	Standing-dead trees
	number
Black locust	14,093,242
Virginia pine	10,624,025
Sassafras	10,545,682
White oak	9,050,838
Eastern redcedar	8,364,247
Yellow-poplar	7,131,268
Red maple	4,477,203
Black oak	4,247,522
Scarlet oak	3,833,311
Chestnut oak	3,818,733

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

Numerous tree species, however, were found to have relative standing-dead tree populations larger than the mean for all species of 1.8 percent (fig. 53). Some of these tree species may be experiencing either short-term or longer-term forest health issues.

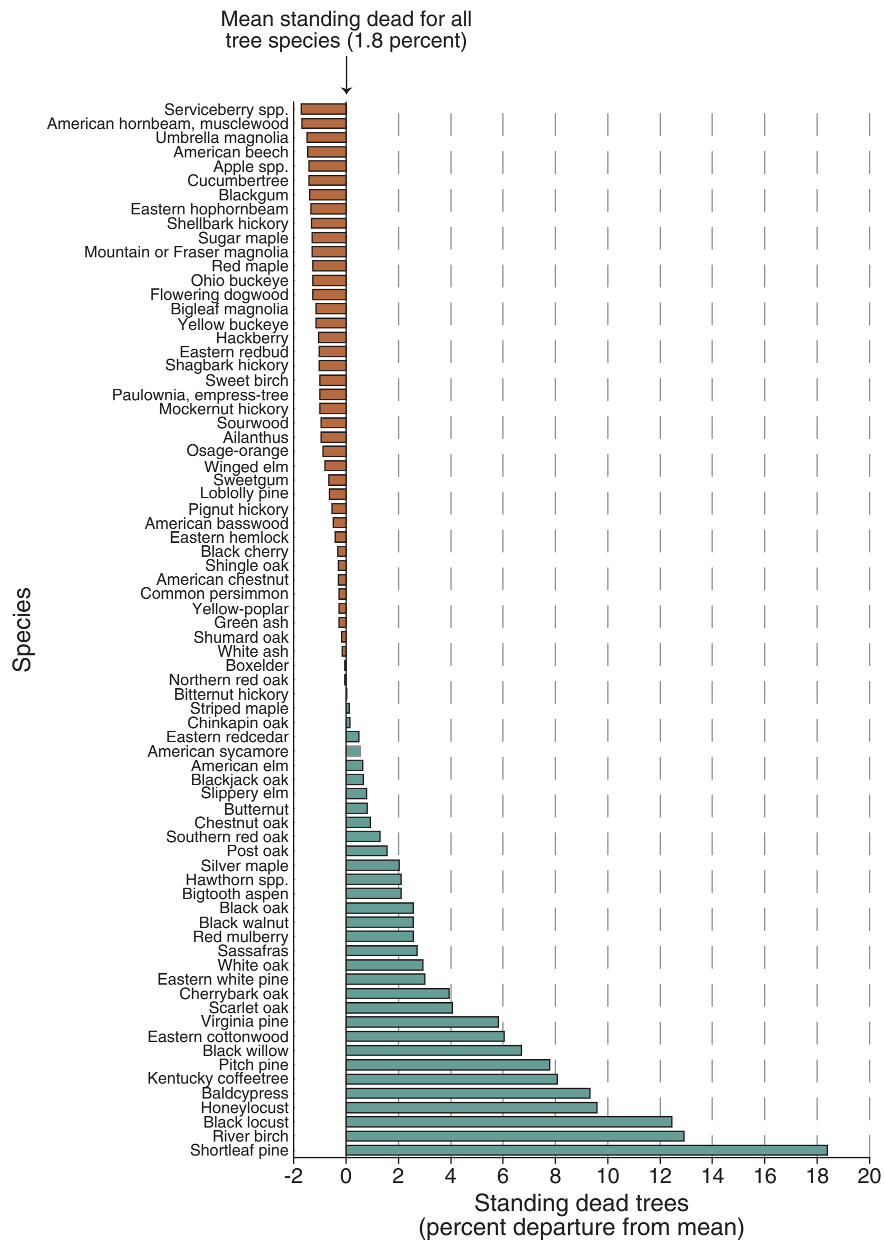


Figure 53—Percent departure from the mean total standing dead-tree population (as a percentage of total standing trees, ≥5 inches d.b.h., live and dead) by species on forest land, Kentucky, 2009.

Crown Condition

FIA includes visual assessments of individual tree crown condition on the phase 3 subset of its inventory plots to aid the monitoring of changes and trends in forest health. Tree crown condition can be used to track forest health because a tree undergoing stress reacts by slowing growth and shedding parts of its crown (Millers and others 1989). The shedding of foliage and fine twigs not only changes the tree's appearance but also alters its rate of photosynthesis and carbohydrate production. Thus, poor crown conditions can be a signal of declining growth rates and degraded forest health.

During prolonged drought periods, trees will exhibit a general thinning of the canopy. This is the tree's effort to compensate for root loss and is called defensive dieback. (photo courtesy of William Fountain, University of Kentucky/Bugwood.org)

FIA reports on three tree crown condition variables (crown density, crown dieback, and foliage transparency) and one sapling crown condition variable (sapling crown vigor). Crown dieback is a symptom of recent stress demonstrated by the death of fine twigs and branches in the upper and outer portions of the crown. Crown density and foliage transparency are similar measures, both describing the amount of foliage present on the tree. Crown density measures the amount of sunlight blocked by all biomass produced by the tree (both live and dead), whereas foliage transparency measures the amount of sunlight penetrating only the live, foliated portion of the crown. Within a species, higher crown density, lower foliage transparency, and lower crown dieback typically indicate healthier trees. Each of the tree crown variables is recorded in increments of 5 percent from 0 to 99 percent for all-live trees. Sapling crowns are not developed enough to assess the three crown condition indicators applied to larger trees; instead, they are categorized into three broad vigor classes of good, fair, and poor condition. All four crown condition indicators were summarized by FIA species group for the years 2005 to 2009. In addition, trees and saplings measured in years 2005 to 2009 were paired with their first measurement between 2000 and 2004 to determine whether crown conditions improved, declined, or remained stable during the remeasurement interval.

Current conditions—Overall, 83.4 percent of the trees assessed exhibited <5 percent crown dieback. Mean dieback was 0.7 percent for softwoods and 2.0 percent for hardwoods and ranged as high as 5.7 percent for the other eastern hard hardwoods group (table 28). Mean crown density was 42.9 percent for softwoods and 35.9 percent for hardwoods, and ranged from 29.8 percent for basswood to 43.5 percent for the other eastern softwoods (table 29). Mean foliage transparency was 20.7 percent for all trees combined and ranged from a low of 17.9 percent for sweetgum to a high of 26.0 percent for the other eastern hard hardwoods (table 30).

Table 28—Mean crown dieback and other statistics[a] for live trees (≥5 inches d.b.h.) on forest land by species group, Kentucky, 2009

Species group	Plots[b]	Trees	Mean	SE[c]	Minimum	Median	90th percentile	Maximum
	- - *number* - -		- - - - - -	- - - -	*percent*	- - - -	- - - -	- - - -
Softwoods								
Loblolly and shortleaf pines	112	2	0.0	—	0	0	0	0
Other yellow pines	10	16	1.3	—	0	0	5	10
Eastern white and red pines	2	3	0.0	—	0	0	0	0
Eastern hemlock	4	9	0.0	—	0	0	0	0
Cypress	1	1	0.0	—	0	0	0	0
Other eastern softwoods	20	137	0.7	0.3	0	0	0	40
Total	35	168	0.7	0.3	0	0	0	40
Hardwoods								
Select white oaks	70	223	1.3	0.3	0	0	5	50
Select red oaks	40	76	1.7	0.6	0	0	5	30
Other white oaks	41	189	0.7	0.2	0	0	5	10
Other red oaks	48	130	2.5	0.5	0	0	10	25
Hickory	82	289	2.7	0.7	0	0	5	99
Hard maple	58	253	0.7	0.1	0	0	0	20
Soft maple	62	224	1.4	0.3	0	0	5	40
Beech	29	73	1.2	0.6	0	0	0	25
Sweetgum	12	31	0.6	0.5	0	0	0	15
Tupelo and blackgum	48	82	1.4	0.5	0	0	5	20
Ash	46	139	2.3	0.8	0	0	5	99
Cottonwood and aspen	2	4	0.0	—	0	0	0	0
Basswood	8	23	0.4	0.3	0	0	0	5
Yellow-poplar	55	178	1.6	0.8	0	0	0	99
Black walnut	21	36	1.8	0.7	0	0	5	20
Other eastern soft hardwoods	79	297	3.2	0.9	0	0	5	99
Other eastern hard hardwoods	33	84	5.7	2.9	0	0	5	99
Eastern noncommercial hardwoods	55	116	4.1	1.4	0	0	10	99
Total	141	2,447	2.0	0.2	0	0	5	99
Species total	141	2,615	1.9	0.2	0	0	5	99

Data collected from 2005 to 2009; d.b.h. = diameter at breast height; SE = standard error.

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

[a] The mean and SE calculations consider the clustering of trees on plots.

[b] The total number of plots on which trees were measured. Plot totals are not cumulative because multiple species may occur on any given plot.

[c] Standard errors are not presented for species groups with the number of trees <20.

Table 29—Mean crown density and other statistics[a] for live trees (≥5 inches d.b.h.) on forest land by species group, Kentucky, 2009

Species group	Plots[b]	Trees	Mean	SE[c]	Minimum	Median	Maximum
	- - *number* - -		- - - - - - - - - - - - - *percent* - - - - - - - - - - - - -				
Softwoods							
Loblolly and shortleaf pines	2	2	32.5	—	25	33	40
Other yellow pines	10	16	37.8	—	25	38	55
Eastern white and red pines	2	3	41.7	—	30	45	50
Eastern hemlock	4	9	45.0	—	40	40	60
Cypress	1	1	35.0	—	35	35	35
Other eastern softwoods	20	137	43.5	1.5	10	45	75
Total	35	168	42.9	1.3	10	40	75
Hardwoods							
Select white oaks	70	223	37.2	0.9	15	40	60
Select red oaks	40	76	37.4	1.1	20	40	50
Other white oaks	41	189	37.7	0.9	5	40	60
Other red oaks	48	130	36.4	0.9	15	38	55
Hickory	82	289	38.0	1.1	0	40	70
Hard maple	58	253	36.1	1.1	15	35	65
Soft maple	62	224	36.5	0.9	10	35	60
Beech	29	73	40.2	2.7	20	40	65
Sweetgum	12	31	34.2	2.7	20	35	50
Tupelo and blackgum	48	82	38.5	1.1	20	40	55
Ash	46	139	34.5	1.4	0	35	60
Cottonwood and aspen	2	4	30.0	—	25	30	35
Basswood	8	23	29.8	2.5	20	30	45
Yellow-poplar	55	178	37.1	1.1	0	40	60
Black walnut	21	36	30.1	1.7	15	30	50
Other eastern soft hardwoods	79	297	32.7	0.9	0	35	55
Other eastern hard hardwoods	33	84	32.3	1.8	0	35	50
Eastern noncommercial hardwoods	55	116	32.2	1.2	0	33	55
Total	141	2,447	35.9	0.5	0	35	70
Species total	141	2,615	36.4	0.6	0	35	75

Data collected from 2005 to 2009; d.b.h. = diameter at breast height; SE = standard error.

— = negligible.

[a] The mean and SE calculations consider the clustering of trees on plots.

[b] The total number of plots on which trees were measured. Plot totals are not cumulative because multiple species may occur on any given plot.

[c] Standard errors are not presented for species groups with the number of trees <20.

Table 30—Mean foliage transparency and other statistics[a] for live trees (≥5 inches d.b.h.) on forest land by species group, Kentucky, 2009

Species group	Plots[b]	Trees	Mean	SE[c]	Minimum	Median	Maximum
	- - *number* - -		- - - - - - - - - - - - - *percent* - - - - - - - - - - - - -				
Softwoods							
Loblolly and shortleaf pines	2	2	22.5	—	20	23	25
Other yellow pines	10	16	23.4	—	10	25	35
Eastern white and red pines	2	3	23.3	—	20	25	25
Eastern hemlock	4	9	20.0	—	15	20	25
Cypress	1	1	20.0	—	20	20	20
Other eastern softwoods	20	137	20.2	0.8	5	20	50
Total	35	168	20.6	0.7	5	20	50
Hardwoods							
Select white oaks	70	223	20.2	0.4	10	20	30
Select red oaks	40	76	20.8	0.7	10	20	30
Other white oaks	41	189	19.8	0.5	15	20	30
Other red oaks	48	130	20.3	0.6	10	20	35
Hickory	82	289	19.5	0.7	5	20	99
Hard maple	58	253	19.2	0.5	10	20	35
Soft maple	62	224	22.0	0.5	10	20	50
Beech	29	73	20.5	0.6	10	20	35
Sweetgum	12	31	17.9	0.7	10	20	25
Tupelo and blackgum	48	82	20.1	0.7	5	20	35
Ash	46	139	22.3	1.2	10	20	99
Cottonwood and aspen	2	4	16.3	—	10	18	20
Basswood	8	23	18.5	0.7	15	20	25
Yellow-poplar	55	178	21.8	0.8	5	20	99
Black walnut	21	36	19.3	1.2	10	20	35
Other eastern soft hardwoods	79	297	21.6	0.8	5	20	99
Other eastern hard hardwoods	33	84	26.0	2.5	15	20	99
Eastern noncommercial hardwoods	55	116	21.3	1.0	10	20	99
Total	141	2,447	20.8	0.3	5	20	99
Species total	141	2,615	20.7	0.3	5	20	99

Data collected from 2005 to 2009; d.b.h. = diameter at breast height; SE = standard error.
— = negligible.
[a] The mean and SE calculations consider the clustering of trees on plots.
[b] The total number of plots on which trees were measured. Plot totals are not cumulative because multiple species may occur on any given plot.
[c] Standard errors are not presented for species groups with the number of trees <20.

Overall, 75.9 percent of the sapling crowns were categorized as good (table 31). With the exception of hardwood crown density, these crown condition means are typical for the region (Randolph 2006). Hardwood crown density conditions were in general lower than what might be expected (about 45 percent), and what was observed in surrounding States during the same time period (fig. 54).The poorest conditions occurred primarily in 2005 (fig. 55), but the reason for the low crown densities is unknown.

Table 31—Distribution of sapling crown vigor class for all-live saplings (1 to <5 inches d.b.h.) on forest land by species group, Kentucky, 2009

Species group	Plots[a]	Trees	Good		Fair		Poor	
			Percent	SE[b]	Percent	SE[b]	Percent	SE[b]
	number							
Softwoods								
Loblolly and shortleaf pines	1	3	0.0	—	66.7	—	33.3	—
Other yellow pines	2	2	100.0	—	0.0	—	0.0	—
Eastern hemlock	2	2	100.0	—	0.0	—	0.0	—
Other eastern softwoods	9	27	81.5	12.3	14.8	9.3	3.7	3.1
Total	14	34	76.5	11.9	17.6	8.6	5.9	3.5
Hardwoods								
Select white oaks	10	17	70.6	—	29.4	—	0.0	—
Select red oaks	2	2	100.0	—	0.0	—	0.0	—
Other white oaks	11	14	85.7	—	14.3	—	0.0	—
Other red oaks	7	8	87.5	—	12.5	—	0.0	—
Hickory	16	19	89.5	—	10.5	—	0.0	—
Hard maple	28	51	92.2	4.2	5.9	3.9	2.0	2
Soft maple	30	83	75.9	5.2	21.7	4.8	2.4	1.8
Beech	16	30	96.7	3.4	3.3	3.4	0.0	0
Sweetgum	3	16	93.8	—	6.3	—	0.0	—
Tupelo and blackgum	17	24	66.7	8.1	29.2	7.5	4.2	4.2
Ash	18	23	69.6	9.5	26.1	8.9	4.3	4.3
Yellow-poplar	19	45	88.9	4.5	8.9	4.1	2.2	1.7
Other eastern soft hardwoods	42	78	62.8	7.1	30.8	6.6	6.4	3.1
Other eastern hard hardwoods	36	66	66.7	8.2	31.8	7.8	1.5	1.5
Eastern noncommercial hardwoods	51	130	70.0	4.3	25.4	3.8	4.6	1.9
Total	123	606	75.9	2.2	21.1	2	3.0	0.6
Species total	126	640	75.9	2.2	20.9	1.9	3.1	0.7

Data collected 2005 to 2009; d.b.h. = diameter at breast height; SE = standard error.

— = negligible; 0.0 = no sample for the cell or a value of >0.0 but <0.05 indicates not presented due to insufficient sample.

[a] Total number of plots on which trees were measured. Plot totals are not cumulative because multiple species may occur on any given plot.

[b] SE calculations consider the clustering of trees on plots. Standard errors are not presented for species groups with the number of trees <20.

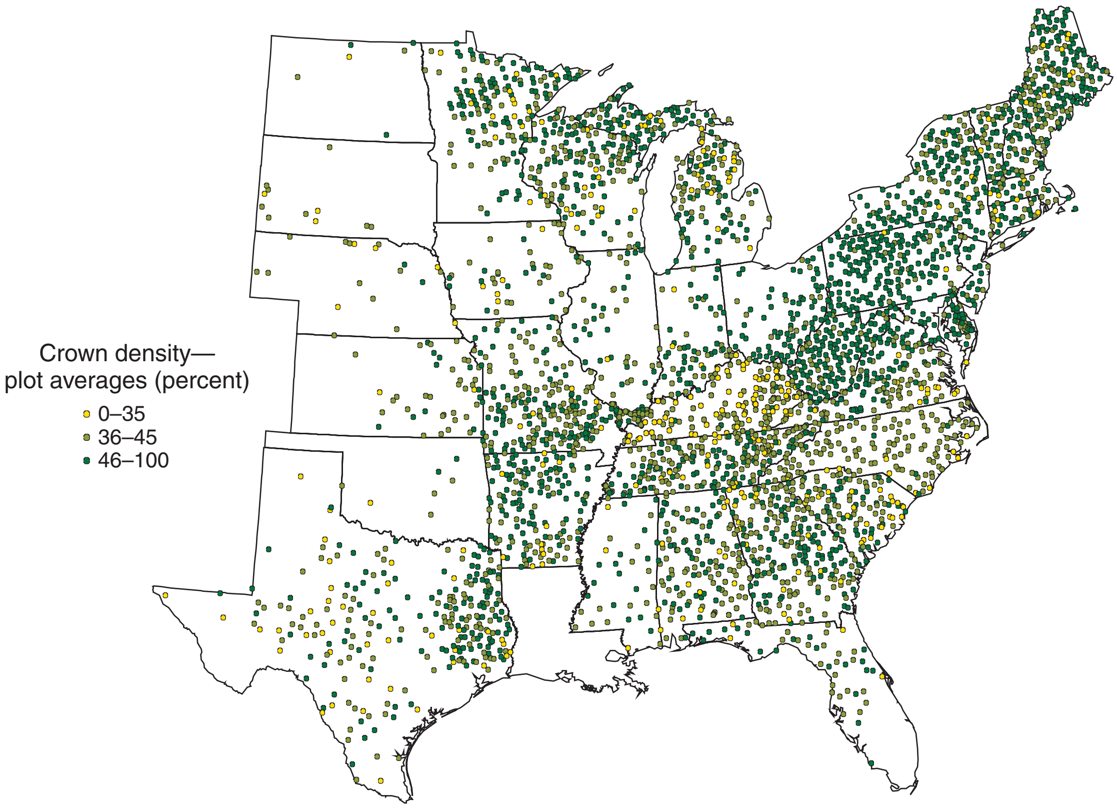


Figure 54—Average hardwood crown density by plot, Eastern United States, 2005–09. (Plot locations are approximate.)

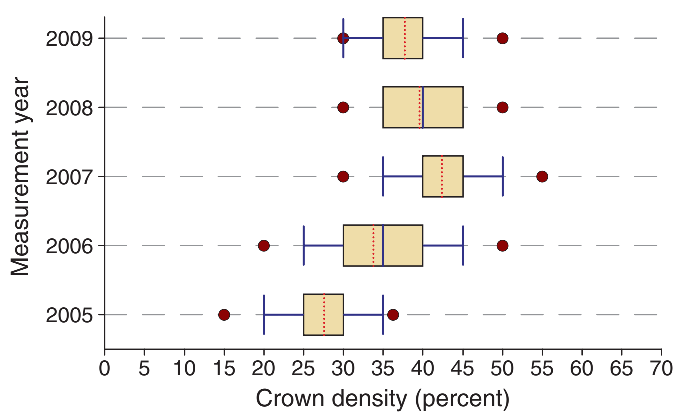


Figure 55—Distribution of the hardwood crown density observations by year, Kentucky, 2005–09. The left and right boundaries of the boxes indicate the 25th and 75th percentiles, respectively. The solid line in the boxes indicates the median and the dotted line indicates the mean. The box whiskers indicate the 10th and 90th percentiles and the circles indicate the 5th and 95th percentiles.

Change in Conditions—As an indicator of degraded health, poor crown conditions are potential signals of impending mortality. On average, trees that died between the two assessments had poorer crown conditions between 2000 and 2004, than the trees that survived (fig. 56). Likewise, saplings with poor crown vigor between 2000 and 2004 suffered a larger percentage of mortality than saplings with good or fair crown vigor (fig. 57). Among the saplings that survived the remeasurement interval, 23.4 percent had an improvement in crown vigor class and 16.0 percent had a decline in crown vigor class. No change in vigor class was observed for the remaining 60.6 percent of the saplings. Among the trees that survived the remeasurement interval, crown conditions remained relatively stable overall (fig. 58) although a significant decline in crown density occurred for black walnut. Average crown density for black walnut was 37.8 percent in 2004 and 28.5 percent in 2009. Though the remeasured sample of black walnut was small (only 23 trees), crown conditions for this species should be watched, particularly given the spread of the walnut twig beetle (*Pityophthorus juglandis*) and associated thousand cankers disease (TCD) (canker-producing fungus *Geosmithia morbida*) into the Eastern United States.

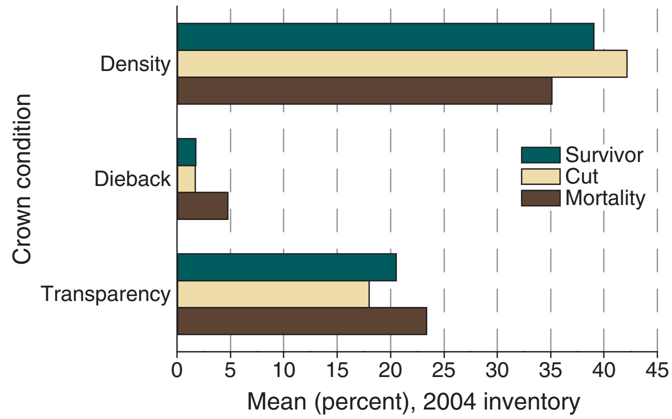


Figure 56—Mean crown conditions from the 2004 inventory by tree status in the 2009 inventory (remeasured trees only), Kentucky.

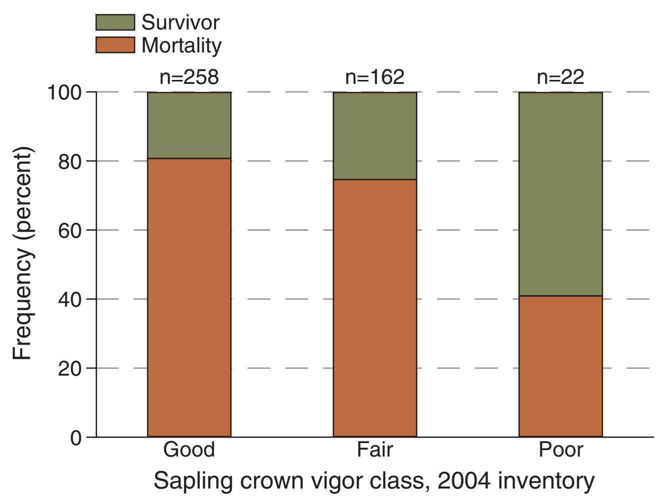


Figure 57—Tree status distribution in the 2009 inventory by sapling crown vigor class in the 2004 inventory (remeasured trees only), Kentucky.

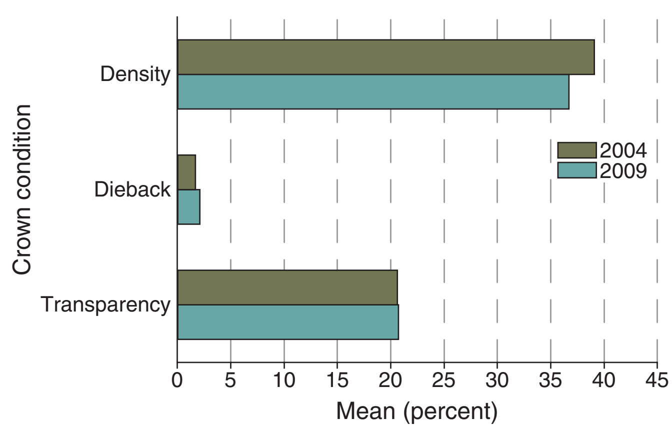
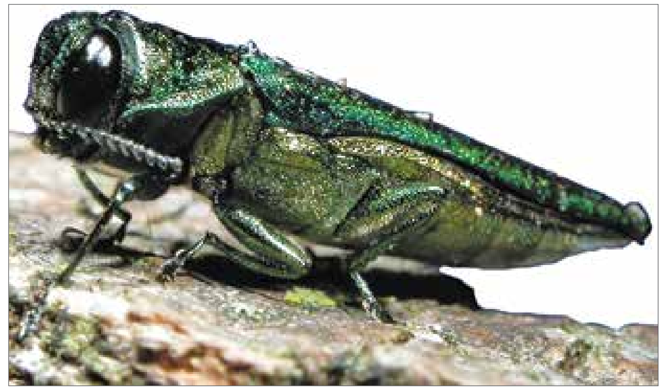


Figure 58—Mean crown conditions for remeasured trees (survivors only), 2004 versus 2009, Kentucky.

Emerald Ash Borer

Ash trees in Kentucky are important, both economically and ecologically, and are currently under threat by an invasive beetle. The emerald ash borer (EAB; *Agrilus planipennis*) is a nonnative invasive beetle that has been causing ash mortality in the United States since it was first discovered in Michigan in 2002. EAB is considered a significant threat to ash trees in Kentucky. To date, the EAB has been detected only in north-central Kentucky counties. However, positive EAB collections have been made in every State bordering Kentucky, including Tennessee. Therefore, the entire population of ash trees in Kentucky is at risk.



Emerald ash borer (*Agrilus planipennis*). (photo by U.S. Department of Agriculture)

In 2009, the ash population in Kentucky totaled 252 million trees. Green ash and white ash each represent approximately 1.7 percent of all-live trees and are among the top 20 most common trees in the State. The green and white ash population is estimated at slightly >121 million trees each. The population of blue ash, the only other ash species in Kentucky, is estimated to be 9.5 million trees. The entire ash population accounts for an estimated 5 percent of net volume of live trees across Kentucky, which is a significant amount. While some of the largest concentrations of green and white ash are in north-central Kentucky, both species are widely distributed across the State (fig. 59). Blue ash is primarily found in central Kentucky, in the Bluegrass unit (fig. 59).

Between 2004 and 2009, standing-dead ash trees (sawtimber size) increased approximately 37 percent from 675,000 to 927,000 trees. An increase in the standing-dead ash population may be early signs of EAB activity. Although EAB has been trapped only in north-central Kentucky, standing-dead ash trees appear to have been sampled with greater frequency in 2009 (fig. 60a) than in 2004 (fig. 60b) across all of Kentucky. This increase in standing-dead ash trees may be a sign that EAB could potentially be in other parts of the State.

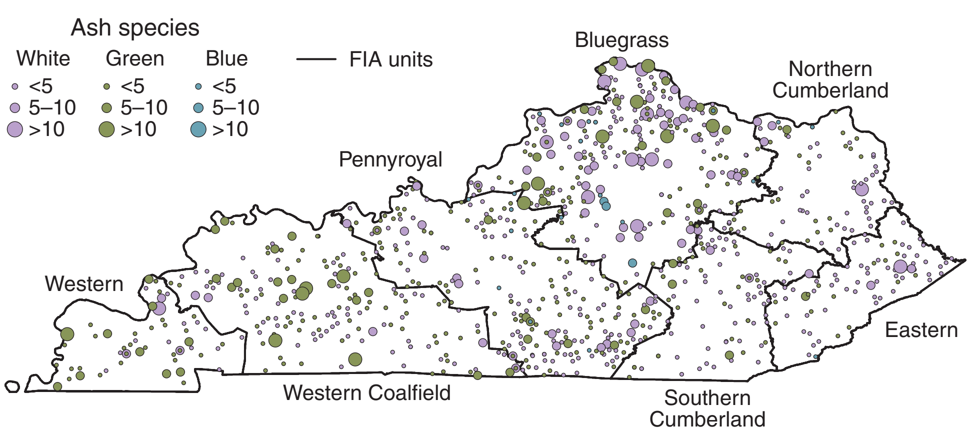


Figure 59—Distribution of sampled ash trees on forest land, Kentucky, 2009. (Plot locations are approximate.)

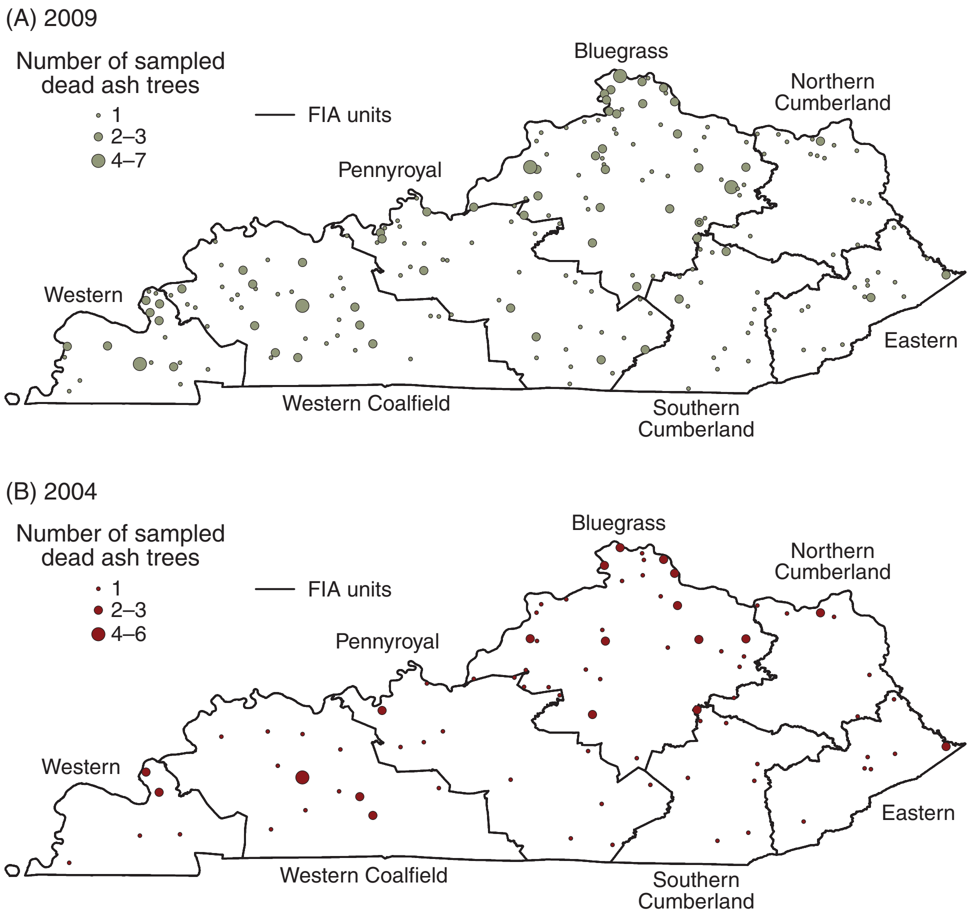


Figure 60 —Distribution of sampled standing dead ash trees (≥5 inches d.b.h.) on forest land, Kentucky, (A) 2009 and (B) 2004. (Plot locations are approximate.)

Emerging Threats

Thousand cankers disease and hemlock woolly adelgid—In addition to the numerous existing threats such as invasive plants and EAB, new threats to Kentucky's forests are unfortunately emerging. Recent announcements have revealed that TCD as well as the hemlock woolly adelgid (HWA; *Adelges tsugae*) have been found in east Tennessee. TCD, a pest complex caused by a fungus and transported by the walnut twig beetle, has been causing walnut mortality in many western States. The recent observation of TCD in east Tennessee is the first within the native range of black walnut and poses a serious threat to the species in Kentucky and the Eastern United States. The HWA was first described in western North America in 1924 and first reported in the Eastern United States in 1951 near Richmond, VA. Although HWA has been in eastern forests for quite some time, only recently (circa 2006) has it been found regularly in eastern Kentucky.

Dieback in top of black walnut (*Juglans nigra*) tree—characteristic of TCD. (photo courtesy of Elizabeth Bush, Virginia Polytechnic Institute and State University/Bugwood.org)

In Kentucky, TCD poses a threat to the estimated 43 million black walnut trees (≥1.0 inch d.b.h.). If the estimated 262 million cubic feet of wood volume found in trees ≥5 inches d.b.h. is lost to TCD, it would be a significant economic loss to Kentucky landowners interested in black walnut wood products. Trees of walnut species (including butternut) in Kentucky are found throughout most of the State with the highest concentrations being sampled in the Bluegrass unit (fig. 61). In 2009, the highest concentrations of sampled dead walnut were also in the Bluegrass unit (fig. 62).

The hemlock population in Kentucky consists only of eastern hemlock with an estimated 206 million trees according to the FIA sample. All of the sample eastern hemlock trees were observed in the heavily forested eastern portion of Kentucky with the exception of one plot located within the Mammoth Cave National Park (fig. 63) All sampled standing-dead hemlocks were located in the east (fig. 62), but no increase in number was found between 2004 and 2009.

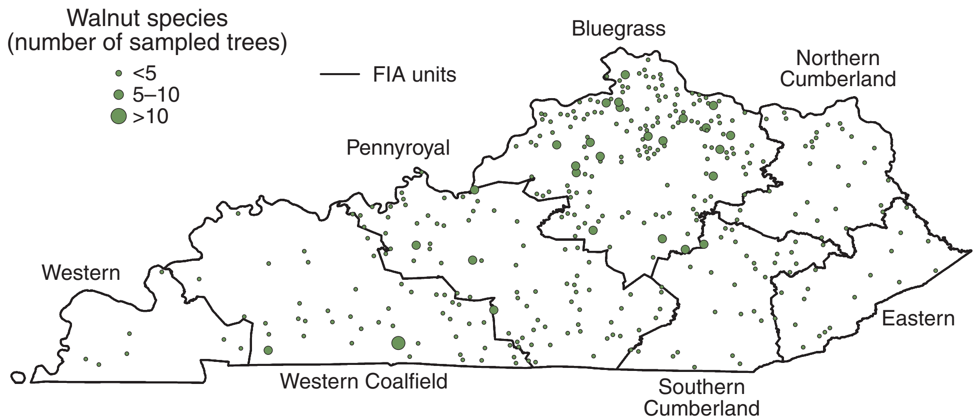


Figure 61—Distribution of sampled walnut trees on forest land, Kentucky, 2009. (Plot locations are approximate.)

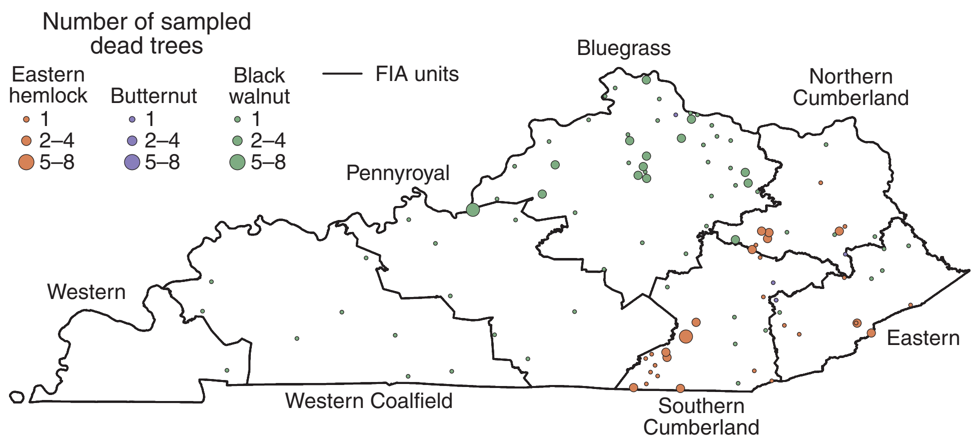


Figure 62—Distribution of sampled standing dead eastern hemlock, butternut, and black walnut trees (≥5 inches d.b.h.) on forest land, Kentucky, 2009. (Plot locations are approximate.)

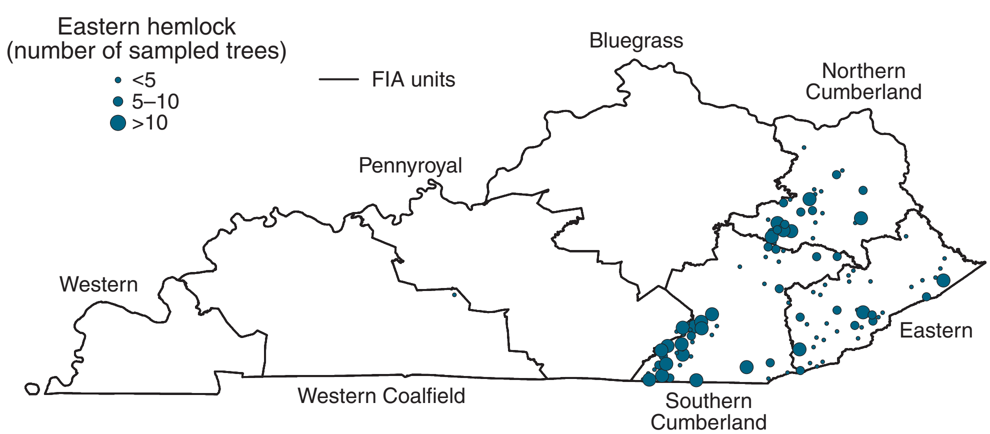


Figure 63—Distribution of sampled eastern hemlock trees on forest land, Kentucky, 2009. (Plot locations are approximate.)

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Kentucky Warbler (*Oporornis formosus*) feeding chicks. (photo courtesy of Steve Maslowski, U.S. Fish and Wildlife Service/ Wikimedia.org)

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Glossary

Afforestation—Area of land previously classified as nonforest that is converted to forest by planting of trees or by natural reversion to forest.

Average annual mortality—Average annual volume of trees ≥5.0 inches d.b.h. that died from natural causes during the intersurvey period.

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. in the absence of cutting (gross growth minus mortality) during the intersurvey period.

Basal area—The area in square feet of the cross section at breast height of a single tree or of all the trees in a stand, usually expressed in square feet per acre.

Bioindicator species—A tree, woody shrub, or nonwoody herb species that responds to ambient levels of ozone pollution with distinctive visible foliar symptoms.

Biomass—The aboveground fresh weight of solid wood and bark in live trees ≥1.0-inch d.b.h. from the ground to the tip of the tree. All foliage is excluded. The weight of wood and bark in lateral limbs, secondary limbs, and twigs <0.5 inch in diameter at the point of occurrence on sapling-size trees is included but is excluded on medium- and large-diameter-size trees.

Blind check—A remeasurement done by a qualified inspection crew without production crew data on hand; a full remeasurement of the plot is recommended for the purpose of obtaining a measure of data quality. If a full plot remeasurement is not possible, then it is strongly recommended that at least two full subplots be 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. Blind checks are done on production plots only. This procedure provides a quality assessment and evaluation function. The statistics band recommends a random subset of plots be chosen for remeasurement.

Bole—That portion of a tree between a 1-foot stump and a 4-inch top d.o.b. in trees ≥5.0 inches d.b.h.

Census water—Streams, sloughs, estuaries, canals, and other moving bodies of water ≥200-feet wide, and lakes, reservoirs, ponds, and other permanent bodies of water ≥4.5 acres in area.

Coarse woody debris or coarse woody material—Down pieces of wood leaning >45 degrees from vertical with a diameter of at least 3.0 inches and a length of at least 3.0 feet (decay classes 1 through 4). Decay class 5 pieces must be at least 5.0 inches in diameter, at least 5.0 inches high from the ground, and at least 3.0 feet in length.

Cold check—An inspection done either as part of the training process, or as part of the ongoing QC 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. Cold checks are done on production plots only. This type of quality control measurement is a "blind" measurement in that the crews do not know when or which of their plots will be remeasured by the inspection crew and cannot therefore alter their performance because of knowledge that the plot is a QA plot.

The entire western third of Kentucky is dotted with cypress and tupelo swamps, some small (just a few acres) some vast (thousands of acres). This is one of the latter at Ballard Wildlife Management Area, composed of nearly 9,000 acres. (photo courtesy of Wikimedia.org)

Compacted area—Type of compaction measured as part of the soil indicator. Examples include the junction areas of skid trails, landing areas, work areas, etc.

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.

Crown—The part of a tree or woody plant bearing live branches or foliage.

Crown density—The amount of crown stem, branches, twigs, shoots, buds, foliage, and reproductive structures that block light penetration through the visible crown. Dead branches and dead tops are part of the crown. Live and dead branches below the live crown base are excluded. Broken or missing tops are visually reconstructed when forming this crown outline by comparing outlines of adjacent healthy trees of the same species and d.b.h./d.r.c. (root collar diameter).

Crown dieback—This is recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds toward the trunk. Dieback is only considered when it occurs in the upper and outer portions of the tree. When whole branches are dead in the upper crown, without obvious signs of damage such as breaks or animal injury, assume that the branches died from the terminal portion of the branch. Dead branches in the lower portion of the live crown are assumed to have died from competition and shading. Dead branches in the lower live crown are not considered part of crown dieback, unless there is continuous dieback from the upper and outer crown down to those branches.

D.b.h. (diameter at breast height)—Tree diameter in inches (outside bark) at breast height (4.5 feet aboveground).

Decay class—Qualitative assessment of stage of decay (5 classes) of coarse woody debris based on visual assessments of color of wood, presence/absence of twigs and branches, texture of rotten portions, and structural integrity.

Diameter class—A classification of trees based on tree d.b.h. Two-inch diameter classes are commonly used by FIA, with the even inch as the approximate midpoint for a class. For example, the 6-inch class includes trees 5.0–6.9 inches d.b.h.

D.o.b. (diameter outside bark)—Stem diameter including bark.

Down woody material (DWM)— Woody pieces of trees and shrubs that have been uprooted (no longer supporting growth) or severed from their root system, not self-supporting, and are lying on the ground. Previously named down woody debris (DWD).

Duff—A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified.

Effective cation exchange capacity (ECEC)—The sum of cations that a soil can adsorb in its natural pH. Expressed in units of centimoles of positive charge per kilogram of soil.

Erosion—The wearing away of the land surface by running water, wind, ice, or other geological agents.

Fine woody debris or fine woody material—Down pieces of wood with a diameter <3.0 inches, not including foliage or bark fragments.

Foliage transparency—The amount of skylight visible through microholes in the live portion of the crown, i.e. where you see foliage, normal or damaged, or remnants of its recent presence. Recently defoliated branches are included in foliage transparency measurements. Macroholes are excluded unless they are the result of recent defoliation. Dieback and dead branches are always excluded from the estimate. Foliage transparency is different from crown density because it emphasizes foliage and ignores stems, branches, fruits, and holes in the crown.

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

Forest land—Land at least 10 percent stocked by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use. The minimum area considered for classification is 1 acre. Forested strips must be at least 120-feet wide.

Forest management type—A classification of timberland based on forest type and stand origin.

Pine plantation—Stands that (1) have been artificially regenerated by planting or direct seeding, (2) are classed as a pine or other softwood forest type, and (3) have at least 10-percent stocking.

Natural pine—Stands that (1) have not been artificially regenerated, (2) are classed as a pine or other softwood forest type, and (3) have at least 10-percent stocking.

Oak-pine—Stands that have at least 10-percent stocking and classed as a forest type of oak-pine.

Upland hardwood—Stands that have at least 10-percent stocking and classed as an oak-hickory or maple-beech-birch forest type.

Lowland hardwood—Stands that have at least 10-percent stocking with a forest type of oak-gum-cypress, elm-ash-cottonwood, palm, or other tropical.

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

Forest type—A classification of forest land based on the species forming a plurality of live-tree stocking. Major eastern forest-type groups are:

White-red-jack pine—Forests in which eastern white pine, red pine, or jack pine, singly or in combination, constitute a plurality of the stocking. (Common associates include hemlock, birch, and maple.)

Spruce-fir—Forests in which spruce or true firs, singly or in combination, constitute a plurality of the stocking. (Common associates include maple, birch, and hemlock.)

Longleaf-slash pine—Forests in which longleaf or slash pine, singly or in combination, constitute a plurality of the stocking. (Common associates include oak, hickory, and gum.)

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.)

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.)

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 would be classified oak-pine. (Common associates include yellow-poplar, elm, maple, and black walnut.)

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 would be classified as oak-pine. (Common associates include cottonwood, willow, ash, elm, hackberry, and maple.)

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.)

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.)

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

Forested tract size—The area of forest within the contiguous tract containing each FIA sample plot.

Fresh weight—Mass of tree component at time of cutting.

Fuel bed—Accumulated mass of all DWM components above the top of the duff layer. The fuel bed does not include live shrubs or herbs.

Fuel hour classes—Fuel classes defined by the approximate amount of time it takes for moisture conditions to fluctuate. Larger coarse woody material will takes longer to dry out than smaller fine woody pieces (Small = 1 hour, Medium = 10 hour, Large = 100 hour, Coarse woody material = 1,000 hour).

Gross growth—Annual increase in volume of trees ≥5.0 inches d.b.h. in the absence of cutting and mortality. (Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality before death.)

Growing-stock trees—Living trees of commercial species classified as sawtimber, poletimber, saplings, and seedlings. Trees must contain at least one 12-foot or two 8-foot logs in the saw-log portion, currently or potentially (if too small to qualify), to be classed as growing stock. The log(s) must meet dimension and merchantability standards to qualify. Trees must also have, currently or potentially, one-third of the gross board-foot volume in sound wood.

Growing-stock volume—The cubic-foot volume of sound wood in growing-stock trees ≥5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.

Hardwoods—Dicotyledonous trees, usually broadleaf 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.

Hexagonal grid (Hex)—A hexagonal grid formed from equilateral triangles for the purpose of tessellating the FIA inventory sample. Each hexagon in the base grid has an area of 5,937 acres (2,403.6 ha) and contains one inventory plot. The base grid can be subdivided into smaller hexagons to intensify the sample.

Humus—A soil layer dominated by organic material derived from the decomposition of plant and animal litter and deposited on either an organic or a mineral surface. This layer is distinguished from the litter layer in that the original organic material has undergone sufficient decomposition that the source of this material (e.g., individual plant parts) can no longer be identified.

Land area—The area of dry land and land temporarily or partly covered by water, such as marshes, swamps, and river floodplains (omitting tidal flats below mean high tide), streams, sloughs, estuaries, and canals <200-feet wide, and lakes, reservoirs, and ponds <4.5 acres in area.

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

Lichen—An organism generally appearing to be a single small leafy, tufted or crust-like plant that consists of a fungus and an alga or cyanobacterium living in symbiotic association.

Lichen community indicator—The set of macrolichen species collected on a FIA lichen plot using standard protocols, which serves as an indicator of ecological condition (e.g., air quality or climate) of the plot.

Lichen plot—The FIA lichen plot is a circular area, total 0.935 acre (0.4 ha), with a 120-foot (36.6 m) radius centered on subplot 1, and excluding the 4 subplots.

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

Live trees—All living trees. All size classes, all tree classes, and both commercial and noncommercial species are included.

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. Measurement quality objectives 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. Measurement quality objectives can be set for measured data elements, observed data elements, and derived data elements.

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

Mineral soil—A soil consisting predominantly of products derived from the weathering of rocks (e.g., sands, silts, and clays).

Net annual change—Increase or decrease in volume of live trees ≥5.0 inches d.b.h. Net annual change is equal to net annual growth minus average annual removals.

Noncommercial species—Tree species of typically small size, poor form, or inferior quality that normally do not develop into trees suitable for industrial wood products.

Nonforest land—Land that has never supported forests and land formerly forested where timber production is precluded by development for other uses.

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

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

Other removals—The growing-stock 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.

Ozone. O_3—A gaseous air pollutant produced primarily through sunlight-driven chemical reactions of NO_2 and hydrocarbons in the atmosphere and causing foliar injury to deciduous trees, conifers, shrubs, and herbaceous species.

Ozone bioindicator site—An open area in which ozone injury to ozone-sensitive species is evaluated. The area must meet certain site selection guidelines regarding size, condition, and plant counts to be used for ozone injury evaluations in FIA.

Ownership—The property owned by one ownership unit, including all parcels of land in the United States.

National forest land—Federal land that has been legally designated as national forests or purchase units, and other land

Bulbous bittercress (*Cardamine bulbosa*) in riparian forest, Fort Boonesborough State Park, Madison County. (photo courtesy of Wikimedia.org)

under the administration of the Forest Service, including experimental areas and Bankhead-Jones Title III land.

Forest industry land—Land owned by companies or individuals operating primary wood-using plants.

Nonindustrial private forest 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.

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 3 (P3)—FIA activities conducted on a subset of phase 2 plots. Additional attributes related to forest health are measured on phase 3 plots.

Poletimber-size trees—Softwoods 5.0 to 8.9 inches d.b.h. and hardwoods 5.0 to 10.9 inches d.b.h. Now referred to as medium-diameter trees.

Productive-reserved forest land—Forest land sufficiently productive to qualify as timberland but withdrawn from timber utilization through statute or administrative regulation.

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.

Reforestation—Area of land previously classified as forest that is regenerated by tree planting or natural regeneration.

Rotten trees—Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each ≥8 feet, now or prospectively, primarily because of rot or missing sections, and with less than one-third of the gross board-foot tree volume in sound material.

Rough trees—Live trees of commercial species not containing at least one 12-foot saw log, or two noncontiguous saw logs, each ≥8 feet, now or prospectively, primarily because of roughness, poor form, splits, and cracks, and with less than one-third of the gross board-foot tree volume in sound material; and live trees of noncommercial species.

Sapling—Live trees 1.0 to 4.9 inches (2.5 to 12.5 cm) in diameter (d.b.h.).

Saw log—A log meeting minimum standards of diameter, length, and defect, including logs ≥8-feet long, sound and straight, with a minimum diameter inside bark for softwoods of 6 inches (8 inches for hardwoods).

Saw-log portion—The part of the bole of sawtimber trees between a 1-foot stump and the saw-log top.

Saw-log top—The point on the bole of sawtimber trees above which a conventional saw log cannot be produced. The minimum saw-log top is 7.0 inches d.o.b. for softwoods and 9.0 inches d.o.b. for hardwoods.

Sawtimber-size trees—Softwoods ≥9.0 inches d.b.h. and hardwoods ≥11.0 inches d.b.h. Now referred to as large-diameter trees.

Sawtimber volume—Growing-stock volume in the saw-log portion of sawtimber-size trees in board feet (International ¼-inch rule).

Seedlings—Trees <1.0-inch d.b.h. and >1-foot tall for hardwoods, >6 inches tall for softwoods, and >0.5 inch in diameter at ground level for longleaf pine.

Select red oaks—A group of several red oak species composed of cherrybark, Shumard, and northern red oaks. Other red oak species are included in the "other red oaks" group.

Select white oaks—A group of several white oak species composed of white, swamp chestnut, swamp white, chinkapin, Durand, and bur oaks. Other white oak species are included in the "other white oaks" group.

Site class—A classification of forest land in terms of potential capacity to grow crops of industrial wood based on fully stocked natural stands.

Small-diameter trees—Trees 1.0 to 4.9 inches in diameter at breast height/diameter at root collar. These were called sapling-seedling sized trees in prior surveys. See: Stand-size class.

Softwoods—Coniferous trees, usually evergreen, having leaves that are needles or scalelike.

Yellow pines—Loblolly, longleaf, slash, pond, shortleaf, pitch, Virginia, sand, spruce, and Table Mountain pines.

Other softwoods—Cypress, eastern redcedar, white-cedar, eastern white pine, eastern hemlock, spruce, and fir.

Soil bulk density—The mass of soil per unit volume. A measure of the ratio of pore space to solid materials in a given soil. Expressed in grams per cubic cm of oven dry soil.

Soil compaction—A reduction in soil pore space caused by heavy equipment or by repeated passes of light equipment that compress the soil and break down soil aggregates. Compaction disturbs the soil structure and can cause decreased tree growth, increased water runoff, and soil erosion.

Soil texture—The relative proportions of sand, silt, and clay in a soil.

Stand age—The average age of dominant and codominant trees in the stand.

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.

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.

Stocking—The degree of occupancy of land by trees, measured by basal area or the number of trees in a stand and spacing in the stand, compared with a minimum standard, depending on tree size, required to fully utilize the growth potential of the land.

Density of trees and basal area per acre required for full stocking:

D.b.h. class	Trees per acre for full stocking	Basal area
inches		*square feet per acre*
Seedlings	600	—
2	560	—
4	460	—
6	340	67
8	240	84
10	155	85
12	115	90
14	90	96
16	72	101
18	60	106
20	51	111

— = not applicable.

Timberland—Forest land capable of producing 20 cubic feet of industrial wood per acre per year and not withdrawn from timber utilization.

Transect diameter—Diameter of a coarse woody piece at the point of intersection with a sampling plane.

Tree—Woody plant having one erect perennial stem or trunk ≥3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of ≥13 feet (at maturity).

Tree grade—A classification of the saw-log portion of large-diameter trees based on: (1) the grade of the butt log or (2) the ability to produce at least one 12-foot or two 8-foot logs in the upper section of the saw-log portion. Tree grade is an indicator of quality; grade 1 is the best quality.

Upper-stem portion—The part of the main stem or fork of large-diameter trees above the saw-log top to a minimum top diameter of 4.0 inches outside bark or to the point where the main stem or fork breaks into limbs.

Vigor class—A visual assessment of the apparent crown vigor of saplings. The purpose is to separate excellent saplings with superior crowns from stressed individuals with poor crowns.

Volume of live trees—The cubic-foot volume of sound wood in live trees ≥5.0 inches d.b.h. from a 1-foot stump to a minimum 4.0-inch top d.o.b. of the central stem.

Volume of saw-log portion of large-diameter trees—The cubic-foot volume of sound wood in the saw-log portion of large-diameter trees. Volume is the net result after deductions for rot, sweep, and other defects that affect use for lumber.

Appendix A—Data Sources and Techniques

A State-by-State inventory of the Nation's forest land began in the mid-1930s. These surveys primarily were designed and conducted to provide estimates of forest area, wood volume, tree growth, removals, and mortality. Throughout the years, numerous technical innovations and national concerns over perceived and real trends in forest resource conditions have led to many improvements (Reams and others 2004). The primary purpose for conducting forest inventories has remained unchanged, but the methods have undergone substantial change. The following is a general description of the current sample design used to collect the information and procedures used to derive the forest resource estimates provided in this report. A brief discussion of past sample designs and procedures is included to alert users to substantive changes.

The fifth survey (this report represents the sixth survey) of Kentucky's forest marked a shift in design, intensity, and timeliness of data collection. The Agricultural Research Extension and Education Reform Act of 1998 (Farm Bill) mandated annual surveys of U.S. forests. The annual surveys feature: (1) a nationally consistent, fixed-radius, four-point plot configuration; (2) a systematic national sampling design consisting of a base grid of approximately 6,000-acre hexagons; (3) integration of the forest inventory and forest health monitoring sample designs; (4) annual measurement of a fixed proportion of permanent plots across the State; (5) reporting of data or data summaries within 6 months after yearly sampling; (6) an annual estimator based on a default 5-year moving average, with provisions for optional estimators based on techniques for updating information; and (7) a summary report every 5 years. Additional information about annual surveys is available at www.fia.fs.fed.us.

Blackjack oak (*Quercus marilandica*) leaves, Crooked Creek Barrens State Nature Preserve, Lewis County. (photo courtesy of Mason Brock/Wikimedia.org)

The current inventory is a three-phase, fixed-plot sample design conducted on an annual basis. Phase 1 (P1) provides the forest land area estimates for the inventory. Phase 2 (P2) involves on-the-ground measurements of sample plots by field personnel. Phase 3 (P3) is a subset of the P2 plot system where additional measurements are made by field personnel to assess forest health indicators. The three phases of the current sampling method are based on a hexagonal-grid design (fig. A.1). There are approximately 25 P1 points for every P2 plot. There are 16 P2 plots for every P3 plot. P1 points and P2 and P3 plots represent approximately 222 acres, 6,000 acres, and 96,000 acres, respectively.

The inventory design and methods used to collect and process the information needed to derive the forest resource estimates for the 2004 and 2009 surveys of Kentucky have undergone change since the periodic survey conducted in 1988. The survey's sample design has changed in three major ways from the periodic inventories. The first change was in the method of collecting forest area estimations. Secondly, the timing of collecting the ground samples switched from periodic to annual. There are also changes in volume equations, variable definitions, processing methods, and algorithms. Although all of these changes, alone or in combination, weaken comparisons among surveys, they are necessary to improve upon survey accuracy and allow comparisons with other surveys throughout the region, the entire continental United States, and the world. A clear understanding of these changes is necessary when making rigorous comparisons between inventories, particularly when comparing periodic survey data to annual survey data.

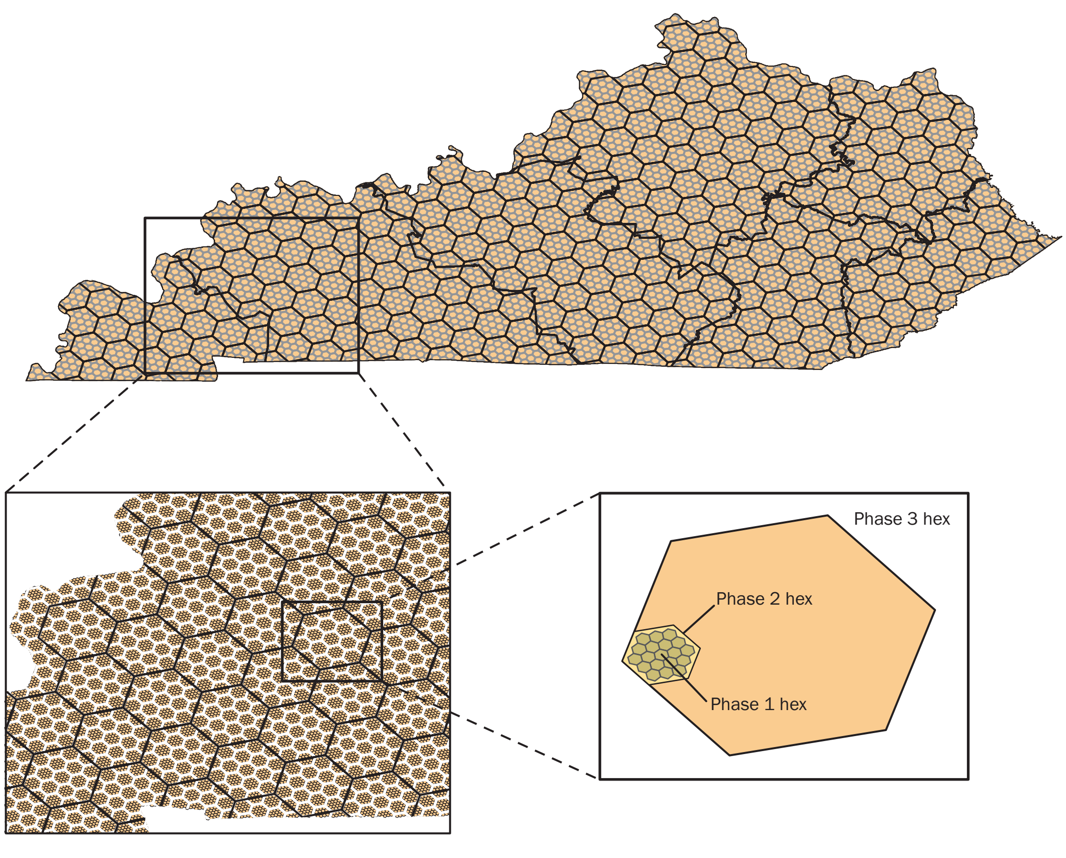


Figure A.1—The FIA hexagonal grid system for locating phase 1, 2, and 3 plots in Kentucky.

Sample Design Phases

Current P1 forest area estimates—Forest Inventory and Analysis (FIA) now bases the three phases of the current sampling method on a hex-grid design (fig. A.1), with each successive phase sampled with less intensity. There are 16 P2 hexes for every P3 hex, and 27 P1 hexes for every phase 2 hex. P1 hexes represent approximately 222 acres, and P2 and P3 hexes represent roughly 6,000 acres and 96,000 acres, respectively.

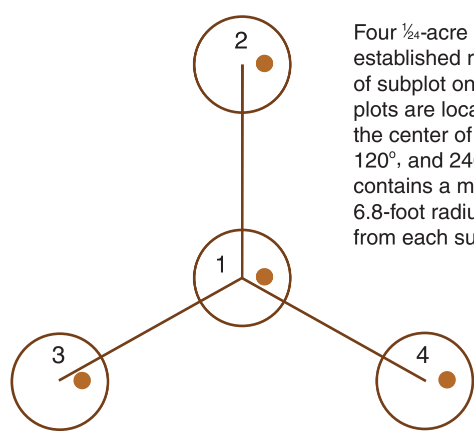
P1 involves assigning a plot to the P1 hexes on digital imagery; currently FIA uses the National Land Cover Database (NLCD). Each hex point, or "dot," is classified as either forest or nonforest and a percentage for each class is derived for the entire State. The P1 point classifications are then checked at permanent ground sample locations that make up the P2 sample. Two correction factors are created by comparing the forest and nonforest classifications on the digital imagery to the classifications of the same points made at ground sample locations. These correction factors are used to adjust the percent forest derived from the original (P1) estimate. These correction factors adjust for possible misclassifications in the NLCD and for change on the ground that occurred since the date of the digital imagery used for land cover classification.

P2 locations generally are not placed in the center of the hex. If a sample location from a prior inventory exists in a phase 2 hex, then that same location is used again. If two sample locations from a prior survey existed within the same hex, then one is dropped. For P2 hexes containing no prior sample location, a new sample location is created at a random point within the hex. This process is performed in a manner that maintains as many existing plots as possible. Although prior surveys used enumeration for selected owner classes, the current survey does not.

The areas assigned to various characteristics (such as ownership, stand size, and forest type) are based on the expansion factor assigned and derived in the first phase.

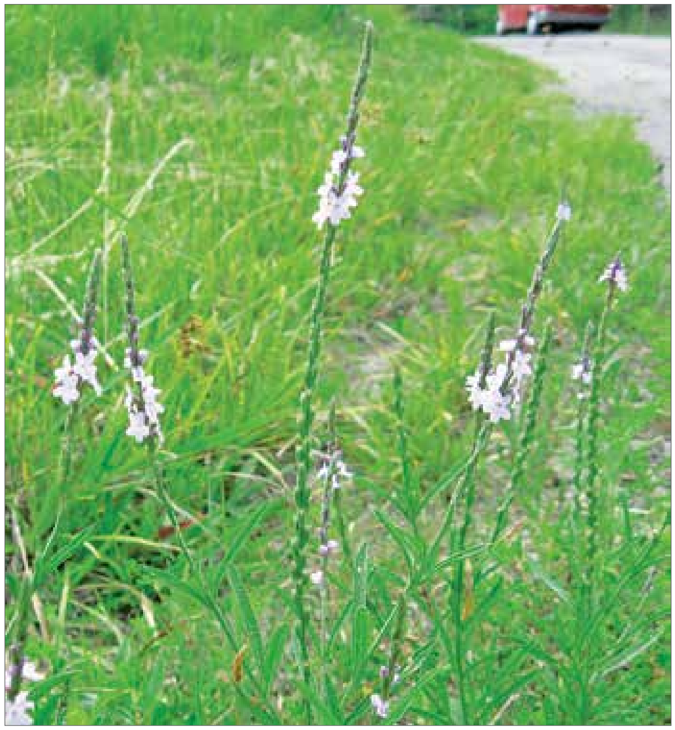
Current P2 forest inventory—In the 2009 inventory, the plot design used a fixed plot composed of four subplots spaced 120 feet apart (fig. A.2). The sample area of these four subplots was 1/6 of an acre, and the footprint of the cluster was approximately 1 acre. Trees ≥5 inches d.b.h. were measured on each subplot (1/24 of an acre; 24-foot radius). Trees ≥1.0–4.9 inches d.b.h. and seedlings (<1.0 inch d.b.h.) were measured on a microplot (1/300 of an acre; 6.8-foot radius) on each of the four subplots. The cluster of four fixed-area subplots sampled forest land at 2,344 ground sample locations.

A unique feature of this plot design was in the mapping of different land use and forest conditions that are encountered on the plot cluster. The plots were placed on the ground without bias, (that is, systematically but at a scale large enough so that placement could be considered random), so there was a probability that the plot cluster might straddle more than one type of land use or forest condition.



Four 1/24-acre subplots are established relative to the center of subplot one. The 24-foot radius plots are located 120 feet from the center of subplot one at 360°, 120°, and 240°. Each subplot contains a microplot with a 6.8-foot radius, 12 feet (at 90°) from each subplot center.

Figure A.2—Layout of annual fixed-radius plot design. The cluster plot is a circle circumscribing the outer edge of the four subplots.



Narrowleaf vervain (*Verbena simplex*), roadside in high quality prairie remnant near Pennyrile Forest State Resort Park, Christian County. (photo courtesy of Mason Brock/ Wikimedia.org)

Furthermore, the four subplots were not relocated into the same land use. If a plot happened to straddle multiple land uses and forest conditions, then the crew identified the differences encountered on the plot. There were two steps in the mapping process. The first step involved identifying forest and nonforest areas on the plot and establishing a boundary line on the plot if both were present. The second step involved identifying differing conditions in the forested portion of the plot based on six factors: (1) forest type, (2) stand size, (3) ownership, (4) stand density, (5) regeneration status, and (6) reserved status. These, too, were mapped into separate entities.

P3 forest health—In the 2009 inventory, forest health variables (P3) were collected on approximately $^{1}/_{16}{}^{th}$ of the P2 sample plots. P3 data are coarse descriptions, and are meant to be used as general indicators of overall forest health over large geographic areas. This dataset was not collected in Kentucky until 2000, so there is no previous methodology to compare.

P3 data collection includes variables pertaining to tree crown health, down woody material, foliar ozone injury, lichen diversity, and soil composition. Tree crown health, down woody material, and soil composition measurements were collected using the same plot design as for P2 data collection. Lichen data were collected within a 120-foot-radius circle centered on subplot 1 of each FIA P3 field plot.

Biomonitoring sites for ozone data collection were based on specific criteria and were located independently of the FIA grid. Sites chosen were 1-acre fields or similar open areas adjacent to or surrounded by forest land, and contained at least a minimum number of plants of at least two identified bioindicator species (Smith and others 2007). Plants were evaluated for ozone injury, and voucher specimens were submitted to a regional expert for verification of ozone-induced foliar injury.

Annual Versus Periodic

Periodic surveys of Kentucky (before the year 2000) required the measurement of all plots within 1 to 2 years with remeasurement approximately every 10 years. The current, annual inventory design was implemented to provide more up-to-date information about forest resources. The goal of the annual inventory system is to measure 20 percent (referred to as a panel or subcycle) of the total plots in the State each year so that all plots are measured within a 5-year period (one cycle). Each year's panel of plots is selected on a subgrid that is slightly offset from the previous year's plots. Thus each year covers essentially the same sample area (both spatially and in intensity) as the prior year. 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 (consisting of data from five panels of plots) is available for a 5-year report. This dataset consists of data collected at different times: 20 percent of the data would be <1 year old, 20 percent would be between 1 and 2 years old, and so on.

One of the major impacts on data interpretation and analyses of switching to the annual inventory design is the length of time for data collection (5 years, versus 1 or 2 years). Data collected over a longer period of time has a higher probability of sampling a specific event, such as a tornado or fire, but only on a small proportion of the sample. However, data collected over a shorter time span may miss an event entirely until the next periodic measurement, at which time all of the sample plots reflect the event. This may be further complicated by the number of years passing since the event, before remeasurement occurs.

Volume Estimation

See Oswalt and Conner (2011).

Growth, Removals, and Mortality Estimation

Estimates of growth, removals, and mortality were determined from the remeasurement of 2,388 permanent sample plots established in the previous inventory. Remeasurement information was used in the calculation of seven components of change: (1) survivor growth, (2) ingrowth, (3) growth on ingrowth, (4) mortality, (5) growth on mortality, (6) removals, and (7) growth on removals. Estimates of gross growth, net growth, and net change were made following Beers and Miller (1964).

Statistical Reliability

A relative standard of accuracy has been incorporated into the forest survey. 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) bias, which is caused by instruments not properly calibrated; (2) compensating, which is caused by instruments of moderate precision; and (3) accidental, which is caused by human error in measuring and compiling. All of these are held to a minimum by a system that incorporates training, check plots, and editing and checking for consistency. Editing and checks in the office screen out logical and data entry errors for all plots. It is not possible to determine measurement error statistically, only hold it to a minimum.

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.

FIA inventories supported by the full complement of sample plots are designed to achieve reliable statistics for the region. Sampling error increases as the area or volume considered decreases in magnitude. Sampling errors and associated confidence intervals are often unacceptably high for small components of the total resource. 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 is available from online retrievals using the Forest Inventory Data Online (FIDO II) at http://199.128.173.26/fido/mastf/index.html or can be calculated using the following formula. (Note: 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 State total

SE_t = sampling error for State total

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

X_t = total area or volume for State.

Inventory Quality Assurance and Quality Control

The goal of the FIA Quality Assurance (QA) Program is to provide a framework that ensures that forest assessments meet given standards for completeness, accuracy, and absence of bias. This program is organized in accordance with the protocols set forth in the American National Standard for Quality of Environmental Data collection (Part B of American Society for Quality Control 1994). One of the goals of the FIA Program is to include data quality documentation in all nationally available reports, including State reports and national summary reports. This report includes a summary of P2 variables and measurement quality objective (MQO) analyses from FIA blind-check measurements. Quality assessments of the P3 data will be addressed in future reports. Quality Control (QC) procedures include feedback to field staff to provide assessment and improvement of crew performance. Additionally, data quality is assessed and documented using performance measurements and post-survey assessments. These assessments then are used to identify areas of the data collection process that need improvement or refinement in order to meet quality objectives of the program.

QA and QC methods—FIA implements QA methods in several different ways. These methods include nationally standardized field manuals, portable data recorders (PDRs), training and certification of field crews, and field audits. The PDRs help assure that specified procedures are followed. The national standards for annual training of field crews are: (1) ≥40 hours for new employees and (2) ≥8 hours for return employees. Field crew members are certified via an in-situ test plot. All crews are required to have at least one certified person present on the plot at all times.

Field audits—A hot check is an inspection normally done as part of the training process. The inspector is present with crew members to document crew performance as they measure plots. The recommended intensity for hot checks is 2 percent of the plots installed.

Cold checks are done at regular intervals throughout the field season. The crew that installed the plot is not present at the time of inspection and does not know when or which plots will be remeasured. The inspector visits the completed plot, evaluates the crew's data collection, and notes corrections where necessary. The recommended intensity for cold checks is 5 percent of the plots installed.

A blind check is a complete reinstallation measurement of a previously completed plot. However, the QA crew remeasurement is done without the previously recorded data. The first measurement of the plot is referred to as the field measurement and the second measurement as the QA measurement. The field crews do not know in advance when or which of their plots will be measured by a QA crew. This type of blind measurement provides a direct, unbiased observation of measurement precision from two independent crews. Plots selected for blind checks are chosen to be a representative subsample of all plots measured and are randomly selected. Blind checks are planned to be made within 2 weeks of completion of the field measurement. The recommended intensity for blind checks is 3 percent of the plots installed.

Measurement quality objectives—Each variable collected by FIA is assigned a measurement quality objective (MQO) with desired levels of tolerance for data analyses. The MQOs are documented in the FIA National Field Manual and reported on nationally (Pollard and others 2006). In some instances the MQOs were established as a "best guess" of what experienced field crews should be able to consistently achieve. Tolerances are somewhat arbitrary and were based on the ability of crews to make repeatable measurements or observations within the assigned MQO. Field crew performance is evaluated by calculating the differences between the data collected on blind-check plots by the field crew and the QA crew. 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 and QA crew observations 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. The table below (table A.1) shows the percentage of observations that fell within the program tolerances in Kentucky and the Southern Region during 2005–09.

Table A.1—Performance of data collection on achieving measurement quality objectives for plot-, condition-, and tree-level variables, Kentucky and the Southern Region, 2005–09

			Percent within tolerance	
Variables	Tolerance	Observations	Kentucky	Southern Region
		- - number - -	*- - - - percent - - - -*	
Plot-level				
Distance to road	No tolerance	1,165	84.6	78.9
Water on plot	No tolerance	66	90.9	87.8
Latitude	±2.3 degrees	69	100.0	100.0
Longitude	±2.3 degrees	69	100.0	99.7
Elevation	No tolerance	66	42.4	29.2
Elevation with tolerance	±5 feet	59	45.8	42.9
Contiguous forest	No tolerance	49	87.8	88.4
Distance to agriculture	No tolerance	59	84.7	74.8
Distance to urban area	No tolerance	59	78.0	70.9
Human debris	No tolerance	49	93.9	83.9
Accessibility	No tolerance	14	92.9	86.2
Number of conditions	No tolerance	14	78.6	58.9
Plot in correct county	No tolerance	14	100.0	99.6
Condition-level				
Condition status	No tolerance	102	100.0	99.8
Reserve status	No tolerance	77	93.5	99.0
Owner class	No tolerance	77	98.7	96.5
Owner group	No tolerance	77	100.0	99.1
Owner status	No tolerance	77	100.0	97.9
Forest type (type)	No tolerance	77	88.3	84.8
Forest type (group)	No tolerance	77	100.0	91.2
Stand size	No tolerance	77	88.3	85.8
Regeneration status	No tolerance	77	100.0	96.6
Regeneration species	No tolerance	72	100.0	96.6
Tree density	No tolerance	77	100.0	99.4
Stand age	±10 percent	77	79.2	62.6
Disturbance 1	No tolerance	18	94.4	90.4
Disturbance year 1	±1 year	2	0.0	88.6
Disturbance 2	No tolerance	14	100.0	98.9
Disturbance year 2	±1 year	0	0.0	0.0
Disturbance 3	No tolerance	13	100.0	99.4
Disturbance year 3	±1 year	0	0.0	0.0
Treatment 1	No tolerance	18	100.0	94.4
Treatment year 1	±1 year	1	100.0	76.6
Treatment 2	No tolerance	13	100.0	95.5
Treatment year 2	±1 year	0	0.0	90.3
Treatment 3	No tolerance	13	100.0	99.2
Treatment year 3	±1 year	0	0.0	92.9
Physiographic class	No tolerance	59	89.8	91.9
Present nonforest use	No tolerance	18	72.2	82.7

continued

Table A.1—Performance of data collection on achieving measurement quality objectives for plot-, condition-, and tree-level variables, Kentucky and the Southern Region, 2005–09 (continued)

			Percent within tolerance	
Variables	Tolerance	Observations	Kentucky	Southern Region
		- - number - -	*- - - - percent - - - -*	
Condition-level (continued)				
Land use	No tolerance	102	98.0	97.6
Tract size	No tolerance	77	100.0	100.0
Percent forest	No tolerance	77	94.8	90.2
Stand structure	No tolerance	67	92.5	91.4
Distance to water	±10 feet	59	69.5	77.7
Prescribed fire	No tolerance	67	98.5	96.7
Grazing	No tolerance	67	100.0	97.9
Operability	No tolerance	67	83.6	87.1
Water source	No tolerance	59	71.2	86.1
Site class	±1 year	7	100.0	89.8
Weather event	±1 year	7	100.0	100.0
Urban-land use	No tolerance	0	0	100.0
Tree-level				
Condition number	No tolerance	298	100.0	100.0
D.b.h.	±0.1/20 inch	1,098	89.9	86.6
D.r.c.	±0.1/20 inch	0	0.0	0.0
Azimuth	±10 degrees	1,097	98.4	98.0
Horizontal distance	±0.2/1.0 feet	1,097	95.5	95.3
Species	No tolerance	1,107	94.8	96.1
Genus	No tolerance	1,107	99.3	99.1
Tree status	No tolerance	1,107	99.5	99.0
Reconcile	No tolerance	62	93.5	96.1
Total length	±10 percent	1,026	80.9	73.6
Actual length	±10 percent	61	59.0	55.3
Compacted crown ratio	±10 percent	1,095	85.2	80.5
Crown class	No tolerance	1,095	84.6	83.4
Decay class	±1 class	77	94.8	94.5
Standing dead	No tolerance	87	100.0	99.3
Cause of death	No tolerance	87	90.8	92.6
Mortality year	±1 year	87	94.3	95.9
Azimuth	±3 degrees	1,097	89.7	90.7
Tree class	No tolerance	1,086	93.3	91.8
Tree grade	No tolerance	62	59.7	75.9
Utilization class	No tolerance	1,029	99.8	99.2
Board foot cull	±10 percent	1,040	97.2	97.5
Cubic foot cull	±10 percent	1,029	96.7	97.3
Fusiform rust/dieback incidence	No tolerance	979	99.3	98.3
Fusiform rust/dieback severity	No tolerance	1,030	99.0	98.9

D.b.h. = diameter at breast height; d.r.c. = diameter root collar.

Table B.1—Species list by common and scientific name, Kentucky, 2009

Common name	Scientific name[a b]	Common name	Scientific name[a b]
Boxelder	*Acer negundo*	Green ash	*Fraxinus pennsylvanica*
Black maple	*A. nigrum*	Blue ash	*F. quadrangulata*
Striped maple	*A. pensylvanicum*	Honeylocust	*Gleditsia triacanthos*
Norway maple	*A. platanoides*	Kentucky coffeetree	*Gymnocladus dioicus*
Red maple	*A. rubrum*	American holly	*Ilex opaca*
Silver maple	*A. saccharinum*	Butternut	*Juglans cinerea*
Sugar maple	*A. saccharum*	Black walnut	*J. nigra*
Mountain maple	*A. spicatum*	Eastern redcedar	*Juniperus virginiana*
Yellow buckeye	*Aesculus flava*	Sweetgum	*Liquidambar styraciflua*
Ohio buckeye	*A. glabra*	Yellow-poplar	*Liriodendron tulipifera*
Ailanthus	*Ailanthus altissima*	Osage-orange	*Maclura pomifera*
Mimosa, silktree	*Albizia julibrissin*[c]	Cucumbertree	*Magnolia acuminata*
Serviceberry spp.	*Amelanchier spp.*	Mountain or Fraser magnolia	*M. fraseri*
Pawpaw	*Asimina triloba*	Bigleaf magnolia	*M. macrophylla*
Yellow birch	*Betula alleghaniensis*	Umbrella magnolia	*M. tripetala*
Sweet birch	*B. lenta*	Southern crab apple	*Malus angustifolia*
River birch	*B. nigra*	Apple spp.	*M. spp.*
		White mulberry	*Morus alba*
American hornbeam, musclewood	*Carpinus caroliniana*	Red mulberry	*M. rubra*
Mockernut hickory	*Carya alba*	Water tupelo	*Nyssa aquatica*[c]
Water hickory	*C. aquatica*	Swamp tupelo	*N. biflora*
Bitternut hickory	*C. cordiformis*	Blackgum	*N. sylvatica*
Pignut hickory	*C. glabra*	Eastern hophornbeam	*Ostrya virginiana*
Pecan	*C. illinoinensis*	Sourwood	*Oxydendrum arboreum*
Shellbark hickory	*C. laciniosa*	Paulownia, empress-tree	*Paulownia tomentosa*
Shagbark hickory	*C. ovata*	Shortleaf pine	*Pinus echinata*
Sand hickory	*C. pallida*[c]	Pitch pine	*P. rigida*
American chestnut	*Castanea dentata*	Eastern white pine	*P. strobus*
Chinese chestnut	*C. mollissima*	Loblolly pine	*P. taeda*
Northern catalpa	*Catalpa speciosa*	Virginia pine	*P. virginiana*
Sugarberry	*Celtis laevigata*	Water-elm, planertree	*Planera aquatica*
Hackberry	*C. occidentalis*	American sycamore	*Platanus occidentalis*
Eastern redbud	*Cercis canadensis*	Eastern cottonwood	*Populus deltoides*
Yellowwood	*Cladrastis kentukea*	Bigtooth aspen	*P. grandidentata*
Flowering dogwood	*Cornus florida*	Swamp cottonwood	*P. heterophylla*
Downy hawthorn	*Crataegus mollis*	American plum	*Prunus americana*[c]
Hawthorn spp.	*C. spp.*	Black cherry	*P. serotina*
Common persimmon	*Diospyros virginiana*	Chokecherry	*P. virginiana*
American beech	*Fagus grandifolia*	White oak	*Quercus alba*
White ash	*Fraxinus americana*	Swamp white oak	*Q. bicolor*

continued

Threepart violet (*Viola tripartita*) growing in a forest near Hawk Creek, Laurel County. (photo courtesy of Mason Brock/ Wikimedia.org)

Table B.1—Species list by common and scientific name, Kentucky, 2009 (continued)

Common name	Scientific name[a b]	Common name	Scientific name[a b]
Scarlet oak	*Quercus coccinea*	Post oak	*Quercus stellata*
Southern red oak	*Q. falcata*	Black oak	*Q. velutina*
Shingle oak	*Q. imbricaria*	Black locust	*Robinia pseudoacacia*
Overcup oak	*Q. lyrata*	Black willow	*Salix nigra*
Bur oak	*Q. macrocarpa*	Sassafras	*Sassafras albidum*
Blackjack oak	*Q. marilandica*	Baldcypress	*Taxodium distichum*
Swamp chestnut oak	*Q. michauxii*	American basswood	*Tilia americana*
Chinkapin oak	*Q. muehlenbergii*	White basswood	*T. americana* var. *heterophylla*
Water oak	*Q. nigra*	Eastern hemlock	*Tsuga canadensis*
Cherrybark oak	*Q. pagoda*	Winged elm	*Ulmus alata*
Pin oak	*Q. palustris*	American elm	*U. americana*
Willow oak	*Q. phellos*	Siberian elm	*U. pumila*
Chestnut oak	*Q. prinus*	Slippery elm	*U. rubra*
Northern red oak	*Q. rubra*	September elm	*U. serotina*
Shumard oak	*Q. shumardii*	Rock elm	*U. thomasii*

[a] Little (1979).
[b] U.S. Department of Agriculture Natural Resources Conservation Service (2006).
[c] Observed only as seedling.

Table C.1—Description of the forest sector industry groups

Forest sector industry group	NAICS 2007 code	IMPLAN sector	Description
Timber, logging	1131-2	15	Forestry, forest products, and timber tract production
	1133	16	Commercial logging
Primary			
Sawmill, panel	3211	95	Sawmills and wood preservation
	321211-2	96	Veneer and plywood manufacturing
	321219	98	Reconstituted wood product manufacturing
Pulp	32211	104	Pulp mills
	32212	105	Paper mills
	32213	106	Paperboard mills
Secondary			
Durable goods	321213-4	97	Engineered wood member and truss manufacturing
	32191	99	Wood windows and doors and millwork manufacturing
	32192	100	Wood container and pallet manufacturing
	321991	101	Manufactured home (mobile home) manufacturing
	321992	102	Prefabricated wood building manufacturing
	321999	103	All other miscellaneous wood product manufacturing
	33711	295	Wood kitchen cabinet and countertop manufacturing
	337122	297	Nonupholstered wood household furniture manufacturing
	337129	300	Wood television, radio, and sewing machine cabinet manufacturing
	337211-12	301	Office furniture and custom architectural woodwork and millwork manufacturing
Nondurable goods	32221	107	Paperboard container manufacturing
	322221-2	108	Coated and laminated paper, packaging paper, and plastics film manufacturing
	322223-6	109	All other paper bag and coated and treated paper manufacturing
	32223	110	Stationery product manufacturing
	322291	111	Sanitary paper product manufacturing
	322299	112	All other converted paper product manufacturing

NAICS = North American industry classification system; IMPLAN = IMpact analysis for PLANning.

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This resource bulletin consolidates data from the sixth complete survey of Kentucky's forest resources, which was conducted during the period 2005–09 by the U.S. Department of Agriculture Forest Service, Forest Inventory and Analysis (FIA) Program in coordination with the Kentucky Department for Natural Resources Division of Forestry. 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 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.

Keywords: Annual inventory, FIA, forest health indicators, forest ownership, nontimber forest products, timber product output.

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Dense canopy of a Kentucky hardwood forest. (photo by Angie Rowe, U.S. Forest Service)

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