Kentucky's

Forests, 2004

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and Kadonna C. Randolph

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Front cover: top left, Cumberland Falls in Cumberland Falls State Resort Park (photo by John J. Cox); top right, fall foliage, Pine Mountain (photo by Tom Barnes); bottom, jack in the pulpit (courtesy of Kentucky Division of Forestry). Back cover: top left, mature mixed hardwood forest (photo by Ray D.Campbell); top right, Cumberland Falls in Cumberland Falls State Resort Park (photo by John J. Cox); bottom, bull elk in eastern Kentucky (photo by John J. Cox).

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Firepink is a common wildflower in Kentucky. (photo by John J. Cox)

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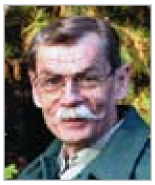
Cumberland Falls in Cumberland Falls State Resort Park. (photo by John J. Cox)

Welcome...

Leah W. MacSwords



Peter J. Roussopoulos

The Commonwealth of Kentucky celebrates a rich history rooted in its natural environment and a forest resource that is diverse and productive. The citizens of Kentucky receive multiple benefits from Kentucky's extensive forest land, including timber and nontimber forest products, recreational opportunities, e.g. hiking, hunting, and camping, and clean air and water. With so much at stake and because the general public, policymakers, and managers need information that documents changes taking place in our forests, it is important to have the means for assessing the extent and condition of our forest resources. Since the 1930s, the Forest Service, U.S. Department of Agriculture has provided these means through the Forest Inventory and Analysis Program (FIA), which conducts inventories of public and private land, nationwide, at regular time intervals.

Over the last 10 years, FIA has approached this inventory work in an exciting new manner by forming partnerships with State forestry organizations. The working partnership between the Kentucky Division of Forestry and the Forest Service Southern Research Station FIA has strengthened and improved Kentucky's forest inventory. The quality of this resource bulletin is a direct result of that sustained cooperation.

This bulletin contains information on the forest lands of the Commonwealth of Kentucky that can be used by decisionmakers, foresters, students, and researchers involved in forestry and forestry-related fields. Because forest resources are much more than just tree volume and numbers of trees, this bulletin includes information on forest health, ecological values, and socioeconomic benefits, and includes an evaluation of the goals and objectives of Kentucky forest landowners.

It is with great pride that we present this information about the forests of Kentucky. It is our goal that the partnership between our two organizations and the cooperative nature of this effort will continue to deliver the best information on the forests of Kentucky now and in the future.

Leah W. MacSwords
Kentucky State Forester and Director,
Kentucky Division of Forestry

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About Forest Inventory and Analysis Inventory Reports

This resource bulletin consolidates data from the fifth survey of Kentucky's forest resources by the Forest Service, U.S. Department of Agriculture. Data on the extent, condition, and classification of forest land and associated timber volumes, and on growth, removals, and mortality rates are described and interpreted. Data on forest health and the characteristics of forest landowners are evaluated also.

The fifth survey of Kentucky's forests marks 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 about 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; (5) reporting of data or data summaries within 6 months after yearly sampling; (6) a default 5-year moving average estimator, 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 http://www.fia.fs.fed.us.

In 1999, the Forest Inventory and Analysis Research Work Unit (FIA) of the Southern Research Station and the Kentucky Division of Forestry began implementing the new annual survey strategy in Kentucky. The strategy involves rotating measurements of five systematic samples (or panels), each of which represents about 20 percent of all plots in the Commonwealth. A panel may take more than or less than 1 year to complete. For Kentucky, data collection for all five panels was completed in 6 years. Four previous periodic inventories, completed in 1949, 1963, 1975, and 1988, provide statistics that can be used to measure changes and trends over the past 55 years. This analysis focuses primarily on changes and trends in recent years and their implications for Kentucky's forests.

Tabular data included in FIA reports are designed to provide a comprehensive array of forest resources statistics, but additional data are available to those who require more specialized information. The Forest Inventory and Analysis Database (FIADB) for the United States can be accessed directly via the Internet at http://www.ncrs2.fs.fed.us/4801/fiadb. Additional forest resource information on the Southern States is available on the Internet at http://www.srsfia2.fs.fed.us.

Information about any aspect of this survey may be obtained from:

Forest Service
U.S. Department of Agriculture
Southern Research Station
Forest Inventory and Analysis
4700 Old Kingston Pike
Knoxville, TN 37919
Phone: 865-862-2000

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(courtesy of Kentucky
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Oak-hickory forests are the dominant forests in Kentucky.
(photo courtesy of Kentucky Division of Forestry)

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Dave Maehr radio collaring a sedated black bear. The population, on its own, has recolonized Kentucky in the last 25 years. (photo by John J. Cox)

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Mixed hardwood forest along a western Kentucky creek. (photo by Larry Lowe)

Forest Features

• Since 1988, Kentucky's forest land area has decreased an estimated 729,000 acres (6 percent), to about 11.97 million acres. Forests occupy 47 percent of Kentucky's total land area.

• Timberland occupies 11.6 million acres (97 percent of the total forest land area). The remaining 3 percent of forest land area is either public reserved forest land—removal of timber from such land is prohibited by law—or considered to be unproductive.

• Overall, 115 individual tree species were recorded during the recent forest inventory. Red maple is the most common species in terms of number of individual stems recorded on forest land, and yellow-poplar is the species with the greatest amount of timber volume. Today, yellow-poplar represents an estimated 13 percent of total volume on Kentucky's timberland.

• Hardwood forest types other than oak-pine occupy 9.9 million acres, or 85 percent of timberland in the Commonwealth. Oak-hickory is the predominant forest-type group in Kentucky, occupying 8.4 million acres. Oak-pine is second in extent at 1.1 million acres (a 26-percent increase since 1988). Softwood forest-type groups totaled 571,300 acres (a 16-percent decrease since 1988).

• Sawtimber is the predominant stand-size class, occupying 7.6 million acres (65 percent of the timberland area), a 7-percent increase since 1988. Poletimber, the second most extensive stand-size class, occupies 2.8 million acres.

Tree Volume

• The live-tree volume on forest land was estimated to be 21.9 billion cubic feet in 2004.

• Volume of all live trees on timberland totaled 21.2 billion cubic feet in 2004, an increase of 4.6 billion cubic feet, or 28 percent, since 1988.

• Hardwood live-tree volume on timberland increased 28 percent, to 19.7 billion cubic feet. Softwood live-tree volume increased 17 percent, to 1.4 billion cubic feet.

• Yellow-poplar (2.6 billion cubic feet) and white oak (2.5 billion cubic feet) are the most abundant species by volume on forest land.

Yellow-poplar is one of the most numerous trees in Kentucky. (U.S. Forest Service photo)

• In 2004, almost three-quarters (73 percent) of the growing-stock volume on timberland was in trees in the 12-inch or greater diameter classes.

• Sawtimber volume on timberland increased by 32 percent between 1988 and 2004, to 60.4 billion cubic feet.

• The volume of sawtimber trees that are 15.0 inches d.b.h. or larger (39.4 billion board feet) is 65 percent of the total sawtimber volume. The amount of hardwood sawtimber volume in the higher quality tree grades (grades 1 and 2) increased from 16.1 to 23.1 billion board feet (adjusted).

Growth and Removals

• Net annual growth of all live trees on timberland averaged 565.0 million cubic feet between 1988 and 2003. Total removals of all live trees averaged 319.5 million cubic feet per year during that period. The great majority of growth (525.2 million cubic feet) was in hardwoods.

• Between 1988 and 2004, net annual growth of sawtimber trees increased 43 percent, to 2.2 billion board feet, while annual removals of sawtimber volume averaged 1.2 billion board feet. The ratio of growth to removals for sawtimber on Kentucky timberland fluctuated between 1.6 and 2.7 between 1949 and 2004.

• Net change in the inventory of all live-tree volume on timberland was a positive 245.5 million cubic feet per year. Net change in the inventory of sawtimber volume was a positive 1.0 billion board feet per year.

A Growing Population

• In 2004, 12 counties averaged at least 1,000 people per square mile of forest land. Of those 12 counties, only Campbell, Kenton, and Boone remained at least 30 percent forested in 2004.

Forest products ready to be put to use. (photo by Rodney Kindlund)

Kentucky's Forest Landowners

• Private individuals own 78 percent of the timberland in Kentucky. Nine percent is publicly administered by local, Commonwealth, or Federal agencies.

• Eighty-eight percent of the family forest landowners surveyed by the National Woodland Owner Survey stated they had no written management plan, and only 17 percent had sought advice on managing their forested acreage.

• Forest industry owns about 2 percent of the timberland in Kentucky.

• Federal, Commonwealth, and local government agencies manage 1.03 million acres, or 11 percent, of the forest land in Kentucky. The Forest Service manages 590,300 acres, or 56 percent, of the public forest land. Other public agencies own and manage about 439,700 acres of forest land in Kentucky.

The Economic Impact of Kentucky's Forests

• In 2003, more than 21,500 individuals were directly employed at wood-processing mills. The total annual payroll in 2003 was $714 million.

• In 2003, the total value of wood products manufactured in the Commonwealth was more than $5.8 billion. The total direct, indirect, and induced effects of the forest products industry were nearly $8.7 billion.

• Saw logs are the primary wood product produced by mills in Kentucky. Saw-log production increased from 117 million cubic feet in 1986 to 160 million cubic feet in 2003. Pulpwood production increased from 35 million cubic feet in 1986 to 53 million cubic feet in 2003.

• Kentucky ranks second in the South, behind North Carolina, in total number of nontimber forest product (NTFP) enterprises.

Black cohosh growing in the understory of a mixed hardwood stand. (photo by David Stephens, bugwood.org)

• Many species of medicinal plants grow in Kentucky's forests, and 54 percent of the 4,921 NTFP enterprises in Kentucky depend on medicinal plants.

• Since 1995, >212,000 pounds of ginseng have been harvested from Kentucky forests, and harvesters have received in excess of $63 million in direct payments for this ginseng. Kentucky has been the number one supplier of wild-harvested ginseng for the last 10 years.

• The 2002 census revealed that Kentucky had 230 Christmas tree farms, of which 123 were harvesting trees.

• In 2002, 38 maple syrup farms had a total of 4,142 active taps. These farms produced about 416 gallons of syrup, representing about 9 percent of total maple syrup production in the South.

Pink lady's slipper *(Cypripedium acaule)*. (photo by John J. Cox)

Features of the Forest Land Base

Data from the phase 1 (P1) aerial photopoints were used to determine the area of forest land in the Commonwealth. The large number of photo sample points ensures a high level of precision in the estimates of forest land area at the unit (multicounty) or Commonwealth level. However, the number of photopoints per county is limited, so users should be cautious when interpreting or using data for individual counties.

Data from the phase 2 (P2) ground plots were used to describe forest characteristics. P2 data provide estimates of stand size, forest type, ownership, reserved status, stand origin, site productivity, stand age, stocking levels, and other stand variables. The area estimates are presented in acres. Equivalent estimates in hectares are available on the FIADB Web site.

The data collected on the P2 ground plots are not valid at the county level. Users should also be aware that, due to changes in inventory design, not all of the ground plots sampled in 2004 are the same as the ones that were established in 1988. Differences between the previous and current plot design are discussed in the "Inventory Methods" section of the appendix.

Fall foliage, Pine Mountain. (photo by Tom Barnes)

Forests covered 11.97 million acres or 47 percent of Kentucky's total land area. This was 729,000 acres less than the area of forest land reported in 1988.

The Extent of Kentucky's Forests

Forests covered 11.97 million acres or 47 percent of Kentucky's total land area. This was 729,000 acres less than the area of forest land reported in 1988 (Alerich 1990). The Cumberland Plateau and the Appalachians in the eastern portion of Kentucky were the most heavily forested (fig. 1). The central and western portions of the Commonwealth, although less densely forested, accounted for 50 percent of the total forest land area.

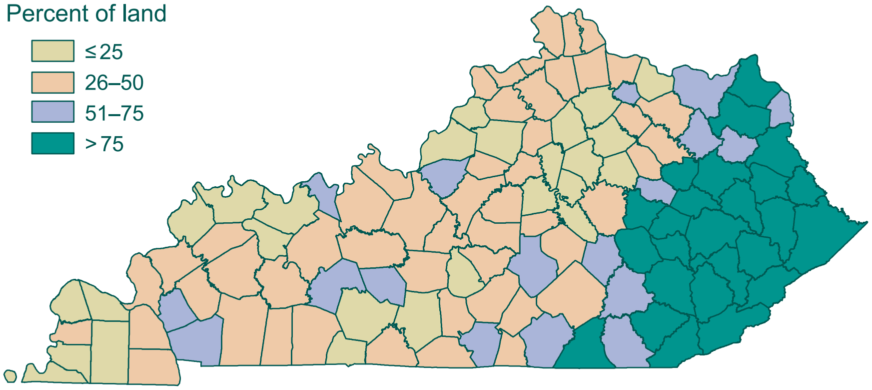


Figure 1—Percentage of land in forest by county, Kentucky, 2004.

Kentucky Land Classifications

FIA classifies forest land area into two broad classes: (1) timberland and (2) other forest land. Timberland is forested land that is capable of producing at least 20 cubic feet of wood volume per acre per year. Other forest land, referred to as woodland or unproductive in previous FIA reports, does not meet this minimum productivity standard. Other forest land is generally characterized by sterile soils, poor drainage, high elevation, rockiness, or steep slopes. At the time of the 2004 inventory, the area of unproductive forest land was 37,847 acres (included in "Other/reserved" in table 1). This figure was basically unchanged from the 1988 inventory estimate of 36,500 acres. Although some forest land is not considered productive for timber purposes, all forest land provides benefits unrelated to timber harvesting, including ecological, aesthetic, and recreational value.

Table 1—Area by land class, Kentucky

Land class	1963	1975	1988	2004
		million acres		
Timberland	11.7	11.9	12.3	11.6
Other/reserved	0.1	0.3	0.4	0.3
Total forest area	11.9	12.2	12.7	12.0
Agricultural land [a]	11.6	11.3	10.1	10.0
Other nonforest land [b]	2.1	2.0	2.6	3.5
Total nonforest land	13.7	13.3	12.7	13.5
Total land area [c]	25.5	25.5	25.4	25.4
		percent		
Forested	46	48	50	47
Agricultural	45	44	40	39
Other nonforest	8	8	10	14

Totals may not sum due to rounding.
Total land area estimates changed slightly over time due to improvements in measurement techniques and refinements in classification of small bodies of water and streams.
[a] Source: USDA, National Agriculture Statistics Service, Census of Agriculture.
[b] Includes urban and other land not considered agricultural land or forest land, including some areas considered water by FIA but not by Bureau of the Census.
[c] Source: U.S. Department of Commerce, Bureau of the Census.

Publicly owned forest land that has been withdrawn from timber production by legal statute or administrative regulation is termed reserved forest land, regardless of its productivity class. Reserved forest land does not include private land that has been placed in conservation easements or is controlled by other private contracts that limit or exclude timber harvesting.

The vast majority of Kentucky's total forest land area in 2004 was considered available for timber production (11.6 million acres or 97 percent of the total forest land area) (table 1). The amount of reserved forest land area sampled on P2 ground plots in the 2004 inventory represented 284,709 acres. Over one-half of the reserved land was located in designated wilderness areas on the Daniel Boone National Forest and the Land Between the Lakes National Recreation Area. About 20 percent of the reserved forest land was administered by the National Park Service, and another 15 percent was managed by other Federal Agencies. Nearly 10 percent of the reserved forest land was owned by the Commonwealth of Kentucky.

The 1988 inventory reported over 300,000 acres of reserved forest land. The relatively small difference between the two estimates is most likely due to changes in how reserved forest land was measured between the two surveys rather than any real change in the amount of reserved forest land (see the discussion on inventory methods in the "Inventory Methods" section of the appendix).

While this report does include data on all forest land areas, it primarily focuses on timberland—the portion of the forest land area that is available for timber production. Users who compare data from different inventories are cautioned to be sure that the data have the same basis—either total forest land or timberland. In most previous inventory reports, the only data presented have been based on the timberland component.

Forest Composition

The species composition of a forested stand defines that stand's character, likely future development, ecosystem function, and dynamics, and provides insight into its historical evolution. As such, analysis of current and past species composition aids in understanding the existing forest character and potential developmental paths.

A wide variety of tree species are found in Kentucky. These include hardwoods such as yellow-poplar, oak, hickory, maple, beech, birch, and black locust and softwoods such as shortleaf pine, Virginia pine, loblolly pine, eastern redcedar, and cypress. Overall, 115 individual species were recorded during the recent forest inventory. Red maple is the most common species in terms of number of individual stems recorded on forest land (fig. 2) and the species with the greatest amount of volume is yellow-poplar (fig. 3).

No one tree species dominates Kentucky's forest land both in terms of numbers of live trees and in terms of volume. The statistics more or less reflect the ecological niche and silvical characteristics of the common species. Species such as yellow-poplar, white oak, and many red oaks appear to be larger and the dominant canopy species in much of the forest. Some species, such as red maple, flowering dogwood, and eastern redbud, are more numerous but smaller in diameter and typically occupy midstory and understory positions.

There does appear to be a shift in species dominance in Kentucky's forests since the late 1940s and early 1950s. For instance, yellow-poplar, the species currently representing the greatest growing-stock volume on Kentucky timberland, has experienced significant gains in dominance. In 1952, yellow-poplar accounted for an estimated 6 percent of the total volume on commercial forest area (now defined as timberland). Today, yellow-poplar represents an estimated 13 percent of the total volume on timberland (fig. 4). Red

No one tree species dominates Kentucky's forest land both in terms of numbers of live trees and in terms of volume. The statistics more or less reflect the ecological niche and silvical characteristics of the common species.

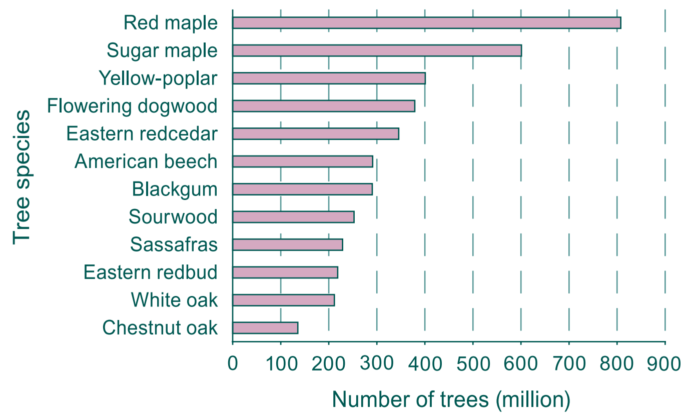


Figure 2—Top 12 tree species in terms of number of live trees occurring on Kentucky's forest land, 2004.

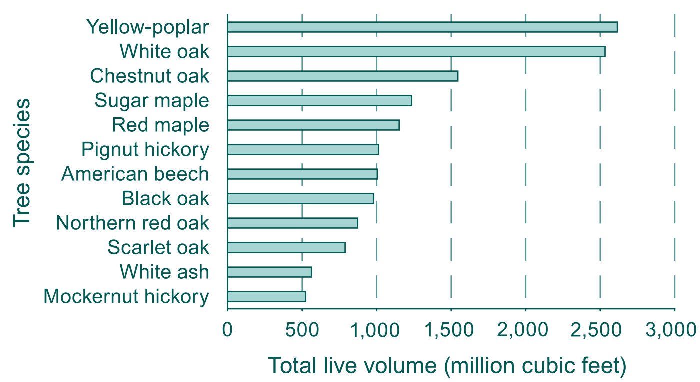


Figure 3—Top 12 tree species in terms of total volume of live trees occurring on Kentucky's forest land, 2004.

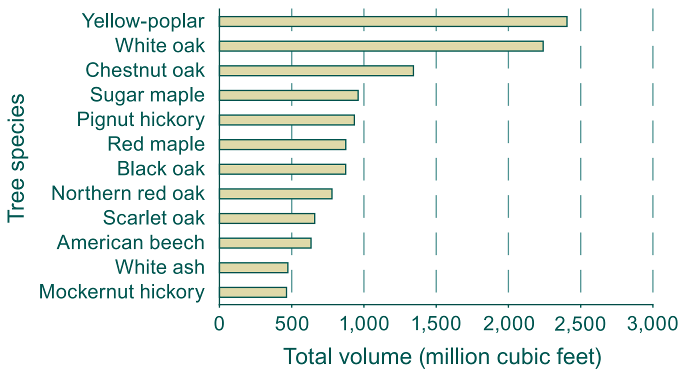


Figure 4—Top 12 tree species in terms of total volume of growing stock on Kentucky's timberland, 2004.

maple accounted for 2 percent of volume on commercial forest area in 1952 and now accounts for 5 percent of volume on timberland, while sugar maple made up 3 percent of volume on commercial forest area in 1952 and now makes up 5 percent of volume on timberland. Relative volumes of individual species in the red oak group have generally declined since 1952. For example, black oak accounted for 15 percent of total wood volume on timberland in 1952 but only 5 percent in 2004 (fig. 4).

Kentucky Forest Types

The forest type is a classification derived from the species that make up the plurality of the live trees sampled within a stand. Utilizing forest types allows for stand level information to be analyzed across wide geographical areas and results in more meaningful and less complicated conclusions. Forest-type nomenclature is derived from those dominant species. Examples include detailed types such as red oak/white oak/hickory, and yellow-poplar/white oak/northern red oak. The detailed forest types are grouped into broad forest-type groups composed of ecologically similar types, such as maple-beech-birch or oak-hickory. FIA commonly reports the broad forest-type groups instead of detailed forest types.

Two methods are used to determine the forest-type classification. The first method uses field crews' evaluations based on the majority of species on the acre surrounding and including the plot. The second method involves a computer algorithm that evaluates only the tree data collected within the boundary of the plot area. The forest-type data in this bulletin was based solely on the field crews' evaluations.

Kentucky Division of Forestry crew collecting forest resource information. (photo by Ray D. Campbell)

Algorithm results were not available for this bulletin, although the previous forest-type information was generated by an algorithm. Please refer to the FIA field guide for complete descriptions of each detailed forest type.

Hardwood types dominate Kentucky's forests. Oak-hickory was the predominant forest-type group in the Commonwealth, occupying 8.4 million acres of timberland (72 percent) (fig. 5). This group is composed of upland forest types containing oak-hickory, yellow-poplar, and other upland hardwoods commonly found in the central hardwood region of the United States. Upland stands composed of a mixture of oak and pine covered 9 percent of the timberland area. Maple-beech-birch and aspen-birch upland forests combined covered 7 percent of the timberland area. Two lowland hardwood forest-type groups—oak-gum-cypress and elm-ash-cottonwood—combined covered 6 percent of the timberland area. Softwood forest types including white pine, hemlock, southern yellow pines, and eastern redcedar together occupied 5 percent of timberland area.

Natural and Planted Stands

Stand origin is a classification that describes how the sampled forest originated—either naturally or by being planted. Planted forests in Kentucky account for an estimated 84,051 acres of timberland in 2004, <1 percent of the total timberland area (table 2). Loblolly pine accounted

Table 2—Area by State and stand origin

			Stand origin	
State	Year	Total timberland	Natural stands	Planted stands
		- - - - - - - - - - - - *acres*	- - - - - - - - - - - -	
Alabama	2000	22,925,815	17,138,176	5,787,639
Arkansas	1995	18,392,130	15,975,255	2,416,875
Florida	1995	14,650,660	9,705,626	4,945,034
Georgia	2004	24,151,017	16,732,336	7,069,000
Kentucky	2004	11,647,891	11,563,840	84,051
Louisiana	1991	13,783,023	11,137,253	2,645,770
Mississippi	1994	18,587,406	14,476,679	4,110,727
North Carolina	2002	17,684,407	14,860,603	2,823,804
Oklahoma	1993	6,233,573	5,598,047	635,526
South Carolina	2001	12,221,404	9,076,138	3,145,266
Tennessee	1999	13,965,050	13,366,364	598,687
Texas	2003	11,884,780	8,961,090	2,923,690
Virginia	2001	15,467,010	13,348,965	2,118,046
Total		201,594,167	161,940,371	39,653,796

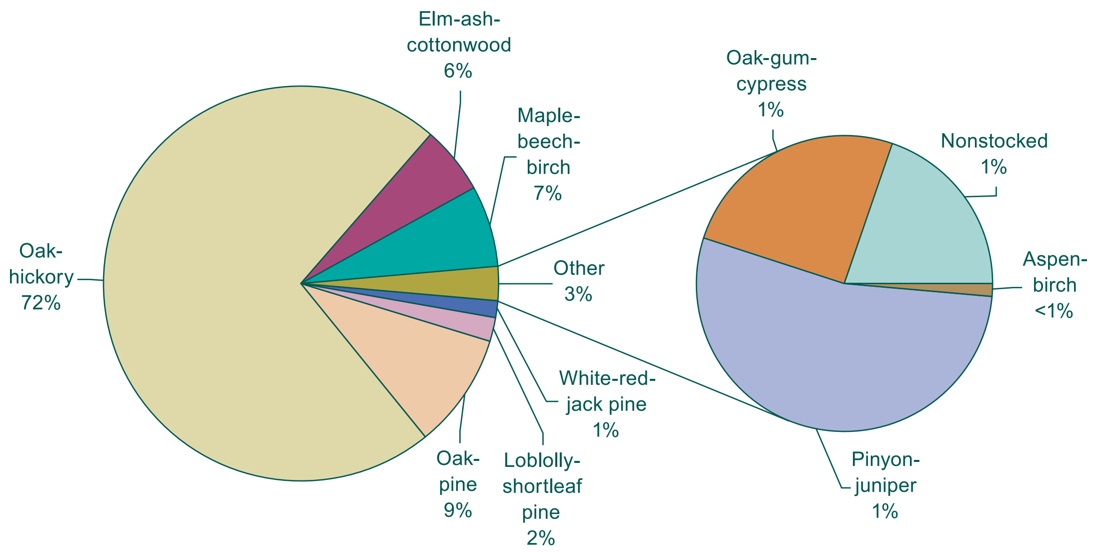


Figure 5—Area of timberland by forest-type group, Kentucky, 2004.

Planted oak stand. (photo by Christopher M. Oswalt)

for about 40 percent of the planted area. White pine, Virginia pine, and shortleaf pine combined were also planted on about 40 percent of the planted timberland area. The remainder was planted in black locust or black walnut, in addition to very small amounts of cottonwood and cypress.

In order to quantify planting activity between inventories, we have annualized the acreage of planted stands <16 years of age for the 16-year period between the 1988 and current inventories. About 34,100 planted acres of Kentucky timberland are 16 years old or less. Thus, we estimate that according to FIA estimates an average of approximately 2,130 acres of timberland were planted each year since the last inventory.

By comparison, an average of 21,700 acres of timberland was planted annually in Tennessee from 1989 to 1999 (Schweitzer 2000). In 1999, Tennessee had a total of nearly 600,000 planted acres (table 2), which was 4 percent of the timberland area in that State (13.965 million acres). In North Carolina, 100,500 acres were planted annually from 1990 to 2002, and planted timberland in that State totaled about 2.8 million acres (or 16 percent of the timberland area) in 2002 (Brown 2004). The vast majority of the planted acreage in the other Southern States, such as North Carolina, is being planted in conifer species, particularly loblolly pine. Kentucky, much like Tennessee, is primarily a hardwood State. Artificial regeneration of hardwood stands is less common and less widespread than artificial regeneration of conifer stands. In addition, Kentucky is outside the natural range of loblolly pine and this heavily influences the number of acres planted to pine each year.

Due to the scale of the FIA data collection effort, smaller planted stands, unlike the larger pine plantations of many of the other Southern States, may be underrepresented in the estimate. According to the "Database of Tree Planting in the U.S." (Tree Planters Notes 2006) an average of 12,216 acres were planted annually in Kentucky during the period of 1988 to 1999 (the period for which data were readily available). This supports the idea that planted stands in Kentucky may be underestimated by FIA. Regardless, the amount of planted pine in Kentucky is minimal by either measure.

Stand Size

It is important to know the size of the trees that make up our forests. Armed with this knowledge we are able to better understand the structure of the forested stands in Kentucky and the habitat that exists on the landscape. In addition, trend analysis of stand size (a classification based on 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 utilized by FIA are sapling-seedling, poletimber, sawtimber, and nonstocked. Sapling-seedling stands are forested areas where the majority of the trees are <5.0 inches d.b.h. Poletimber stands are at least 5.0 inches d.b.h. but are not large enough to be sawtimber. In order to be sawtimber size, a softwood species must be 9.0 inches or larger, while hardwood species must be 11.0 inches or larger. Nonstocked means that although the land is considered forested, there are not enough trees on it to categorize it into stand-size category. These generally are forested areas that have recently been harvested but where new tree growth has not regenerated to an adequate level of stocking at the time of the field inventory.

An estimated 7.6 million acres of timberland, or 65 percent of the timberland in Kentucky, is in sawtimber-size stands.

The number of acres in sawtimber increased from 1975 to 1988 and from 1988 to 2004 (fig. 6). An estimated 7.6 million acres of timberland, or 65 percent of the timberland in Kentucky, is in sawtimber-size stands. Since 1988, there has been a 7-percent increase in the number of acres of sawtimber-size stands on Kentucky's timberland. Since 1975 timberland acreage has been aging as stems have been recruited from small stand-size classes into larger classes. As a result, the area in poletimber stands has declined by 12 percent since 1988. Also the total area in the sapling-seedling stand-size class decreased from an estimated 3.75 million acres in 1975 to about 1.2 million acres in 2004, a decrease of 68 percent. Essentially, this represents a decrease in early successional habitat and a loss of habitat available to early successional fauna as the Kentucky forest ages. This aging is also apparent in observed changes in species composition over time (see discussion of species composition).

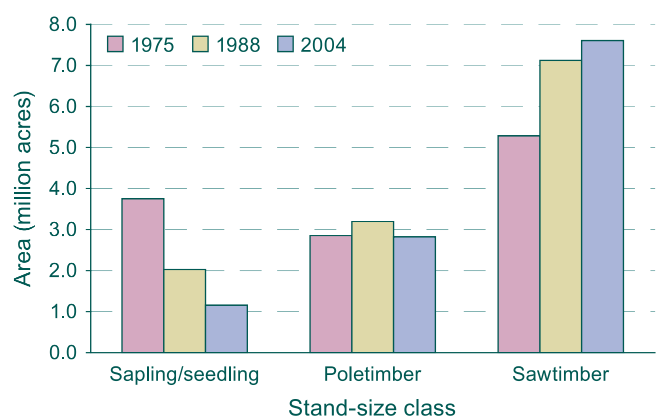


Figure 6—Area of timberland by stand-size class, Kentucky, 1975, 1988, and 2004.

Stand Age

Stand age is the average age of the majority of live trees in the predominant stand-size class. The FIA data from the P2 plots indicate that stand ages are not evenly distributed. Across Kentucky, 68 percent of the timberland was > 40 years old in 2004 (fig. 7). The estimates signify that the total acreage of stands 41 to 50 years of age is greater than the total acreage of stands in any other 10-year age class. As such, a large number of stands in Kentucky appear to have initiated between the years of 1945 to 1963. This corresponds to the increase in forest land area in Kentucky that appeared in FIA surveys in the late 1940s and continued to the late 1980s (fig. 8).

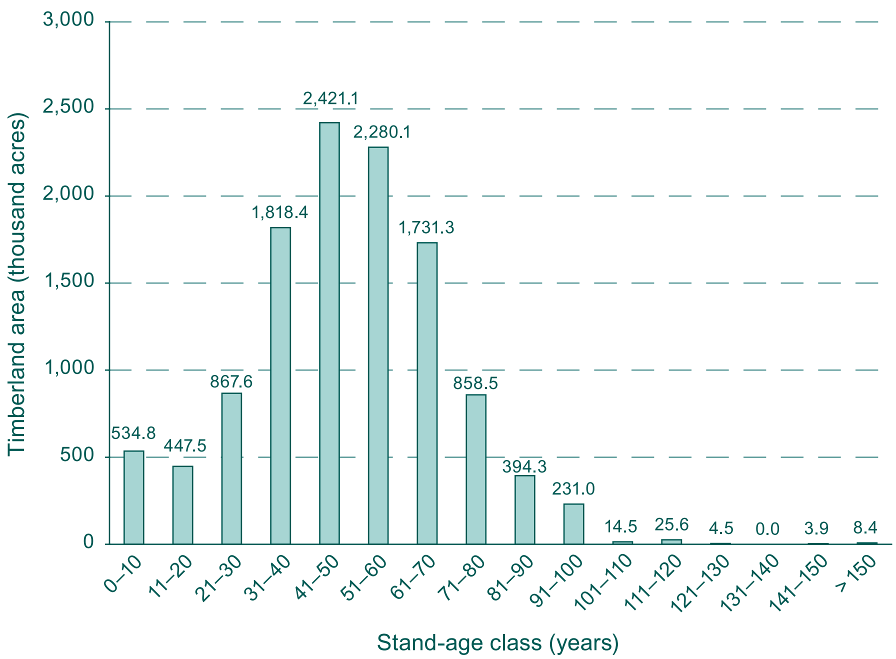


Figure 7—Timberland area by stand-age class, Kentucky, 2004. (Note: no stand age was given for 6.44 thousand acres of timberland.)

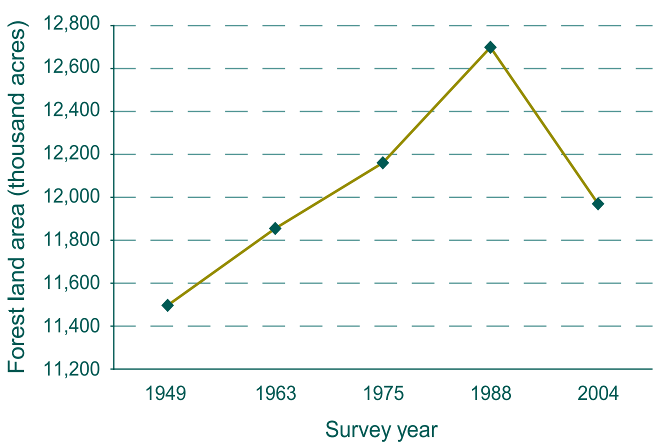


Figure 8—Total forest land area in Kentucky, 1949 to 2004.

Tree Volume on Forest Land and Timberland

Tree data from the P2 ground plots provide volume estimates by species, diameter class, quality, and other individual tree attributes. The volume data can also be evaluated by stand attributes like ownership, stand size, forest type, and other stand variables. The volume estimates are presented in cubic feet and board feet for this resource bulletin.

Previous FIA reports primarily focused only on tree volume located on timberland. While this bulletin discusses wood volume on all forest land area, the tables in the appendix include only the volume located on timberland. Users should be aware of the differences between timberland and forest land, and take care to ensure comparisons between findings from different surveys are valid. Differences between the previous and current plot design are discussed in the "Inventory Methods" section of the appendix.

The volume of wood in each live tree meeting minimum standards is determined by measuring the tree's diameter at breast height (*dbh*) at 4.5 feet above the ground and the tree's total height (*h*), and then applying the following formula:

$$V = \alpha + \beta\,(dbh^2 * Ht) + \varepsilon$$

where

V = volume
α and β = parameters
dbh = diameter at breast height
Ht = height
ε = error

The coefficients correct for species-specific growth differences such as taper, and have been derived from numerous years of FIA wood-utilization studies. The volume equations currently used by FIA in the Southern States represent some of the best equations available for many southern tree species.

Table 3—Net volume of all live trees on forest land by forest land status

Unreserved forests			Reserved forests			All
Timberland	Unproductive	Total	Productive	Unproductive	Total	forest land
million cubic feet						
21,187.9	6.3	21,194.2	719.4	0.0	719.4	21,913.6

All Live-Tree Volume Dominated by Hardwoods

Live-tree volume on forest land in 2004 totaled 21.9 billion cubic feet (table 3). Over 97 percent (21.2 billion cubic feet) of live-tree volume was on timberland, and live-tree volume on timberland was up 28 percent since 1988. Hardwoods, which are predominant in Kentucky, accounted for 93 percent of the 21.9 billion cubic feet of all live-tree volume (20.3 billion cubic feet) on forest land, and an equal percentage of live-tree volume on timberland (19.7 billion cubic feet). The latter is a 28-percent

Peeler logs stacked and ready for processing. (photo by L. David Dwinell) increase over the 15.4 billion cubic feet of hardwood volume on timberland reported in 1988.

The most abundant hardwood species on forest land with respect to live volume was yellow-poplar at 2.6 billion cubic feet (table 4). The second most abundant species was white oak with 2.5 billion cubic feet. Together these two species accounted for one-quarter of live hardwood volume on forest land. Another 48 percent of live hardwood volume was accounted for by chestnut oak, sugar maple, red maple, pignut hickory, American beech, black oak, northern red oak, scarlet oak, white ash, and mockernut hickory combined. The remaining 27 percent of live hardwood volume consisted of over 80 species, with no single species contributing >2 percent and the majority contributing less than one-half of 1 percent.

Table 4—Volume of live hardwood trees by species on forest land, Kentucky, 2004

Species	Volume			
	Cubic feet	Cumulative total	%	Cumulative percent
Yellow-poplar	2,615,100,381	2,615,100,381	13	13
White oak	2,532,328,964	5,147,429,345	12	25
Chestnut oak	1,544,389,660	6,691,819,005	8	33
Sugar maple	1,234,256,115	7,926,075,120	6	39
Red maple	1,151,007,295	9,077,082,415	6	45
Pignut hickory	1,012,999,649	10,090,082,064	5	49
American beech	1,003,953,617	11,094,035,681	5	54
Black oak	978,609,509	12,072,645,190	5	59
Northern red oak	871,857,316	12,944,502,506	4	63
Scarlet oak	788,422,351	13,732,924,857	4	67
White ash	562,028,904	14,294,953,761	3	70
Mockernut hickory	522,770,914	14,817,724,675	3	73
Sycamore	379,758,869	15,197,483,544	2	75
Green ash	338,527,410	15,536,010,954	2	76
Sweetgum	326,858,549	15,862,869,503	2	78
Shagbark hickory	315,123,587	16,177,993,090	2	79
Blackgum	308,563,952	16,486,557,042	2	81
Chinkapin oak	292,913,458	16,779,470,500	1	82
Bitternut hickory	236,059,544	17,015,530,044	1	83
Black walnut	214,118,380	17,229,648,424	1	85
Post oak	211,277,801	17,440,926,225	1	86
American basswood	201,425,566	17,642,351,791	1	87
Black cherry	200,060,585	17,842,412,376	1	88
Southern red oak	198,175,885	18,040,588,261	1	88
Sassafras	181,211,234	18,221,799,495	1	89
Silver maple	144,853,158	18,366,652,653	1	90
American elm	144,322,402	18,510,975,055	1	91
Black locust	128,320,087	18,639,295,142	1	91
Slippery elm	128,145,394	18,767,440,536	1	92
Hackberry	127,439,831	18,894,880,367	1	93
Shellbark hickory	126,633,809	19,021,514,176	1	93
Sweet birch	125,879,550	19,147,393,726	1	94
Sourwood	125,076,263	19,272,469,989	1	95
Boxelder	110,259,317	19,382,729,306	1	95

Softwood live volume on forest land totaled just 1.5 billion cubic feet (table 5). Virginia pine (0.5 billion cubic feet) and eastern redcedar (0.4 billion cubic feet) together accounted for 57 percent of softwood live volume. Eastern hemlock and shortleaf pine accounted for 0.2 billion cubic feet each (22 percent combined), while Eastern white pine, pitch pine, and baldcypress accounted for <0.1 billion cubic feet individually (17 percent combined). With respect to volume, the least abundant softwood species was loblolly pine, accounting for 4 percent of live softwood volume on forest land. The species composition and distribution of live volume are essentially the same for timberland and for forest land.

Growing-Stock Tree Volume

Trees on the P2 ground plots that are suitable for producing sawtimber, now or in the future, are termed growing stock. Growing-stock trees have at least one 12-foot log or two 8-foot logs, and at least one-third of the total board-foot volume in the tree must be utilizable. Trees that meet minimum diameter standards to be classified as sawtimber (9.0 inches d.b.h. and greater for softwoods, and 11.0 inches d.b.h. and greater for hardwoods) are evaluated based on their current form. Trees smaller than sawtimber size are evaluated based on their potential to become growing stock when they do reach the minimum diameter threshold. Trees that do not meet the growing-stock standard are designated as either rough (due to poor form) or rotten cull trees.

It is important to note that the growing-stock classification is based solely on the FIA definition of what is acceptable, a standard that has not significantly changed over time. However, some portion of the cull volume reported by FIA is undoubtedly utilized in modern pulpmills and sawmills due to substantial advances in mill technology (Spelter and Alderman 2005).

In 2004, there was 18.9 billion cubic feet of growing-stock volume on Kentucky's forest land (86 percent of the live-tree volume), including the 18.2 billion cubic feet on timberland. The volume on timberland has increased by 14 percent since 1988.

Hardwood species accounted for 93 percent of growing-stock volume and 93 percent of live-tree volume on forest land and on timberland. The species composition of growing-stock volume on timberland was essentially the same as the species composition of growing-stock volume on forest land (tables 4 through 7).

The overall increase in volume is highlighted by a substantial rise in volume among the 12-inch and greater diameter classes. Kingsley and Powell (1978) estimate that trees in the 12-inch or greater diameter classes accounted for 59 percent of the growing-stock volume on timberland in 1975. Alerich (1990) estimated that such trees accounted for 65 percent of growing-stock volume on timberland by 1988. In 2004, almost three-quarters (73 percent) of the growing-stock volume on timberland was in trees in the 12-inch or greater diameter classes (fig. 9).

Table 5—Volume of live softwood trees by species on forest land, Kentucky, 2004

	Volume			
Species	Cubic feet	Cumulative total	%	Cumulative percent
Virginia pine	471,422,992	471,422,992	31	31
Eastern redcedar	390,933,420	862,356,412	26	57
Eastern hemlock	173,602,769	1,035,959,181	11	68
Shortleaf pine	170,004,103	1,205,963,284	11	79
Eastern white pine	91,475,367	1,297,438,651	6	85
Pitch pine	88,226,787	1,385,665,438	6	91
Baldcypress	80,218,996	1,465,884,434	5	96
Loblolly pine	58,389,427	1,524,273,861	4	100

In 2004, there was 18.9 billion cubic feet of growing-stock volume on Kentucky's forest land (86 percent of the live tree volume), including the 18.2 billion cubic feet on timberland. The volume on timberland has increased by 14 percent since 1988.

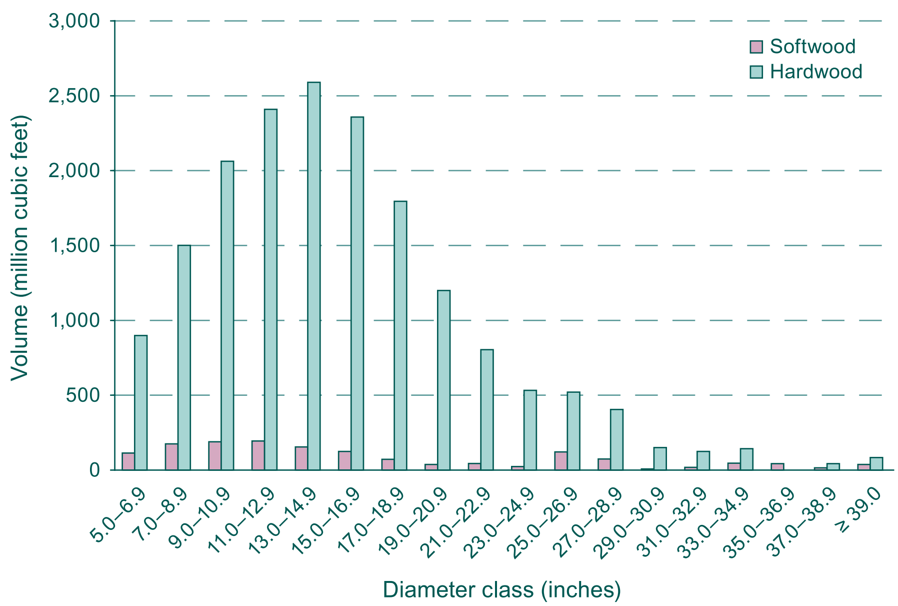


Figure 9—Growing-stock volume on timberland by diameter class, Kentucky, 2004.

Sawtimber Volume

In 2004, sawtimber volume on timberland was 60.4 billion board feet, up 32 percent since 1988. Hardwood species accounted for 56.0 billion board feet, or 93 percent, of sawtimber volume. Yellow-poplar and white oak are the most abundant hardwood species in terms of sawtimber volume on timberland (17.5 billion board feet or 31 percent combined) (table 6).

Table 6—Volume of hardwood sawtimber trees by species on timberland, Kentucky, 2004

	Volume			
Species	Board feet [a]	Cumulative total	%	Cumulative percent
Yellow-poplar	9,214,263,622	9,214,263,622	16	16
White oak	8,258,002,442	17,472,266,064	15	31
Chestnut oak	4,693,591,763	22,165,857,827	8	40
Black oak	3,461,198,400	25,627,056,227	6	46
Northern red oak	3,002,859,542	28,629,915,769	5	51
Pignut hickory	2,857,903,610	31,487,819,379	5	56
Scarlet oak	2,545,859,814	34,033,679,193	5	61
Sugar maple	2,388,592,063	36,422,271,256	4	65
American beech	2,114,064,293	38,536,335,549	4	69
Red maple	1,850,676,258	40,387,011,807	3	72
White ash	1,427,877,599	41,814,889,406	3	75
Mockernut hickory	1,244,040,955	43,058,930,361	2	77
Sycamore	1,203,066,806	44,261,997,167	2	79
Sweetgum	939,971,293	45,201,968,460	2	81
Green ash	882,856,040	46,084,824,500	2	82
Shagbark hickory	781,394,298	46,866,218,798	1	84
Chinkapin oak	697,702,916	47,563,921,714	1	85
Southern red oak	676,407,642	48,240,329,356	1	86
Post oak	643,516,992	48,883,846,348	1	87
Blackgum	629,415,593	49,513,261,941	1	88
American basswood	616,623,898	50,129,885,839	1	89
Bitternut hickory	596,059,440	50,725,945,279	1	91
Eastern cottonwood	510,223,219	51,236,168,498	1	92

[a] The amount of board-foot volume was calculated for all sawtimber-size, growing-stock trees. One board foot is equivalent to a board 1-foot square by 1-inch thick. FIA used the International ¼-inch rule to determine board-foot volume.

Chestnut oak, black oak, northern red oak, pignut hickory, scarlet oak, sugar maple, American beech, red maple, white ash, and mockernut hickory ranked next in sawtimber volume. Together they accounted for 46 percent of the sawtimber volume on timberland (25.6 billion board feet).

In 2004, sawtimber volume on timberland was 60.4 billion board feet, up 32 percent since 1988. Hardwood species accounted for 56.0 billion board feet, or 93 percent, of sawtimber volume.

Virginia pine accounted for most of the softwood sawtimber volume on timberland (1.3 billion board feet or 30 percent of the total) (table 7). However, shortleaf pine and eastern hemlock had more sawtimber volume than eastern redcedar, which ranked second in growing-stock volume on timberland. Baldcypress accounts for an estimated 10 percent of the softwood sawtimber inventory on timberland, but only 5 percent of the growing-stock volume on timberland.

Recently harvested logs. (photo by L. David Dwinell)

Table 7—Volume of softwood sawtimber trees by species on timberland, Kentucky, 2004

	Volume			
Species	Board feet [a]	Cumulative total	%	Cumulative percent
Virginia pine	1,306,795,284	1,306,795,284	30	30
Shortleaf pine	736,175,588	2,042,970,872	17	47
Eastern hemlock	552,063,744	2,595,034,616	13	60
Eastern redcedar	466,934,685	3,061,969,301	11	71
Baldcypress	445,931,688	3,507,900,989	10	81
Eastern white pine	331,414,460	3,839,315,449	8	89
Pitch pine	285,501,723	4,124,817,172	7	95
Loblolly pine	213,384,084	4,338,201,256	5	100

[a] The amount of board-foot volume was calculated for all sawtimber-size, gowing-stock trees. One board foot is equivalent to a board 1-foot square by 1-inch thick. FIA used the International ¼-inch rule to determine board-foot volume.

Forests provide resources that fuel our growing world. (U.S. Forest Service photo)

Hardwood Sawtimber Volume Distribution by Tree Grade

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.

Each sawtimber-size, growing-stock hardwood tree was assigned a tree grade of 1 to 5. Trees suitable for factory lumber were graded 1 to 3, with 1 being the best and grade 3 the lowest quality. Grade 4 trees have too many defects to yield factory lumber but can yield construction timbers or railroad ties. Tree grade 5 indicates that the utilizable material is in the upper stem, too high above the ground for evaluation by field crews. While most of the tree data collected by FIA are quantitative measurements, e.g. diameter and tree height, tree grade is qualitative and somewhat subjective in nature.

Forest products are an important part of the Kentucky economy. (U.S. Forest Service photo)

Prior to completion of the inventory, an investigation of the quality assurance data revealed that field crews overestimated tree grade 1 and underestimated tree grade 4 classifications in Kentucky. Field crews did not significantly overestimate or underestimate other tree grade classifications. Two methods of rectifying the tree grade distribution were outlined in Zarnoch and Turner (2005). The results of that publication were only based on 80 percent of the collected plots. This bulletin relies on analyses that were conducted on 100 percent of the FIA tree grade data collected in Kentucky, and tree grade distributions were adjusted according to the methods of Zarnoch and Turner (2005).

Due to the overall increase in sawtimber volume and increases in the larger diameter classes, the total amount of hardwood sawtimber volume in factory lumber grades 1 to 3 increased (table 8). Grade 1 increased from 5.1 to 7.5 billion board feet (by 47 percent). Grade 2 increased from 11.0 to 15.6 billion board feet (by 42 percent). Grade 3 increased from 15.4 billion to 21.3 billion board feet (by 38 percent). While the total volume in these grades increased, the percentage-wise distribution of volume among the grades did not change much since 1988 (fig. 10).

Table 8—Volume of hardwood sawtimber by tree grade, Kentucky, 1988 and 2004

	Volume [a]		
Tree grade	1988	Unadjusted 2004	Adjusted [b] 2004
	million board feet		
1	5,115	11,267	7,497
2	10,976	15,805	15,585
3	15,412	20,682	21,329
4	7,045	5,144	8,755
5	4,470	3,146	2,879
Total	43,018	56,044	56,045
	percent		
1	12	20	13
2	26	28	28
3	36	37	38
4	16	9	16
5	10	6	5
Total	100	100	100

Total unadjusted and adjusted volume differ due to rounding.

[a] The amount of board-foot volume was calculated for all sawtimber-size, growing-stock trees. One board foot is equivalent to a board 1-foot square by 1-inch thick. FIA used the International ¼-inch rule to determine board-foot volume.

[b] Adjusted volume from Zarnoch and Turner (2005).

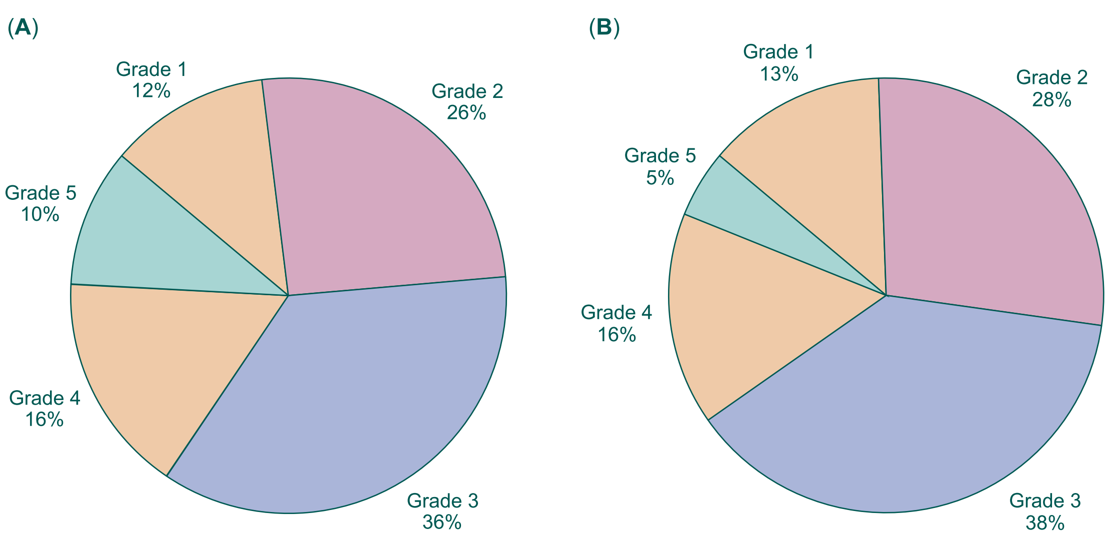


Figure 10—(A) Percentage of 1988 hardwood sawtimber board-foot volume on timberland by tree grade; and (B) percentage of 2004 hardwood sawtimber board-foot volume on timberland by tree grade.

Net Annual Growth, Removals, and Mortality on Timberland

Gross growth of wood volume is the amount of wood that grew onto the inventory since the last survey. Mortality is the amount of wood volume that died due to natural causes, by means other than human activity, over this same period. Net growth is gross growth minus mortality. Positive net growth indicates that more wood grew on timberland than was lost to mortality. At times, negative net growth is estimated and indicates that the volume lost to mortality between inventories was greater than any growth achieved during that same period. Removals volume is wood volume that is removed by human activities such as tree harvesting or other forest management practices, plus the volume of wood on forested areas that were converted to nonforest uses such as land clearing or urbanization.

Average annual rates of net growth, removals, and mortality on Kentucky's timberland were calculated for the years since the previous inventory. Data from the remeasurement of P2 plots established in 1988 were used to calculate these rates of change for all live, growing-stock, and sawtimber volume on timberland (see "Inventory Methods" section in the appendix for detailed explanation). Growth, removals, and mortality were not estimated for reserved and other forest land. Annual rates of change for all live volume and growing-stock volume did not differ greatly. Therefore, discussion in this bulletin focuses on rates of change rates for volume of growing-stock and sawtimber on timberland.

Growth, removals, and mortality for timberland are detailed in tables A.17 through A.29. Gross growth of growing-stock volume on timberland averaged 652.7 million cubic feet annually from 1989 to 2004, a 38-percent increase since the period 1976 to 1988 (fig. 11). Mortality averaged 182.7 million cubic feet, more than double the 88.6 million cubic feet of mortality reported in the previous survey. As a result, the net growth rate averaged 470.0 million cubic feet annually between 1988 and 2004. It is noteworthy that in spite of the increased mortality, the current net growth rate is 23 percent greater than that reported in 1988. More than 98 percent of the total net annual growth was on land that was timberland in 1988 and was still timberland at remeasurement. The remaining 2 percent (8.1 million cubic feet) of net annual growth was on land that was previously nonforest but has reverted to timberland since 1988.

Timber removals averaged an estimated 311.8 million cubic feet per year during the most recent survey period. Although this is a 72-percent increase over the 181.0 million cubic feet of removals reported in 1988, this presents little cause for concern. The latest removals rate is about 66 percent of the average net annual growth of growing-stock volume on Kentucky's timberland. That is, on average each year it is estimated that an additional 158.2 million cubic feet annually in volume is added to Kentucky's growing-stock inventory on timberland (fig. 11).

The latest removals rate is about 66 percent of the average net annual growth of growing-stock volume on Kentucky's timberland. That is, on average each year it is estimated that an additional 158.2 million cubic feet annually in volume is added to Kentucky's growing-stock inventory on timberland.

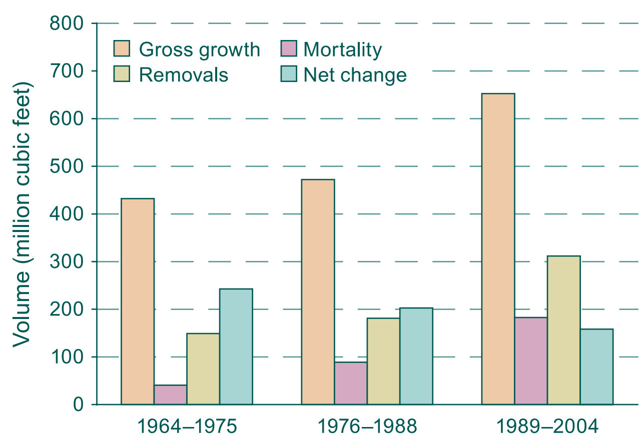


Figure 11—Average annual gross growth, removals, mortality, and net change of growing-stock trees on timberland, Kentucky, 1964 to 2004.

As mentioned previously, removals can arise from two sources: (1) timber management activities and (2) land use change. Land use change is an important land management issue because of its potential effect on the future availability of forest resources. This is particularly true of conversion to an urban use, which typically results in a permanent loss of forest land from the timber base. An estimate of removals volume attributed to land use change is one way of quantifying this loss.

During the most recent survey, conversion of timberland to nonforest land uses accounted for an estimated 68.2 million cubic feet of the annual growing-stock removals. Conversion to agriculture and urban development accounted for nearly equal shares of annual removals volume on land converted from timberland to nonforest uses, of which 87 percent (59.2 million cubic feet annually) was on timberland owned by private individuals in 1988. The removals volume attributed to land use change was 22 percent of Kentucky's total growing-stock removals, and was more than eight times the volume gained through reversion of land from nonforest to timberland. It appears that conversions from forest to nonforest contribute considerably to the amount of volume in annual removals and far outpace any reversions to a forested condition.

In the wildland-urban interface, an area undergoing slow development may see a gradual shift from rural to developed uses; an area undergoing rapid development may see a sudden conversion, with little or no intermediate shift in uses. (photo by Hans Riekerk)

Removals volume, in the case of land use change, can include live trees physically cut and removed from the site as well as live trees that are left standing on the acreage that is converted to a nonforest use. For the 2004 survey of Kentucky, the majority of the removals volume that resulted from land use change is a result of tree harvesting. However, one-quarter of that volume (17.3 million cubic feet annually) was in trees that were left standing after the land use change to a nonforest condition.

Net change in inventory volume is calculated by subtracting removals volume from net growth. If the net change is positive, then wood is being added to the inventory. Such is the case for Kentucky according to the 2004 survey results. Net change in growing-stock volume on Kentucky's timberland averaged 158.2 million cubic feet each year since the previous survey. While that is a substantial annual increase in volume, it is a 22-percent decline from the 202.5 million cubic feet of annual gain in inventory reported in the 1988 survey.

A useful indicator of the status and condition of the timber resource is the net annual growth-to-removals ratio. A ratio >1 indicates that more wood is being added to the inventory than is being removed, which is a desirable and sustainable condition with regard to timber resource management. Conversely, if the growth-to-removals ratio is <1, then the amount of wood being removed by human activity exceeds growth. While this is a less desirable situation, historically it has been short-lived, and becomes a concern only if it becomes a long-term continuing condition. Occasionally, this can occur due to large-scale natural events such as fire, hurricanes, and/or insect and disease epidemics.

The current growth-to-removals ratio for growing-stock volume on timberland is 1.5 (470.0 million cubic feet of growth to 311.8 million cubic feet of removals volume) (tables A.18 and A.21). This means that since 1988, Kentucky's timberland grew 1.5 cubic feet of growing-stock volume for every cubic foot of growing stock removed by timber harvesting or land use change. That is a 29-percent decline from the estimated 2:1 growth-to-removals ratio for growing-stock volume on timberland for the period between 1975 and 1988.

Gross growth of sawtimber volume on timberland averaged 2.7 billion board feet annually since the previous inventory. This is a 54-percent increase over the estimated 1.7 billion board feet of annual gross growth for the period 1974 to 1987. Annual mortality averaged 0.5 billion board feet during 1988 to 2003, more than double the annual sawtimber mortality rate of 0.2 billion board feet for 1974 to 1987. Subtracting current mortality from gross growth results in a net annual growth rate of 2.2 billion board feet as of 2004, a 43-percent increase over the 1988 estimate of 1.5 billion board feet.

Sawtimber removals averaged 1.2 billion board feet each year since the previous inventory. While that is twice as much as the 0.6 billion board feet reported in 1988, it is <2 percent of the entire 2004 sawtimber inventory (60.4 billion board feet). Similarly, average annual removals of growing stock account for <2 percent of the total growing-stock inventory in 2004 (fig. 12). After removals volume is accounted for, the average annual net gain of sawtimber volume on Kentucky's timberland was approximately 1.0 billion board feet as of 2004. This is a 9-percent increase over the average annual net change in sawtimber volume reported for 1974 to 1987.

Sawtimber removals averaged 1.2 billion board feet each year since the previous inventory. While that is twice as much as the 0.6 billion board feet reported in 1988, it is < 2 percent of the entire 2004 sawtimber inventory (60.4 billion board feet).

The current growth-to-removals ratio for sawtimber volume on timberland is 1.8 (2.2 billion board feet of growth to 1.2 billion board feet of removals volume), meaning that nearly 2 board feet of sawtimber grew on timberland for each board foot of sawtimber volume removed. The growth-to-removals ratio for sawtimber volume on timberland has declined from the estimated 2.6 reported for 1974 to 1987. In addition, average annual sawtimber removals from timberland represent about 1.9 percent of the total sawtimber inventory on timberland in Kentucky.

The growth-to-removals rates for individual species generally reflected the overall positive growth rate for Kentucky as a whole, with a range of variation among species. Virginia pine was the only major

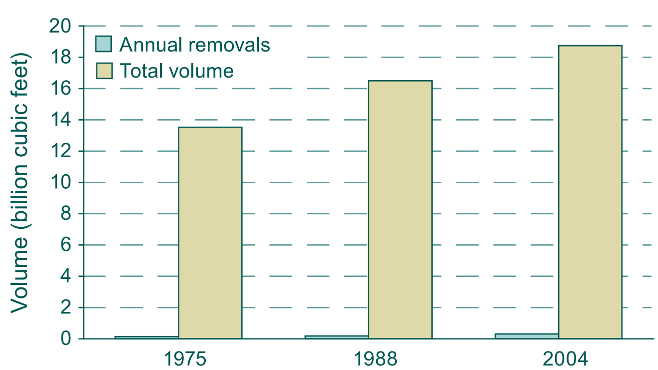


Figure 12—Average annual removals of growing stock vs. total growing-stock volume on timberland, Kentucky, 1975, 1988, and 2004.

species for which growth was significantly lower than removals, with a calculated growth-to-removals ratio of 0.3. This excess of removals over growth was primarily due to relatively high mortality attributable to the southern pine beetle outbreak that occurred across the Southern region between 2000 and 2001. The net growth-to-removals ratios for the most abundant species, in terms of growing-stock volume on timberland, are listed in table 9.

The growth-to-removals ratio for sawtimber on Kentucky timberland has fluctuated between 1.6 and 2.7 between 1949 and 2004 (fig. 13). The estimated growth-to-removals ratio was largest for the 1963 inventory and smallest for the 1949 inventory. This is consistent with the finding that a large portion of Kentucky's present-day timberland was regenerated around the late 1940s. The percentage of the total inventory removed annually has increased slightly since the 1988 estimate. However, for the majority of the last 50 years of the FIA survey, the percentage of Kentucky's total sawtimber inventory that was removed has been declining. This trend corresponds to the significant increase in the standing inventory of sawtimber volume since 1949.

Table 9—Growth-to-removals ratio of growing stock by species

Species	Growth-to-removals ratio of growing stock
Yellow-poplar	1.8
White oak	1.5
Chestnut oak	1.8
Sugar maple	1.7
Pignut hickory	3.3
Red maple	2.5
Black oak	0.9
Northern red oak	1.1
Scarlet oak	1.3
American beech	1.4
White ash	1.6
Mockernut hickory	2.6
Virginia pine	0.3
Sycamore	1.6
Green ash	3.6
Shagbark hickory	3.4
Sweetgum	2.8
Blackgum	3.8
Chinkapin oak	2.1
Eastern redcedar	1.0
Bitternut hickory	6.4
American basswood	2.6
Southern red oak	1.1
Post oak	0.8
Shortleaf pine	2.0
Black walnut	1.1
Black cherry	0.8
Eastern hemlock	4.8

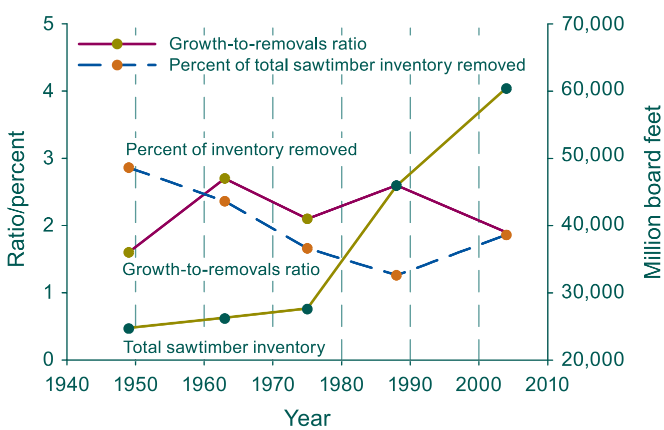


Figure 13—Growth-to-removals ratio, percent of total sawtimber inventory removed, and total inventory of sawtimber on Kentucky timberland, 1949 to 2004.

Influences of a Growing Population

For any parcel of forest land, numerous factors influence forest-related values and certain criteria must be considered before investments are made in commercial forestry. High or increasing forest population density (FPD) can indicate areas where increased population may critically affect decisions about forest resource use and forest management.

FPD at the county level is defined as the number of people in the county divided by the county's area of forest land in square miles (Wear 2002). The resulting FPD, in people per square mile (ppsm) of forest land, provides an index that may be used to assess the relative availability of forest benefits to the residents in each county. Low FPD identifies counties that are considered more rural and where forest amenities are more readily available and easily accessed. As a county's FPD increases the county transitions from rural to urban, a shift that generally results in increased pressures on available forest resources while decreasing the diversity of forest benefits.

More importantly perhaps, threshold FPD values can be identified to help determine the likelihood that commercial forestry will be practiced in a given area of forest. For instance, Wear (2002) found that at an FPD of 20 ppsm there is a 75 percent chance that commercial forestry would be practiced (Wear and others 1999). At just 45 ppsm, there is only a 50-percent chance that forest management is likely to occur. The probability of forest management approaches zero at an FPD of 150 ppsm. These threshold FPD values were used at the county level to identify areas in Kentucky where human influences may affect forest land management activities or rates of land use change. At this scale, the FPD functions as a general indicator of potential effects of changes in population, but does not necessarily represent every forest acre in the county.

The results of a growing population. (photo by Larry Kohrnak)

The 1988 and 2004 FPD estimates for Kentucky counties are shown in figures 14 and 15. The 1988 FPD values in figure 14 were derived by dividing the county population estimates from the 1980 census (U.S. Bureau of the Census 2002) by the county forest land estimates taken from the 1988 FIA survey report (Alerich 1990). The 2004 values in figure 15 are based on the 2000 census (U.S. Bureau of the Census 2002) county population estimates divided by the forest land area as estimated by the 2004 survey of Kentucky. Wear considered an FPD of 1,000 ppsm of forest an indication of a "saturated" condition (Wear 2002), and, therefore, limited the FPD estimates to that maximum value. That cap on FPD was used here, as well.

The 1988 FPD index values for Kentucky counties ranged from a rural condition with as few as 29 ppsm (Menifee County) to the maximum 1,000 in 4 sparsely forested, densely urbanized counties (Campbell, Fayette, Jefferson, and Kenton) (fig. 14). Expectedly, the counties with high FPD values were near urban centers. Just 19 (16 percent) of Kentucky's 120 counties could be considered rural in character in 1988 (having 50 or fewer ppsm of forest land). Most of the rural counties were in

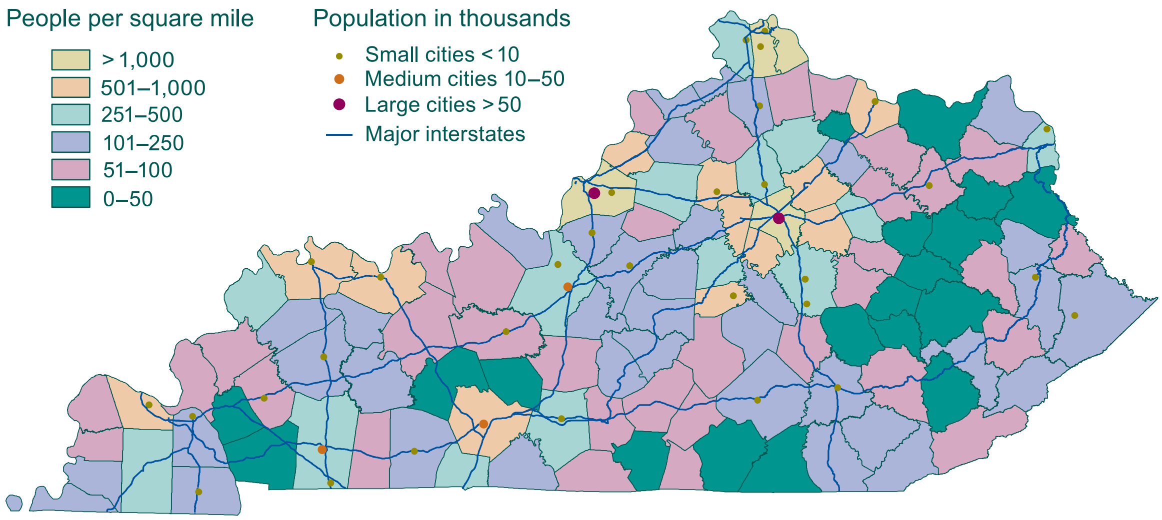


Figure 14—Forest population density, Kentucky, 1988.

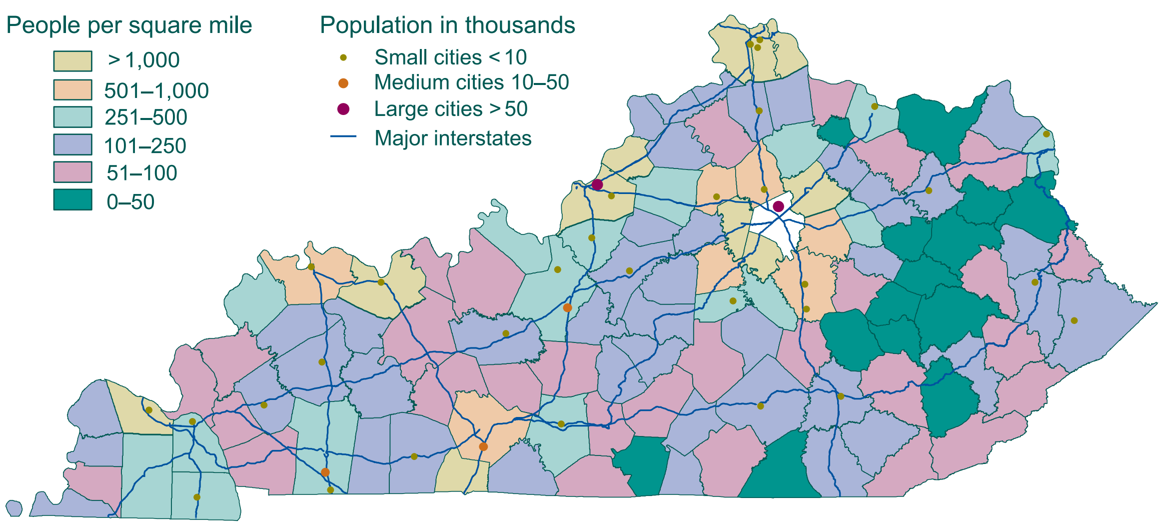


Figure 15—Forest population density, Kentucky, 2004.

the heavily forested eastern third of the Commonwealth. A total of 68 counties had an FPD of 100 or more, including the 4 with the maximum value. As noted above, research has shown that the probability for long-term forest management decreases as FPD decreases to 150 ppsm. Although most people would still classify most of Kentucky as rural in nature, the Commonwealth's increasing population will continue to influence forest resources.

Kentucky, like most Southern States, has experienced a general increase in population since 1980. This increase is reflected in the change in FPD as the number of ppsm of forest land has increased for nearly all counties. The minimum county FPD increased to 32 ppsm of forest (Owsley County). The number of counties averaging 50 or fewer ppsm of forest declined to 14, while counties with an FPD of 100 ppsm or more increased to 78 (fig. 15). As of 2004, 12 counties averaged at least 1,000 ppsm of forest land. Of those 12 counties, only Campbell, Kenton, and Boone remained at least 30 percent forested in 2004. The statewide average FPD for 2004 had increased to 216 ppsm, as Kentucky's population rose to more than 4.0 million and total forest land declined to 18,704 square miles.

Tracking influences of population change on forest-related benefits can be particularly important in those heavily forested counties relied on for a large portion of Kentucky's timber production. As of 2004, 43 of Kentucky's counties were at least 50 percent forested, and the majority of these were in the eastern third of the Commonwealth (fig. 1). Because of the high proportion of forest land in these counties, the recent increase in population had less effect on FPD. However, FPDs in many of these counties are approaching the thresholds used by Wear to help determine the potential for forest management activity. Thirty-one counties have an FPD of <100 ppsm, but only 10 of these counties have FPDs of 45 ppsm or less, the threshold where the odds of commercial forest activity approach 50:50. The remaining 12 counties have a FPD >100 ppsm, but only Boyd, Bullitt, and Laurel Counties had FPDs >150 ppsm, the threshold where long-term forest management is unlikely to occur.

At present, the potential for forest-related benefits and forest management activities in most of Kentucky's counties remains relatively high. As population levels increase, however, forest benefits become scarce and the potential for commercial forest activity declines. Monitoring future changes in FPD values can help identify areas where forest management activities may be limited as counties transition from rural to urban.

At present, the potential for forest-related benefits and forest management activities in most of Kentucky's counties remains relatively high. As population levels increase, however, forest benefits become scarce and the potential for commercial forest activity declines.

Population and Future Land Use Change

Changes in population not only affect the availability of forest benefits but also can have a major influence on land use change. More people typically results in an increase in urbanization and a decline in rural land uses. Factors influencing the distribution of land between rural and urban uses include population density, personal income, and housing values (Wear 2002). The distribution of rural land between agricultural and forest uses is determined by factors such as agricultural costs, land quality, and timber prices. Using these and other factors in an econometric model, Wear (2002) forecasts change in the allocation of land among forest, urban, and agricultural uses for Southern States from 1992 to 2020. The results for Kentucky are shown in figures 16, 17, and 18.

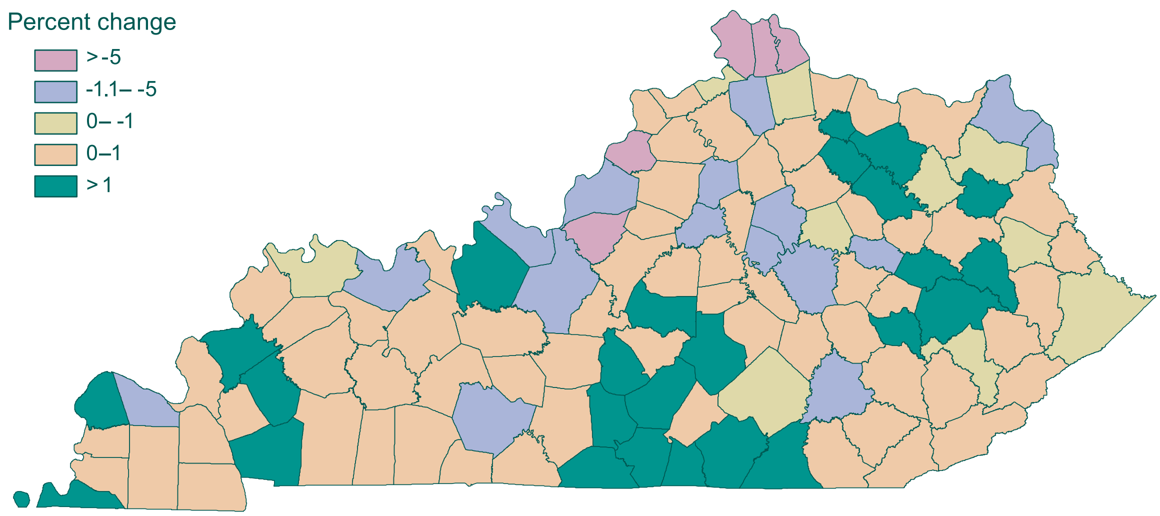


Figure 16—Predicted percent change in forest land, Kentucky, 1992 to 2020.

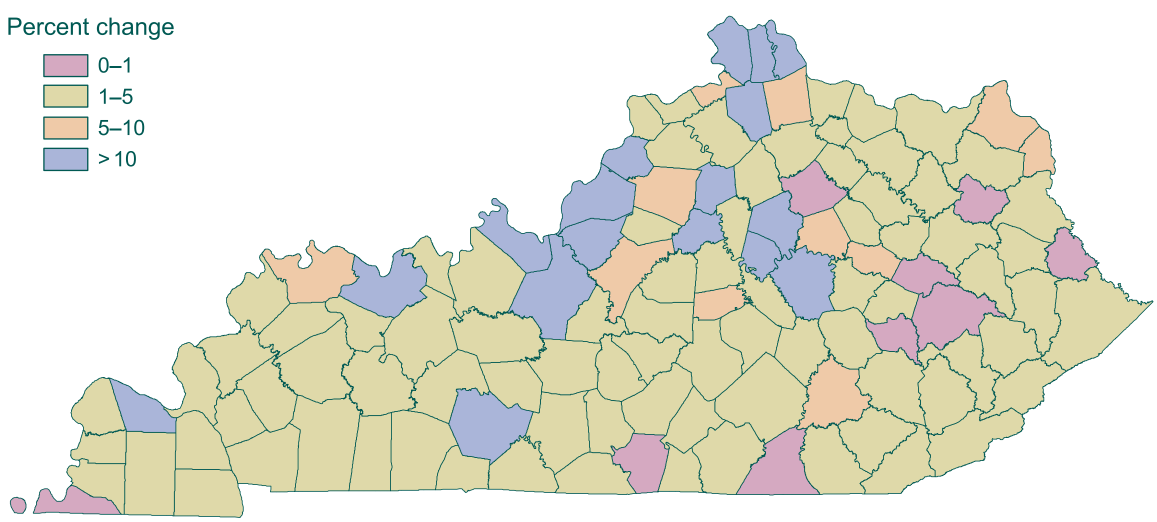


Figure 17—Predicted percent change in urban land, Kentucky, 1992 to 2020.

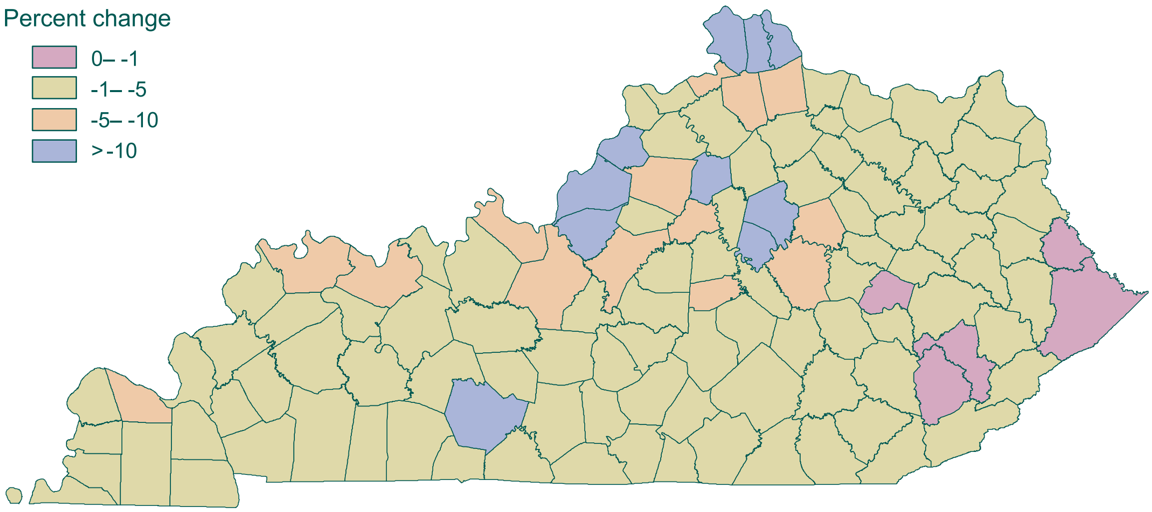


Figure 18—Predicted percent change in agriculture land, Kentucky, 1992 to 2020.

Forest land is not forecast to increase by more than 2 percent by 2020 in any Kentucky county (fig. 16). About one-fourth (31 counties) are forecast to lose forest area, with losses mostly falling in the 1 to 5 percent range (fig. 16). The few counties projected to lose > 5 percent of their forest land (Boone, Bullitt, Campbell, Kenton, and Oldham) are close to existing major urban centers. Moreover, these counties had a small percentage of their land area in forest land to begin with, so small absolute declines can lead to large percentage changes. In real terms, the actual loss is likely to be minimal relative to total forest area for the Commonwealth.

Figure 17 shows the projected change in urban land use in Kentucky counties. All counties are predicted to have greater urban land use by 2020, although most are forecast to see increases of 5 percent or less in urbanized area. The greater increases (>10 percent) in urban land use are forecast for 17 Kentucky counties that already contain or are near large urban centers, including those in adjacent States.

When forest and/or urban land use within a county increases it usually does so at the expense of agricultural land use. All counties in Kentucky are forecast to lose agricultural land by 2020 (fig. 18). Urban land use is predicted to increase in every county, and urbanization rather than conversion to forest will probably account for most of the predicted decline in the State's agricultural land area. The range of loss is expected to be similar to that for forest land; most counties will lose from 1 to 5 percent of their agricultural land base. Those counties forecast to lose >10 percent of their agricultural land are near expanding population centers.

The Owners of Kentucky's Forest Land and Timberland

FIA collects information about who owns the forested land in each State or Commonwealth. Ownership information is collected in two ways. First, field crews collect ownership information on each forested P2 ground plot from publicly available data at local county offices. This ownership information is used to display area, density, and volume estimates by ownership classes such as nonindustrial private forest (NIPF) landowners or various public entities like the Forest Service. In addition, information is collected on land ownership by forest industry, defined as forest landowners who also own a wood-processing facility. Secondly, the nonindustrial private landowners are sent a survey, known as the National Woodland Owner Survey (NWOS) that requests more detailed information about their objectives as owners of forest land.

Note: Federal law requires that private ownership information for FIA plots shall not be made available for public distribution. For this reason, ownership information is presented only as summaries across broad ownership classes and broad spatial scales.

Private individuals own 78 percent of the timberland in Kentucky (fig. 19). Nine percent is publicly administered

Multiple use property, common in Kentucky. (photo by Christopher M. Oswalt)

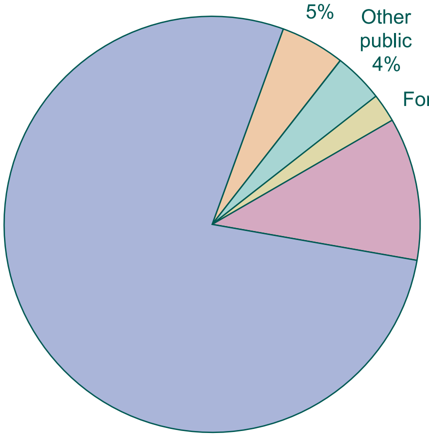


Figure 19—Ownership of timberland, Kentucky, 2004.

Private individuals own 78 percent of the timberland in Kentucky. Nine percent is publicly administered by local, Commonwealth, or Federal agencies. Forest industry owns about 2 percent of the timberland and other corporations own the remaining 11 percent.

by local, Commonwealth, or Federal agencies. Slightly more than one-half of the public timberland is managed by the Forest Service. Forest industry owns about 2 percent of the timberland and other corporations own the remaining 11 percent (fig. 19).

About 76 percent of the timberland owned and administered by the Forest Service is within the Northern and Southern Cumberland survey units and makes up the Daniel Boone National Forest. Other ownership patterns are similar across all survey units and mimic the overall averages for Kentucky as a whole (table 10).

Timberland owned and administered by the Daniel Boone National Forest, which is the only national forest in Kentucky, is in only five forest-type groups: (1) white-red-jack pine, (2) loblolly-shortleaf pine, (3) oak-pine, (4) oak-hickory, and (5) maple-

Table 10—Area of timberland by survey unit and ownership class, Kentucky, 2004

		Ownership class			
Survey unit	All classes	National forest	Other public	Forest industry	Nonindustrial private
	thousand acres				
Eastern	1,794.6	71.3	39.5	24.6	1,659.2
Northern Cumberland	1,884.6	127.3	83.8	56.5	1,616.9
Southern Cumberland	2,063.2	319.5	43.8	49.3	1,650.6
Bluegrass	1,550.5	16.8	36.8	15.9	1,481.0
Pennyroyal	2,041.6	23.8	75.4	52.5	1,890.0
Western Coalfield	1,644.5	—	77.9	23.0	1,543.7
Western	668.9	31.5	82.7	57.0	497.7
Total	11,647.9	590.3	439.7	278.8	10,339.1

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell.

Table 11—Area of timberland by forest-type group and ownership class, Kentucky, 2004

Forest-type group	All classes	Ownership class: National forest	Other public	Forest industry	Nonindustrial private
	thousand acres				
White-red-jack pine	156.8	32.7	3.5	—	120.7
Loblolly-shortleaf pine	244.2	13.5	1.7	2.3	226.7
Pinyon-juniper	170.3	—	9.8	—	160.5
Oak-pine	1,078.7	46.5	60.0	12.5	959.7
Oak-hickory	8,436.3	481.4	292.4	216.9	7,445.7
Oak-gum-cypress	80.0	—	14.4	17.3	48.2
Elm-ash-cottonwood	645.4	—	38.2	5.6	601.6
Maple-beech-birch	769.3	16.3	15.1	24.1	713.8
Aspen-birch	4.1	—	—	—	4.1
Nonstocked	62.8	—	4.6	—	58.2
Total	11,647.9	590.3	439.7	278.8	10,339.1

Numbers in rows and columns may not sum due to rounding.
— = no sample for the cell.

beech-birch (table 11). The majority of the national forest timberland is in the oak-hickory forest-type group. NIPF timberland forests represent nine different forest-type groups.

A large percentage of Kentucky's timberland area is occupied by stands >41 to 50 years of age (see "Stand Age" section). The majority of the timberland in stands >100 years of age is located on NIPF owned land (table 12). FIA estimates that forest industry currently has the greatest percentage (38 percent) of timberland in the younger (<40 years) age classes. The national forest has the lowest percentage of timberland in the younger age classes (18 percent), perhaps because timber harvesting on national forests in the South has been reduced over the last decade.

Table 12—Area of timberland by stand-age class and ownership class, Kentucky, 2004

Stand-age class	All classes	Ownership class: National forest	Other public	Forest industry	Nonindustrial private
	thousand acres				
0–10	534.8	16.9	10.9	31.5	475.5
11–20	447.5	30.1	21.4	11.9	384.1
21–30	867.6	20.6	26.6	34.6	785.8
31–40	1,818.4	37.4	37.2	28.0	1,715.8
41–50	2,421.1	97.7	43.0	20.0	2,260.4
51–60	2,280.1	80.5	117.2	66.9	2,015.6
61–70	1,731.3	144.7	71.2	13.8	1,501.5
71–80	858.5	79.6	61.7	39.6	677.6
81–90	394.3	35.1	27.7	28.2	303.3
91–100	231.0	47.6	15.2	4.4	163.7
101–110	14.5	—	—	—	14.5
111–120	25.6	—	7.7	—	17.9
121–130	4.5	—	—	—	4.5
131–140	—	—	—	—	—
141–150	3.9	—	—	—	3.9
> 150	8.4	—	—	—	8.4
Total	11,647.9	590.3	439.7	278.8	10,339.1

Numbers in rows and columns may not sum to totals due to rounding.
No stand age was given for 6.44 thousand acres of timberland.
— = no sample for the cell.

Young mixed hardwood forest. (photo courtesy of Kentucky Department of Forestry)

Landowner Characteristics and Possible Influences on Kentucky Forests

The National Woodland Owner Survey

The majority of Kentucky's forest land is in private hands. Data from the latest NWOS (Butler and others 2005) suggest that there are about 423,000 private forest landowners in Kentucky (table 13) and that privately owned forest land area totals approximately 9.1 million acres or 76 percent of the forest land in the Commonwealth. The likelihood that a given tract of private forest land is managed depends on many factors, including the number of acres owned and the reasons for owning the land. (It should be noted that estimates based on the NWOS can vary slightly from those based on data from the FIA P2 plots due to definitional, methodological, and analytical differences between the two programs. When the results from both programs are viewed in tandem, as here, a clearer picture of forest ownership within Kentucky can emerge. However, readers must bear in mind that the number of survey respondents is relatively small in the case of the NWOS in Kentucky and that this can affect the accuracy of estimates based on NWOS data.)

Parcel Size Influences Harvesting Decisions

Most private forest landowners in Kentucky have relatively small holdings. In fact, we estimate that 90 percent of the family-owned forest land in Kentucky is estimated to be in parcels of < 500 acres (table 13). As a rule, harvesting costs per unit area increase as the size of landholdings declines. Large landholdings (5,000+ acres) can reasonably be assumed to be available for timber harvesting, but only 27,000 acres of Kentucky's 9.1 million acres of private forest land fall in this size category. Opportunities to conduct commercial forestry activities are generally considered not to exist where the size of forested parcels is below a given size threshold. In the case of Kentucky, the approximately 702,000 acres of family-owned forest in parcels smaller than 10 acres is assumed to be unavailable for sustained timber production.

Landowner Values and Attitudes: Reasons for Owning Forest Land

The widely varied values and attitudes of family forest landowners are reflected in the reasons they give for owning forest land. A plurality of landowners (243,000) selected the production of NTFPs as their most important reason for owning forest land (table 14). Other commonly selected reasons were aesthetics (221,000 landowners), privacy (209,000), and nature protection (176,000) (table 14). Land investment was ranked high (125,000 family forest landowners representing 4.1 million acres) (table 14). Timber production seemingly took a backseat in importance,

Table 13—Area and number of family-owned forests in Kentucky by size of forest landholdings, 2004, according to respondents to the National Woodland Owner Survey

	Area			Ownerships			
Size of forest landholdings	Acres	Standard error	Percent	Number	Standard error	Percent	Survey respondents
acres	*- - - thousand - - -*			*- - - thousand - - -*			*count*
1–9	702	140	7.7	263	66	62.3	26
10–49	2,241	218	24.7	107	12	25.3	83
50–99	2,052	212	22.6	32	3	7.6	76
100–499	3,159	240	34.8	19	2	4.5	117
500–999	513	123	5.7	1	< 1	0.2	19
1,000–4,999	378	109	4.2	< 1	< 1	< 0.1	14
5,000+	27	52	0.3	< 1	< 1	< 0.1	1
Total	9,073	45	100.0	423	65	100.0	336

Table 14—Area and number of family-owned forests in Kentucky by reason for owning forest land, 2004, according to respondents to the National Woodland Owner Survey. Numbers include landowners who ranked each objective as (1) very important or (2) important on a seven-point Likert scale

	Area			Ownerships			
Reason [a]	Acres	Standard error	Percent	Number	Standard error	Percent	Survey respondents
	- - - thousand - - -			*- - - thousand - - -*			*count*
Aesthetics	5,914	240	65.2	221	43	52.2	219
Nature protection	4,861	251	53.6	176	34	41.6	180
Land investment	4,051	250	44.6	125	30	29.6	150
Part of farm, home, or cabin [b]	3,646	247	40.2	150	42	35.5	135
Privacy	4,883	298	53.8	209	62	49.4	127
Family legacy	5,023	250	55.4	157	31	37.1	186
Nontimber forest products	5,860	241	64.6	243	45	57.4	217
Firewood production	1,134	170	12.5	64	29	15.1	42
Timber production	1,404	185	15.5	122	43	28.8	52
Hunting or fishing	2,187	217	24.1	39	10	9.2	81
Other recreation	3,808	249	42.0	125	33	29.6	141
No answer	2,808	233	30.9	158	49	37.4	104

[a] Categories are not exclusive.
[b] Includes primary and secondary residences.

although 122,000 owners with 1.4 million acres did indicate that this was an important reason for forest land ownership. However, these categories are not exclusive, so those who list aesthetics as their most important reason for ownership are not necessarily averse to timber harvesting. In fact, many owners list timber harvest or other forestry activity as a recent event on their land.

Recent Forestry Activity: Timber Harvest and Recreation Are Prominent

According to the NWOS, timber harvest occurred on nearly 5.7 million acres of Kentucky's family forest land, with almost 3.0 million acres harvested within the past 5 years (tables 15 and 16). These acreages are estimated to be on about 170,000 and 84,000 different ownerships, respectively. Other activities related to timber management occurring in the past 5 years include tree planting by an estimated 24,000 ownerships, and the application of chemicals by 38,000 ownerships. Recent efforts to reduce fire hazards occurred on about 837,000 acres. Private recreation was another major forestry activity. Some 135,000 family forest owners with 4.7 million acres listed this as an activity occurring in the past 5 years on their forest land. Public recreation occurred on 1.2 million acres of family-owned forest land.

Table 15—Area and number of family-owned forests in Kentucky by recent (past 5 years) forestry activity, 2004, according to respondents to the National Woodland Owner Survey

	Area			Ownerships			
Activity [a]	Acres	Standard error	Percent	Number	Standard error	Percent	Survey respondents
	- - - thousand - - -			*- - - thousand - - -*			*count*
Timber harvest	2,950	277	32.5	84	19	19.9	79
Collection of NTFPs	1,531	223	16.9	86	39	20.3	41
Site preparation	189	84	2.1	8	7	1.9	7
Tree planting	891	154	9.8	24	9	5.7	33
Fire hazard reduction	837	150	9.2	53	28	12.5	31
Application of chemicals	486	120	5.4	38	27	9.0	18
Road/trail maintenance	2,349	222	25.9	59	27	13.9	87
Wildlife habitat improvement	1,323	181	14.6	46	27	10.9	49
Posting land	3,076	284	33.9	43	10	10.2	80
Private recreation	4,729	299	52.1	135	41	31.9	123
Public recreation	1,153	202	12.7	14	4	3.3	30
Cost share	135	75	1.5	1	1	0.2	5
Conservation easement [b]	81	47	0.9	2	1	0.5	3
Green certification [b]	162	79	1.8	3	3	0.7	6

NTFPs = nontimber forest products.
[a] Categories are not exclusive.
[b] Not limited to past 5 years.

Table 16—Number of family-owned forests along with associated area in Kentucky by reported timber harvesting activities, 2004, according to respondents to the National Woodland Owner Survey

	Area			Ownerships			
Activity	Acres	Standard error	Percent	Number	Standard error	Percent	Survey respondents
	- - - thousand - - -			*- - - thousand - - -*			*count*
Timber harvest							
Yes	5,698	244	62.8	170	33	40.2	211
No	3,213	241	35.4	216	52	51.1	119
No answer	162	79	1.8	36	28	8.5	6
Products harvested [a]							
Saw logs	4,078	251	44.9	100	29	23.6	151
Pulpwood	729	142	8.0	14	7	3.3	27
Firewood	1,836	204	20.2	40	9	9.5	68
Other	1,647	196	18.2	38	12	9.0	61
Received professional consultation	1,161	171	12.8	19	5	4.5	43
Recent harvest (within 5 years)	2,950	277	32.5	84	19	19.9	79

[a] Categories are not exclusive.

Few Landowners Develop a Management Plan or Seek Professional Advice

The reasons family forest landowners have for owning forest land may also influence these landowners' decision about whether to develop a management plan or seek advice in managing their land for timber production, or other forest-related amenities. Only 1 percent of the 423,000 private landowners have a written management plan to help guide their land use decisions (table 17). These owners control about 7 percent or 675,000 acres of Kentucky's 9.1 million acres of family-owned forest land (table 17). Although few have a written plan, some 49,000 family forest landowners (12 percent) at least sought advice about managing their land. Of those, nearly one-half (24,000) consulted with experts from Commonwealth forestry agencies or other State agencies such as extension services, or from a Federal agency. Twenty-eight thousand family forest owners sought advice from other landowners.

These findings indicate that Kentucky's forestry community should encourage more forest landowners to take advantage of professional forest management expertise. Professional opinion is that the best forest management occurs when landowners develop a written plan based on the appropriate scientific and technical expertise that only a forestry professional can provide. It has been demonstrated that the advantages of professionally guided forest land management include producing timber in greater quantity and of higher quality, improvement in wildlife habitat and environmental quality, and improved benefits from other forest related resources [Kentucky Legislative Research Commission (LRC) 2003]. The LRC study proposed ways to foster active forest management through lower tax burdens, increased awareness of existing financial assistance opportunities such as the Forest Stewardship Program, and other incentives.

Table 17—Area and number of family-owned forests in Kentucky by management plan, advice sought, and advice source, 2004, according to respondents to the National Woodland Owner Survey

	Area			Ownerships			
Activity	Acres	Standard error	Percent	Number	Standard error	Percent	Survey respondents
	- - - thousand - - -			*- - - thousand - - -*			*count*
Written management plan							
Yes	675	137	7.4	6	2	1.4	25
No	7,966	168	87.8	380	60	89.8	295
No answer	432	115	4.8	36	27	8.5	16
Sought advice							
Yes	1,539	191	17.0	49	28	11.6	57
No	7,372	199	81.3	343	54	81.1	273
No answer	162	79	1.8	31	27	7.3	6
Advice source [a]							
State forestry agency	1,053	165	11.6	14	4	3.3	39
Extension	270	95	3.0	5	3	1.2	10
Other State agency	81	64	0.9	1	1	0.2	3
Federal agency	243	92	2.7	4	2	0.9	9
Private consultant	297	99	3.3	4	3	0.9	11
Forest industry forester	27	52	0.3	0	0	0.0	1
Logger	351	105	3.9	2	1	0.5	13
Other landowner	162	79	1.8	28	27	6.6	6

[a] Categories are not exclusive.

Timber Products and the Economy

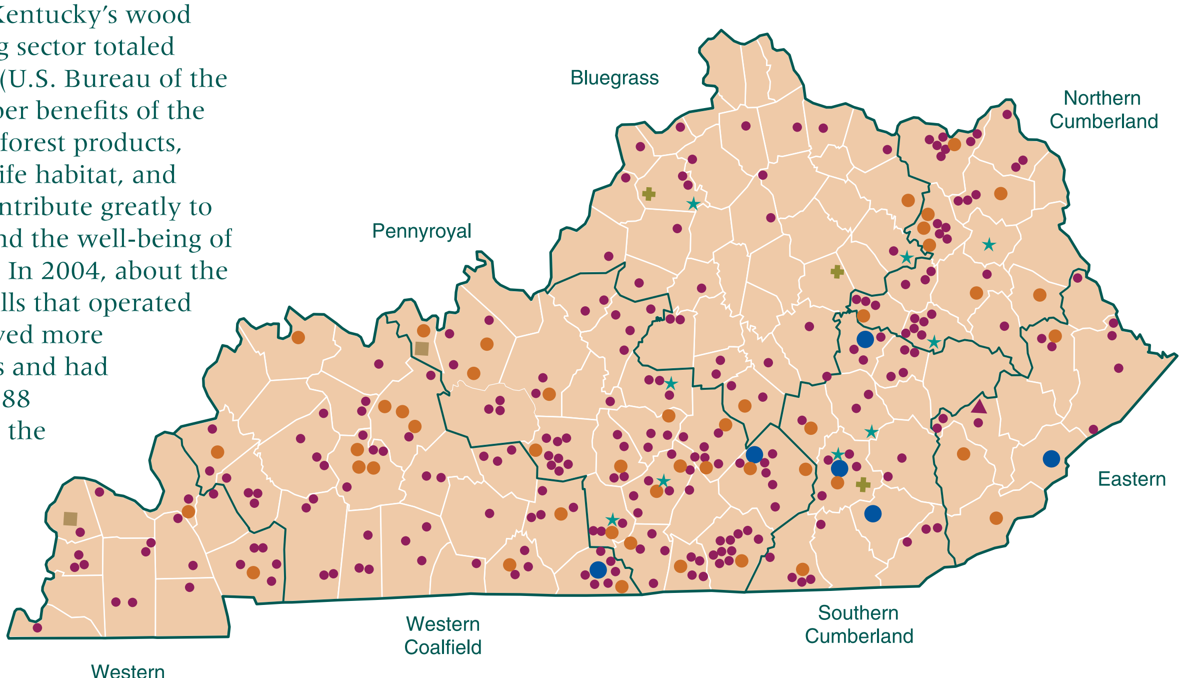
Kentucky's forests are a major asset and are critical to the economic, social, and ecological well-being of the Commonwealth. Kentucky's forest products industry is an important component of the Commonwealth's economy. According to IMpact Analysis for PLANning (Abt 2002), a model generated by the Forest Service, the total economic importance of Kentucky's forests is nearly $8.7 billion annually. The $8.7 billion includes all direct, indirect, and induced effects resulting from forest industry operations.

In 2003, about 297 sawmills, pulpwood mills, and other primary wood-processing plants distributed across Kentucky (fig. 20) directly employed more than 21,500 individuals, with an annual payroll of $714 million (table 18). In 2003, the value of shipments in Kentucky's wood products manufacturing sector totaled more than $5.8 billion (U.S. Bureau of the Census 2003). Nontimber benefits of the forest such as specialty forest products, recreation, water, wildlife habitat, and aesthetic values also contribute greatly to Kentucky's economy and the well-being of the general population. In 2004, about the same number of sawmills that operated in 2003 directly employed more than 22,500 individuals and had an annual payroll of $788 million (U.S. Bureau of the Census 2004). In 2004, the value of shipments in Kentucky's wood products manufacturing sector totaled more than $6.3 billion (U.S. Bureau of the Census

Table 18—Bureau of the Census statistics for forest and forest products industries in Kentucky, 1997 to 2003

Year	Employees	Payroll	Value of shipments
	number	*- - thousand dollars - -*	
2003	21,514	714,148	5,809,912
2002	22,728	737,401	5,945,086
2001	22,808	689,564	5,441,262
2000	23,257	692,033	2,707,169
1999	22,388	660,320	4,963,756
1998	22,492	620,620	4,551,676
1997	21,635	590,756	4,223,931

In 2003, about 297 sawmills, pulpwood mills, and other primary wood-processing plants distributed across Kentucky directly employed more than 21,500 individuals, with an annual payroll of $714 million.



Primary wood-producing mills

- Sawmill (0–5 mmbf)
- Sawmill (5–20 mmbf)
- Sawmill (> 20 mmbf)
- Composite panel
- Veneer
- Pulpmill
- Other mill

Figure 20—Primary wood-using mills by region, Kentucky, 2003.

2004), up 8 percent since the previous year, which represents a significant contribution to Kentucky's economy.

This section presents estimates of average annual roundwood product output and timber removals for the period 1988 through 2003. Estimates of timber product output (TPO) and plant residues were obtained from canvasses (questionnaires) sent to all primary wood-using mills in the State. The canvasses are used to determine the types and amount of roundwood, i.e. saw logs, pulpwood, poles, etc., received by each mill, the county of origin of the wood, the species used, and how the mills dispose of the bark and wood residues produced. The canvasses are conducted every 2 years by personnel from the Kentucky Division of Forestry and the Southern Research Station. These data are used to augment FIA's annual inventory of timber removals by providing the product proportions for the part of removals that is used for products. Individual studies are necessary to track trends and changes in product output levels. Total product output, averaged over the survey period, is the sum of the volume of roundwood products from all sources (growing stock and other sources) and the volume of plant byproducts, or the mill residues.

Total output of timber products, which includes domestic fuelwood and plant byproducts, averaged nearly 287 million cubic feet per year between 1988 and 2003, a 36-percent increase since the period between 1975 and 1987 (see table A.31). Roundwood products made up 74 percent of the total output and plant byproducts made up the remainder. Hardwood species accounted for 273 million cubic feet (95 percent) of total product output volume. Softwoods accounted for 14 million cubic feet (5 percent) of total product output volume.

With the exception of fuelwood, the distribution of total volume among products has changed little over the past four survey periods. Saw logs have been and remain the most important wood product produced by Kentucky's mills. Production of saw logs, which are used mainly in the manufacture of dimensional lumber, increased to 160 million cubic feet, up nearly 38 percent since 1986. Saw-log output accounted for 56 percent of the total TPO volume between 1988 and 2003, compared with 55 percent between 1975 and 1987, 54 percent between 1963 and 1974, 53 percent between 1949 and 1962, and 42 percent between 1939 and 1948 (fig. 21).

Total output of timber products, which includes domestic fuelwood and plant byproducts, averaged nearly 287 million cubic feet per year between 1988 and 2003, a 36-percent increase since the period between 1975 and 1987.

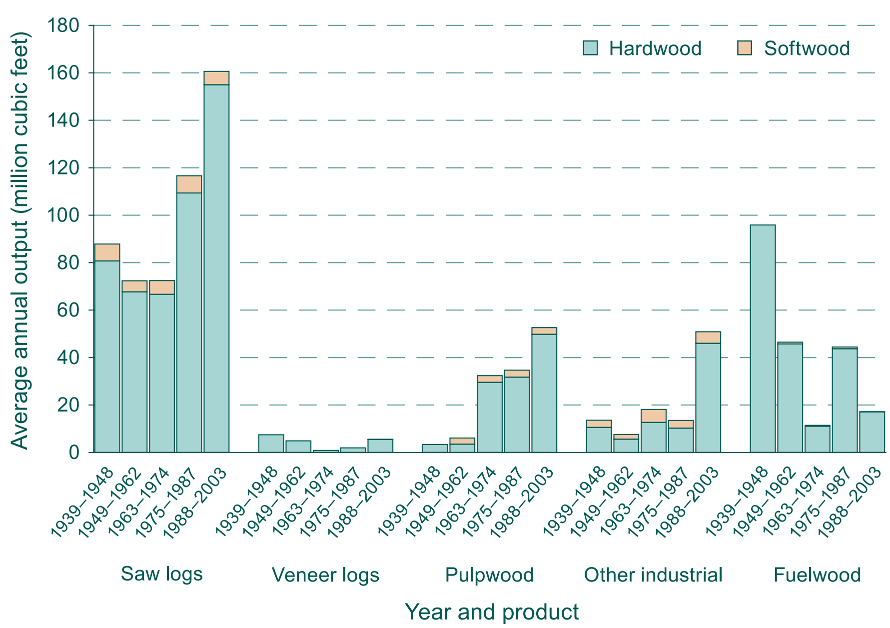


Figure 21—Average annual output of timber products by product and species group, Kentucky, 1948 to 2003.

Pulpwood production increased from 35 million cubic feet in 1986 to 53 million cubic feet. Pulpwood output increased 52 percent, and accounted for 18 percent of the total output volume, about the same proportion as during the past two survey periods. Other industrial products accounted for 45 million cubic feet, or 16 percent, of total product output. Veneer and composite panel production amounted to 6 million cubic feet each and together accounted for 4 percent of total output. Fuelwood output declined 30 percent to 17 million cubic feet, but still accounted for 6 percent of total product output.

Annual output of roundwood products (including fuelwood) averaged 214 million cubic feet between 1986 and 2003, up 32 percent since the previous survey period. Eighty-seven percent of the roundwood products volume came from growing-stock trees (table A.32). Of the roundwood products volume obtained from growing-stock trees, 89 percent came from sawtimber trees and 11 percent from poletimber trees (table A.32). The volume obtained from other sources, which include cull trees, salvable dead trees, and stumps and tops of harvested trees, was 28 million cubic feet, down from 69 million cubic feet since the previous survey period.

Total timber removals, averaged over the time period, are the sum of the volume of roundwood products, logging residues (unused portions of trees left in the woods), and other removals (removals attributed to land clearing or land use changes) from growing-stock and nongrowing-stock sources. Removals from all sources, for softwoods and hardwoods combined, totaled 413 million cubic feet (table 19). Hardwoods accounted for 93 percent of total removals. Volume used for roundwood products totaled 213 million cubic feet, or 52 percent of total removals. Logging residues and other removals amounted to 112 million cubic feet (27 percent) and 88 million cubic feet (21 percent), respectively.

Table 19—Volume of timber removals by removals class, species group, and source, Kentucky, 1988 to 2003

Removals class and species group	All sources	Source: Growing stock	Source: Nongrowing stock
	million board feet [a]		
Roundwood products			
Softwood	10.6	10.0	0.6
Hardwood	202.9	176.1	26.8
Total	213.5	186.0	27.5
Logging residues			
Softwood	4.8	1.6	3.2
Hardwood	106.9	44.4	62.5
Total	111.7	46.0	65.7
Other removals			
Softwood	11.7	11.1	0.6
Hardwood	76.1	68.6	7.5
Total	87.8	79.7	8.1
Total removals			
Softwood	27.1	22.7	4.4
Hardwood	385.9	289.1	96.8
Total	413.0	311.8	101.2

Numbers in rows and columns may not sum to totals due to rounding.
[a] International ¼-inch rule.

Locally harvested ramps are an important plant in Kentucky and other States in the Appalachian Mountain Region. (photo by James L. Chamberlain)

Nontimber Forest Products

Kentucky has been a major producer of NTFPs since the earliest European settlers moved into the region. These products originate from fungi, moss, lichen, herbs, vines, shrubs, or trees. They may include roots, tubers, leaves, bark, twigs, branches, fruit, sap, and wood that is gathered but not cut from timber. The products are not commonly listed as outputs of the forest products industry, but they are important in the herbal medicine, culinary, crafts, and floral industries. They range from edible products such as fruits, nuts, mushrooms, ramps, and maple syrup to medicinal type products such as ginseng and bloodroot, to ornamental products such as galax, pine tips for garlands, and grapevines, to landscape products such as native plants, and to specialty woods such as burl and crotch wood for fine crafts.

Chamberlain and Predny (2004) estimated, on the basis of a survey of county extension agents, that Kentucky had 4,921 NTFP firms as of April 2003. Within the region, the Commonwealth ranked second behind North Carolina in total number of NTFP enterprises, accounting for 19 percent of the total (table 20). Kentucky

Table 20—Distribution of nontimber forest product enterprises by State and type of enterprise, 2003

State	Edible	Specialty wood	Floral and decorative	Landscape	Medicinal	Total
			number			
Alabama	221	377	378	377	58	1,411
Arkansas	224	257	208	120	251	1,060
Florida	216	127	182	837	50	1,412
Georgia	250	186	384	1,086	68	1,974
Kentucky	49	826	562	373	2,670	4,921
Louisiana	249	119	94	81	8	551
Mississippi	234	252	207	192	15	900
North Carolina	526	452	3,283	1,326	770	6,357
Oklahoma	275	148	75	65	14	577
South Carolina	89	81	145	216	25	556
Tennessee	390	794	481	593	314	2,572
Texas	438	210	200	196	27	1,071
Virginia	239	370	698	376	262	1,945
Total	3,841	4,199	6,897	5,838	4,532	25,307
Percent	15	17	27	23	18	100

ranked number one in the South in firms specializing in medicinal plant products, with 2,670 such firms (59 percent of the regional total). The Commonwealth ranked number one for specialty wood products firms (826 firms or 20 percent of the regional total of all specialty wood NTFP enterprises), and second for firms specializing in edible forest products (490 firms or 13 percent of the regional total). Kentucky ranked third in firms that make floral and decorative products from wild-harvested materials (562 firms or 8 percent of the regional total), and seventh in the region for firms that use native plants and plants collected from the wild for landscaping (373 firms or 6 percent of the total).

According to county extension agents, Kentucky has a vast diversity of enterprises that use nontimber forests resources to manufacture products (table 20). Fifty-four percent of the 4,921 NTFP enterprises in Kentucky deal with medicinal plants. Seventeen percent of the NTFP firms in the Commonwealth manufacture specialty wood products, and 10 percent manufacture culinary items from forest harvested resources. Floral and decorative enterprises account for 11 percent of Kentucky's NTFP industry, and landscaping firms that use native plants or plants collected from the wild account for about 8 percent.

According to county extension agents, Kentucky has a vast diversity of enterprises that use nontimber forests resources to manufacture products.

A great variety of medicinal plants grow in the forests of Kentucky. Many are harvested for the burgeoning herbal medicinal industry. Chamberlain (2006) estimated that the Appalachian forests, which are some of the most productive temperate hardwood forests in the world, are the principal source of >50 commonly marketed medicinal plant species. Some of the more popular medicinal plants in the markets today include black cohosh, bloodroot, goldenseal, false unicorn, and slippery elm. Very little information about the market value of these plants is available, but that which is gives us valuable insight.

Goldenseal is one of many plants in Kentucky with medicinal uses. (photo courtesy of Kentucky Department of Forestry)

Kentucky is one of six to eight States or Commonwealths in which black cohosh and goldenseal are harvested from the forests (table 20). Evidence suggests that overall demand for black cohosh roots grew from 183,000 pounds in 1999 to > 500,000 pounds in 2002, an increase of > 170 percent (Predny and Chamberlain, in press). In 2001, about 420,000 pounds of black cohosh with an estimated market value of about $2.25 million were harvested from forests of the Eastern United States. About 250,000 pounds of goldenseal was purchased in 2000, and demand was increasing steadily at that time (Predny and Chamberlain 2005). Unfortunately, it is not possible at this time to determine the portion of these harvests that originates from Kentucky's forests. However, if the market dynamics for these and other medicinal plants mirror those for American ginseng, these plants are significant contributors to rural economies.

American ginseng has been collected from eastern hardwood forests since the mid-1700s, and Kentucky has been a major producer for much of the last 300 years. Since 1995, >212,000 pounds of ginseng have been harvested from Kentucky forests, generating in excess of $63 million in direct payments to harvesters. The Commonwealth has been ranked the number one supplier of wild-harvested ginseng for the last 10 years. Over the past 10 years, Kentucky supplied about 25 percent of the total amount of ginseng wild-harvested in the United States (fig. 22). In 2004, Kentucky ginseng accounted for 28 percent of the total harvest of wild ginseng in the United States.

Kentucky has more counties producing larger volumes of wild-harvested ginseng than any other State or Commonwealth (fig. 23). Twenty-eight counties supplied > 501 pounds of wild-harvested ginseng each in 1999 and 2000, and 3 of the counties supplied >1,000 pounds in each of those 2 years. At an average of $300 per pound paid to harvesters, estimated direct payments to these rural counties during this period ranged from $120,000 to $300,000. The total contribution to Kentucky's economy far exceeds these values.

Almost every county in Kentucky reported the harvest of wild ginseng in 2003 (fig. 24). Most of the counties producing large quantities of wild-harvested ginseng are located in the eastern portion of the Commonwealth. Five counties (Knox, Harlan, Bell, Pike, and Perry) each produced >1,100 pounds of wild ginseng and accounted for about 4.2 percent of Kentucky's total harvest. Of these, Knox County supplied the most—about 1,600

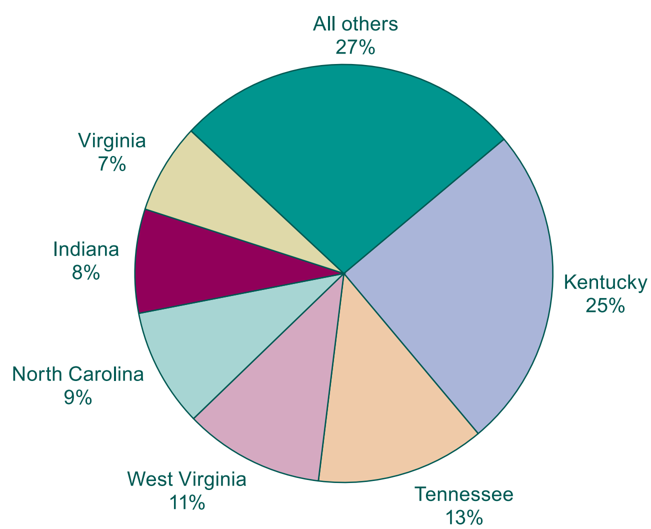


Figure 22—Distribution of State ginseng harvests, 1995 to 2004.

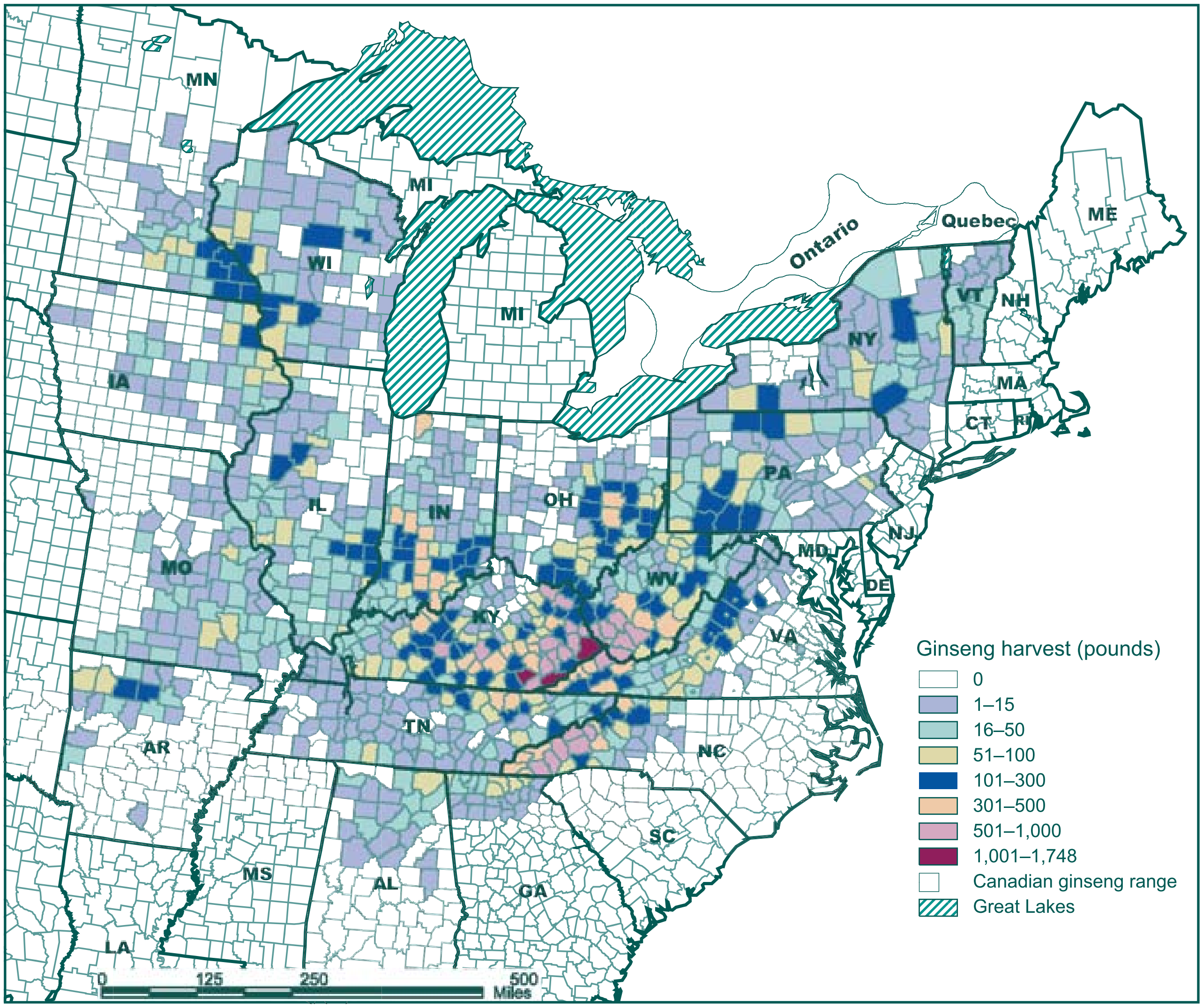


Figure 23—American ginseng average harvest by U.S. county, 1999 to 2000.

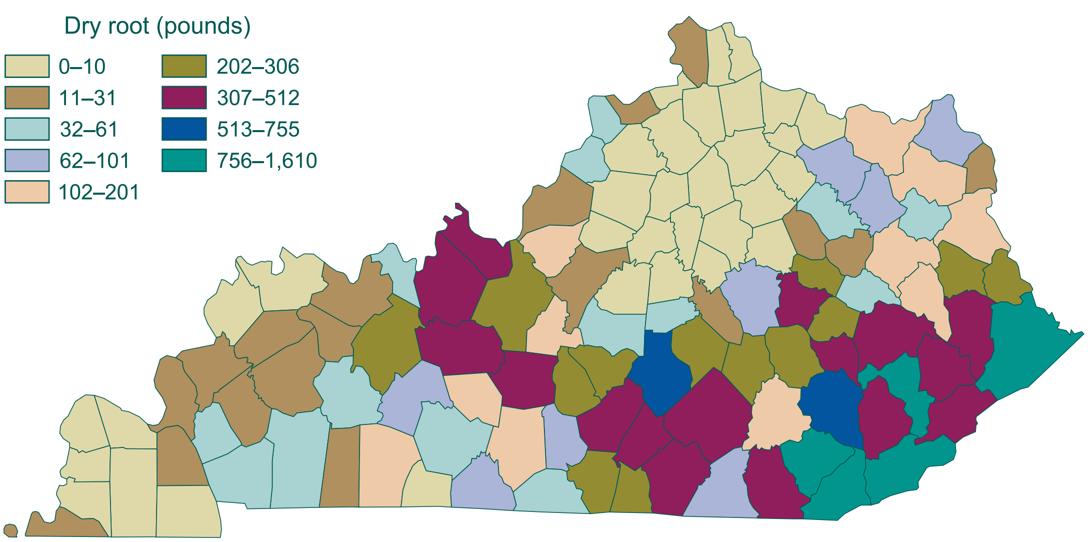


Figure 24—Distribution of ginseng harvest by county, Kentucky, 2003.

pounds of wild-harvested ginseng. Four other counties (Casey, Clay, Wayne, and Leslie) supplied about 2 percent of the total 2003 ginseng harvest. Fifty-four percent of the counties produce <60 pounds of wild-harvested ginseng each. About 27 percent supply between 60 and 305 pounds each, while about 19 percent of the counties supplied >305 pounds each.

From 1981 through 2004, rural residents of Kentucky dug and sold >465,000 pounds of wild-harvested ginseng (fig. 25). Over these 24 years, Kentucky supplied on average about 21,200 pounds each year. Based on a price paid to diggers of $300 per pound, about $6.4 million is added to the State's economy each year from the sale of wild-harvested ginseng.

The Daniel Boone National Forest in Kentucky is a source for many nontimber products. The national forests can generate revenue by selling permits that allow people to collect these products. In 2004, national forests in Region 8 (the Southern Region) generated about $169,000 from such permit sales. The Daniel Boone National Forest generated $4,269 from permit sales, and Kentucky ranked eighth in the region. This revenue came from the sale of permits to collect various NTFPs—including fuelwood, Christmas trees, roots, moss, herbs, and vines. Fuelwood permit sales accounted for 58 percent of the total. The collection of roots, perhaps for medicinal use, generated about 30 percent of the total revenue. The sale of permits for moss, herbs, vines, and Christmas trees generated about 12 percent of the NTFP revenues. The general perception among NTFP experts is that revenues from the sale of permits represent about 10 percent of actual market value. This suggests that permitted removal of NTFPs from the Daniel Boone National Forest potentially had a market value of >$42,000, which is probably a very conservative estimate. Market valuation for most NTFPs is not fully developed and there is no way of knowing how much is taken off the forest without permits.

Floral and decorative products include Christmas trees, vines, foliage, moss, needles, limbs, boughs, and cones. Unfortunately, data for most of these is

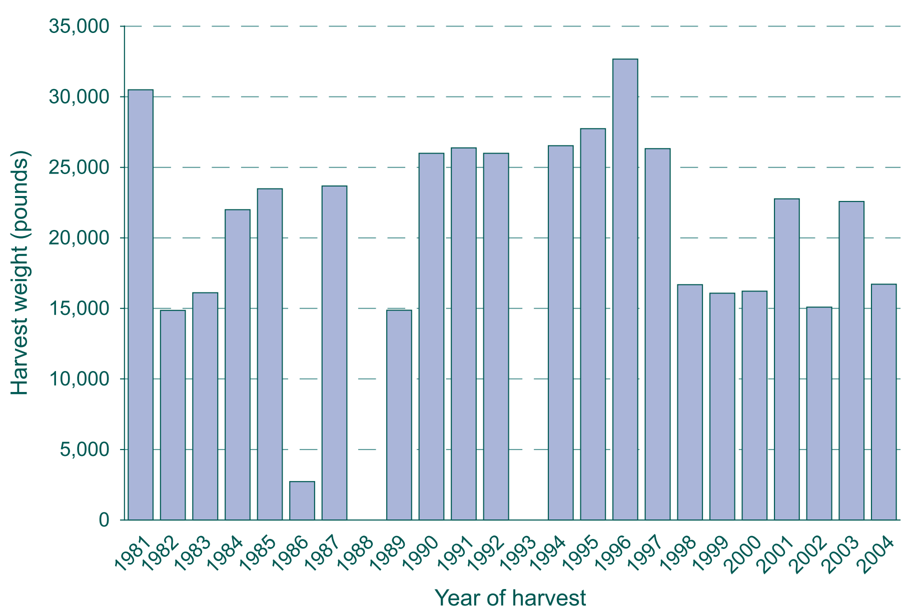


Figure 25—Kentucky ginseng harvest history, 1981 to 2004.

Black walnut is an important tree species in Kentucky. (photo by Paul Wray, Iowa State University, bugwood.org)

lacking. Christmas trees are the only floral and decorative product for which data are readily available. The 2002 census revealed that Kentucky had 230 Christmas tree farms, of which 123 were harvesting trees. The remaining 107 farms will begin harvesting over the next several years. More than 2,000 acres of productive farmland is dedicated to Christmas tree production. In 2002, Kentucky produced about 1.5 percent (56,473) of the total number of Christmas trees harvested in the South. Conners (2003) estimated the value of Kentucky's Christmas tree industry at $500,000 to $750,000 annually.

Edible forest products include berries, wild onions (ramps), nuts, and sap. In Kentucky, sales of hulled black walnuts total $400,000 to $700,000 each year (Conners 2003). In 2002, about 3,200,000 pounds of black walnuts were collected from forests in Kentucky and sold by hullers, who received about $432,000 for them (Conners 2003). In that same year, pickers made about $320,000 from the sale of black walnuts. In 2002, one Mercer County huller sold 257,000 pounds of hulled black walnuts, with an estimated value of $34,695. The total value of Kentucky's 2002 walnut crop was estimated at $2,096,000, which consisted of nut meat ($1,344,000), shells ($320,000), and price to pickers and hullers ($432,000). Kentucky is one of two States or Commonwealths in the South that have maple syrup farms for which statistics are available. In 2002, 38 maple syrup farms in Kentucky had a total of 4,142 active taps. These farms produced about 416 gallons of syrup, representing about 9 percent of total maple syrup production in the Southern Region (Chamberlain and Predny 2004).

The NTFPs discussed here are only some of those on which Kentucky's NTFP industry is based. The available data show that the NTFP industry is a significant contributor to Kentucky's rural economy. Thus, the collection and sale of NTFPs may benefit tens of thousands of Kentucky residents.

Forest Health Indicators in Kentucky

With the development of the Healthy Forest Initiative and the Forest Service Chief's identification of Four Threats to American Forests in the 21st Century, forest health has become a topic of great interest to the scientific and lay community. The Forest Service currently monitors forest health by measuring a combination of indicators much as a doctor would monitor a patient through a combination of discrete measurements like temperature, blood pressure, and weight (McCune 2000). Forest health indicators measured by FIA include crown structure, down woody material (DWM), soil characteristics, vegetation structure and diversity, lichen communities, and ozone damage. Through analysis of each of these variables at statewide, regional, and national levels, scientists are able to identify potential problems and pinpoint areas of concern for intensified research programs. Additionally, trends may be detected and changes tracked over time. Analyses of vegetation structure and diversity and lichen communities are not included in this bulletin.

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The forest health information presented here reflects monitoring conducted by two programs that were merged in 2000: Forest Health Monitoring (FHM) and FIA. FHM initially developed and implemented procedures for collecting data related to forest health. After the merger with FIA, data collection has been implemented in every State resulting in the development of the FIA "phase 3" (forest health) subset of FIA data collection plots (Stolte 2001). In Kentucky, forest health data for variables related to crown structure, DWM, soil characteristics, and ozone damage were collected. Vegetation structure and diversity and lichen community sampling will be added in the future.

Methodology

FIA collects data on forest health variables on a subset of P2 sample plots. The subset is about 1/16th of the P2 dataset and is called phase 3 (P3) of the forest inventory. The data collected on one P3 plot represents conditions on about 96,000 ground acres. Therefore, P3 data are coarse descriptions and are meant to be used as general indicators of overall forest health over a large geographic area. Analyses of P3 data are inappropriate at levels below multiple county aggregates.

FIA collects P3 data for variables related to tree crown health, DWM, ozone damage, lichen diversity, soil composition, and, in some regions, nonwoody understory vegetation and diversity. Tree crown health, DWM, soil composition, and nonwoody understory vegetation and diversity measurements are collected using the same plot structure used during P2 data collection, while lichen data are collected within a 120-foot radius circle centered on subplot 1 of each FIA P3 field plot.

Ideally, data for 20 percent of P3 plots are collected annually (one "panel"), and a data cycle is complete in 5 years. Five years of P3 data present the most accurate statistical representation of the forest land surveyed. Currently, most States have < 5 years' worth of continuously collected forest health data on permanent P3 plots, so reporting is restricted to the available data. Sometimes, restricted sample sizes may result in the exclusion of a variable from analysis until a complete cycle of data has been collected. Future reports will incorporate analysis of data for the full suite of P3 plots. Additional details related to P3 of FIA, including field data collection manuals, can be found by following the "FIA Library" link from our Web site at http://fia.fs.fed.us/.

Deadwood on Kentucky Forest Land

Deadwood plays a range of critical roles in forest ecosystems, from serving as nurse logs for the growth of plants and moss to providing wildlife habitat and functioning as a fuel (Bate and others 2004, Waddell 2002). A multitude of organisms rely on DWM to provide structural or thermal protection, or both, 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 3 of their life-history requirements: food, shelter, and reproduction. Where too much deadwood is present, however, it can sustain damaging wildfires. Therefore, forest managers must strike a balance between maintaining enough deadwood to sustain wildlife, insect, and plant communities and avoiding dangerously high fuel accumulations.

Forest managers must strike a balance between maintaining enough deadwood to sustain wildlife, insect, and plant communities and avoiding dangerously high fuel accumulations.

Despite the importance of deadwood to a variety of organisms and ecosystem functions, little attention has been given to the distribution of woody material on the landscape until relatively recently (Waddell 2002). FIA quantifies the amount and extent of fine and coarse woody debris on the forested landscape, and the number of snags present in the forest.

Deadwood as habitat—Snags, hollow logs, and brush piles provide important habitat for vertebrate communities. Decaying material, litter, and duff provide important habitat for micro- and macroinvertebrates, all of which play important roles in detritus recycling and, therefore, the ecology of forested systems. Many types of vegetation rely on decaying plant material as a growth substrate. Deadwood is not distributed evenly across the landscape, nor is it equally important to wildlife in every forest. For example, live deciduous trees in eastern forests often contain cavities that provide habitat for cavity-nesting animals, decreasing the number of standing dead trees necessary to provide quality nest sites (Mannan and others 1996). In contrast, cavity-nesting animals living in the coniferous forests of the Southeastern United States and the Western United States may be more dependent on standing dead trees as appropriate habitat, increasing the number necessary to provide optimum habitat (Mannan and others 1996). The size and stage of decay of a snag also influence the type and numbers of animals that can use the tree. Generally, trees >14.0 inches d.b.h. are preferred for nesting, though snags of any size or decay class can provide food resources for multiple animals (Mannan and others 1996). The optimal number of snags to retain for wildlife on each acre of forest land depends on multiple conditions, including the management goals for the forest, the wildlife species present or desired, and the size, age, and species of trees present.

FIA collects data on snags on all P2 sample plots in Kentucky. There are about 129 million standing dead trees on Kentucky's forest land today. In Kentucky, hardwoods provide more snags than do softwoods, but the ratio of softwood snags to hardwood snags was higher in the Southern Cumberland and Northern Cumberland regions, areas heavily impacted by the southern pine beetle (fig. 26). Small snags (5.0 to 13.9 inches d.b.h.) outnumber large snags (>14.0 inches d.b.h.) by 8 to 1. There are, on average, 11 snags per acre of forest land in Kentucky. The number of snags per acre varies across the Commonwealth, with the lowest per-acre concentrations in the Western and Western Coalfield regions, and the highest ones in the Bluegrass and Southern Cumberland regions (fig. 27).

Hollow logs and other types of coarse woody material also provide shelter or food for many species during at least some part of their life. Information on coarse woody debris was collected on 62 forest health plots across Kentucky from 2001 to 2003. Measurements of the size and determination of the decay class of individual pieces of debris provide information about the suitability of logs for use by wildlife and the accumulation of new dead material onto the forest floor. Most of the coarse debris sampled in 2001 to 2003 was moderately decayed (decay classes 2 and 3) (fig. 28), and fell into the smaller diameter classes (table A.36). The largest quantity of coarse woody debris occurred in the loblolly-shortleaf pine, oak-pine, and oak-hickory forest-type groups. Per-acre concentrations of down deadwood (fine and coarse material combined) were greater in

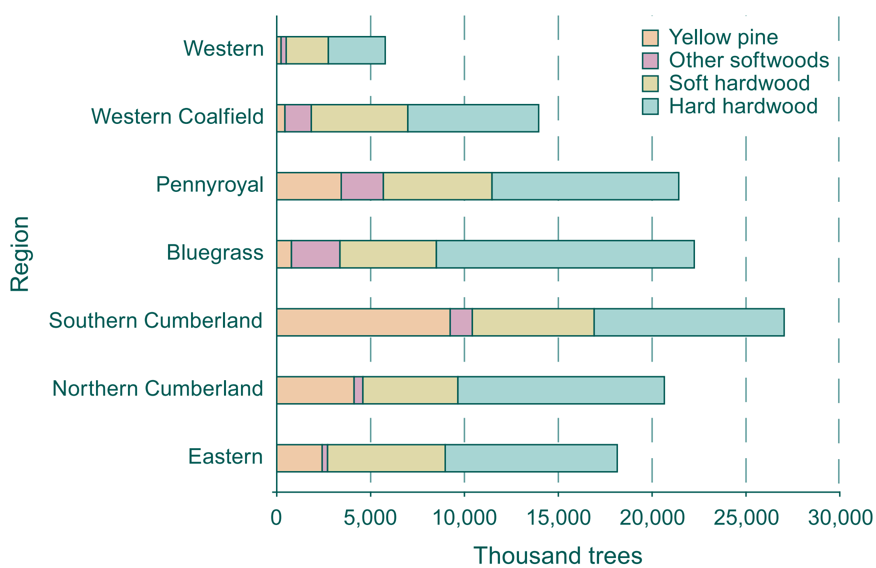

Figure 26—Number of standing dead trees on forest land by major species group and FIA reporting unit, Kentucky.

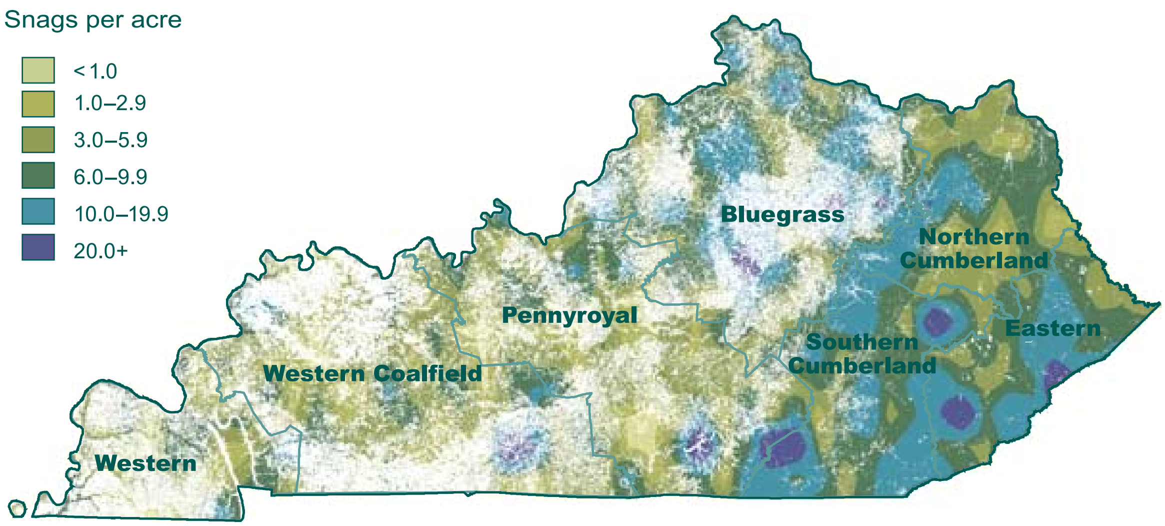

Figure 27—Predictive map of snags per acre by FIA reporting unit using inverse distance weighting, Kentucky, nonforest areas have been removed.

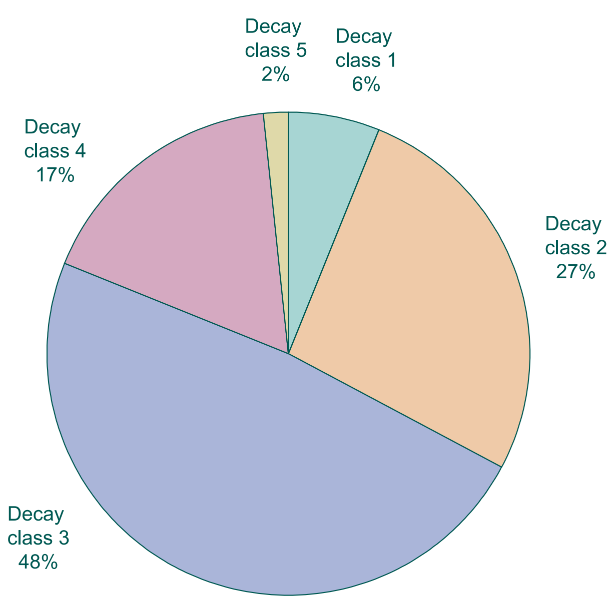

Figure 28—Proportion of coarse woody materials by decay class, Kentucky.

the Northern and Southern Cumberland regions, and in small areas of the Western Coalfield region, than elsewhere in Kentucky (fig. 29).

Deadwood as fuel—Fire plays an important role in shaping landscape communities. As a natural event and a silvicultural tool, fire influences every aspect of forest ecology, including soil chemistry, wildlife habitat, biomass storage, and plant composition (Barnes and others 1998). Some tree species are dependent on forest fires to complete portions of their life cycles. For example, some conifers have evolved serotinous cones that require heat from fire to open. Other species have developed thick leaves and bark that resist fire damage, or seeds that require heat for germination (Barnes and others 1998). Conditions created by forest fires are also favorable for many wildlife species. Forest fires stimulate plant growth that benefits some small and large game in southern forests. Fires also promote the development of live-tree cavities suitable for black bears (Mannan and others 1996).

Forest fires are not always beneficial, however. Federal spending on wildfire suppression and prevention reaches as much as $500 million a year (Butry and others 2001) and continues to climb. Beyond economic losses, catastrophic fires increase air pollution through the emission of carbon monoxide, hydrocarbons, and volatile organic compounds (McMahon 1983). Additionally, intense wildfires can increase the rate of erosion on steep sites as soils are exposed (Barnes and others 1998).

To ignite and burn, a fire requires three primary ingredients: (1) an ignition source, (2) oxygen, and (3) fuel. Surface fuels include the duff (partially decomposed organic matter) and litter (leaves, twigs, and other small pieces of organic matter) layers of the forest floor, fine woody debris and slash piles, and finally, coarse woody debris (McMahon 1983). The accumulation of large amounts of surface fuels, particularly fine woody debris and slash, increases the risk of catastrophic wildfire given the appropriate weather conditions and an ignition source. Small (1-hour and 10-hour) fuels tend to dry out rapidly and ignite quickly, while large (100-hour and coarse debris) fuels tend to retain moisture and smolder rather than ignite (Schulz 2003). Statewide, Kentucky averaged 0.1 tons per acre of 1-hour, 0.8 tons per acre of 10-hour,

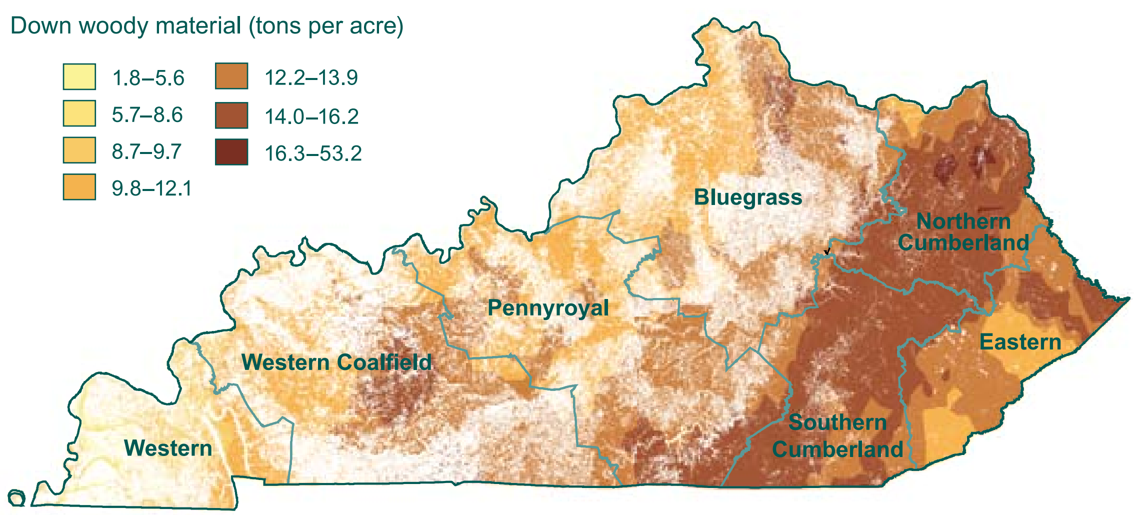

Figure 29—Kriged predictive map of down woody material by FIA reporting unit, Kentucky, nonforest areas have been removed.

Forest management sometimes includes reintroducing fire back in forested systems. (photo by Ray D. Campbell)

and 2.8 tons per acre of 100-hour fine woody fuels on forest land from 2001 to 2003. Although the 2001 to 2003 dataset is small, predictive maps suggest that the Northern and Southern Cumberland regions contain more DWM (tons per acre) than other regions within the State (fig. 29). This trend is to be expected, given the greater total wood volume in those regions, but high levels of DWM may result in increased fire risk.

Ozone and Kentucky's Forests

Ozone (O_3) is a chemical compound that occurs naturally in the Earth's atmosphere. Ozone in the upper atmosphere performs an essential function, protecting the Earth's surface from intense ultraviolet rays coming from the sun. In the troposphere, however, ozone becomes a secondary pollutant, contributing to permanent damage to human respiratory systems. Tropospheric ozone also affects the growth and development of forest vegetation (Skelly 2000).

Tropospheric ozone affects the growth and development of forest vegetation.

Nitrogen oxides (NO_x) are byproducts of organic fuel combustion, and concentrations of them may be especially high near industrial areas. Volatile organic compounds (VOC) are emitted from many natural sources, including trees. VOCs and NO_x combine in the presence of sunlight to form tropospheric ozone. Tropospheric ozone concentrations fluctuate naturally in response to weather events and other changes in the chemistry of the air. Hot, cloudless summer days are the perfect weather conditions for the chemical reactions that combine NO_x and VOCs into harmful ozone.

Pollution due to high concentrations of tropospheric ozone affects forest vegetation growth and directly injures the foliage of sensitive species (Coulston and others

2003, Lefohn and others 1997). Forests in the Eastern United States may be particularly susceptible because of lingering high-pressure systems common in the region, combined with concentrated areas of urbanization and industrialization that generate the precursors to ozone (Skelly 2000). The resulting ozone travels downwind of these population centers, often reaching peak concentrations in remote areas.

High concentrations of ozone in the troposphere may cause visible injuries to forest vegetation. Some species are known to be particularly sensitive to ozone, and exhibit this sensitivity through changes in leaf pigmentation, premature leaf senescence, or other species-specific symptoms. These sensitive species are used as bioindicators of ozone presence and are particularly useful in areas where ozone monitoring stations may not be present, such as remote forest locations (Skelly 2000). In Kentucky, black cherry, sassafras, yellow-poplar, and other species are used as bioindicators (table 21).

In Kentucky, ozone data was collected for 4,919 plants of 8 bioindicator species on a total of 72 sites from 2000 through 2002. At least some plants had ozone-related injury on 33 percent of the evaluated biosites. About 2 percent of the plants sampled exhibited signs of ozone-related injury (table 22). The majority of injured plants fell into category 1, with <5 percent ozone-related damage (table 22).

Data from the U.S. Environmental Protection Agency (EPA) and FIA suggest that ambient ozone exposures are lowest

Table 21—List of bioindicators for Kentucky

Common name	Scientific name
Spreading dogbane	*Apocynum androsaemifolium* L.
Milkweed	*Asclepias* spp.
Bigleaf aster	*Eurybia macrophylla* (L.) Cass.
White ash	*Fraxinus americana* L.
Sweetgum	*Liquidambar styraciflua* L.
Yellow-poplar	*Liriodendron tulipifera* L.
Pin cherry	*Prunus pensylvanica* L. f.
Black cherry	*P. serotina* Ehrh.
Blackberry	*Rubus allegheniensis* Porter
Sassafras	*Sassafras albidum* (Nutt.) Ness

Table 22—Summary of biosite data, Kentucky, 2000 through 2002

	Kentucky biomonitoring program			
Parameter	2000	2001	2002	Total
		number		
Biosites evaluated	20	20	32	
Biosites with injury	1	13	10	
Plants evaluated	554	1,692	2,673	
Plants injured	15	60	45	
		percent		
Sample plants by injury severity category				
0 = no injury	95	60	72	
1 = 1 to 5 percent	0	35	16	
2 = 6 to 25 percent	0	5	9	
3 = 26 to 50 percent	5	0	3	
4 = 51 to 75 percent	0	0	0	
5 = > 75 percent	0	0	0	
		number		
Plants evaluated by species[a]				
Sweetgum	60 (0)	171 (9)	301 (0)	532 (9)
Yellow-poplar	90 (0)	332 (18)	390 (0)	812 (18)
Milkweed	70 (0)	172 (6)	407 (20)	649 (26)
Black cherry	30 (0)	84 (0)	137 (0)	251 (0)
Blackberry	171 (9)	450 (15)	715 (20)	1,336 (44)
Spreading dogbane	0 (0)	55 (11)	142 (1)	197 (12)
White ash	100 (0)	260 (1)	390 (0)	750 (1)
Sassafras	33 (6)	168 (0)	195 (4)	396 (10)

[a] Number of injured plants given in parenthesis.

where forested acreage is highest, while heavily populated areas like Lexington, KY, have relatively high ambient ozone levels (fig. 30). FIA data and EPA air quality data indicate that the air quality in heavily forested eastern Kentucky may be slightly above the average for the Southeastern United States, while air quality in the moderately forested Western region is comparable to that in other Southeastern States.

Crown Condition

FIA conducts visual assessments of individual tree crown condition on the P3 plots. Tree crown condition can be used to track forest health because a tree undergoing stress reacts by slowing growth and shedding parts of its crowns (Millers and others 1989). When a tree sheds foliage and fine twigs it alters its rate of photosynthesis and carbohydrate production. Thus, poor crown condition can be a signal of declining growth rates and degraded forest health.

FIA annually collects information on crown density, crown dieback, and foliage transparency in order to identify localities or species with potential forest health problems. Crown density and foliage transparency describe the amount of foliage present on the tree while crown dieback describes the amount of dead twigs and branches. Vigorous trees typically have high crown density, low foliage transparency, and minimal crown dieback.

Individual tree crown density, crown dieback, and foliage transparency were assessed on 72 plots between 2000 and 2002. Overall, crown density ranged

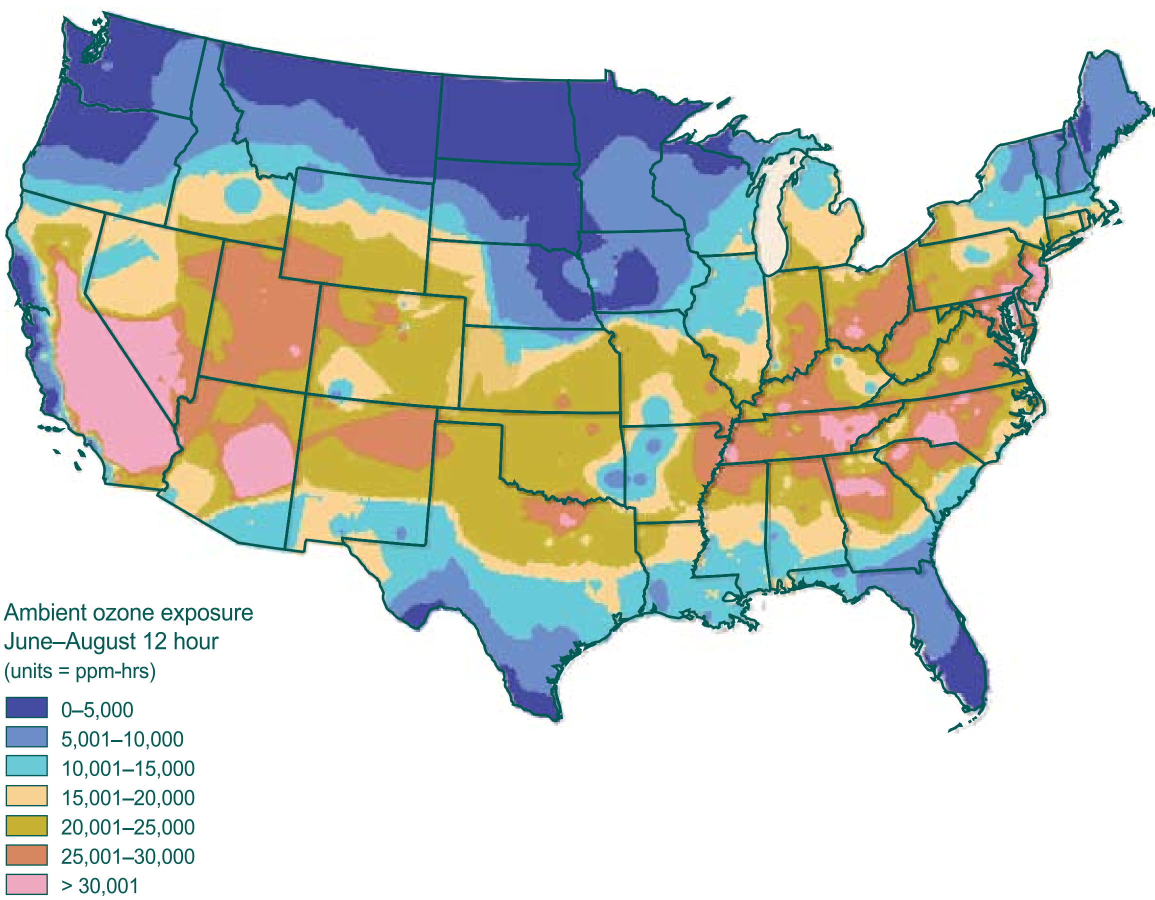

Figure 30—Five-year average of nationwide ozone exposures.

from 5 to 80 percent with means of 50.4 percent for softwoods and 41.5 percent for hardwoods (fig. 31). Crown dieback ranged from 0 to 80 percent (table 23), with the majority of trees having <10 percent dieback (fig. 32). Average crown dieback was 1.6 percent for softwoods and 2.1 percent for hardwoods (table 23).

Foliage transparency ranged from 0 to 85 percent and averaged 17.6 percent for softwoods and 21.2 percent for hardwoods (fig. 33). Overall, average crown conditions in Kentucky are not outside the expected range for trees in the South (Randolph 2006) and may be considered representative of healthy and productive trees.

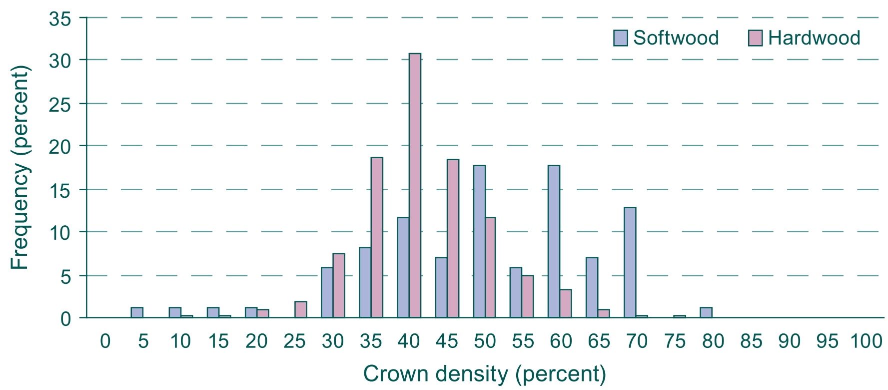

Figure 31—Crown density frequency for all live trees > 4.9 inches d.b.h. by species group, Kentucky, 2000 to 2002.

Table 23—Mean crown dieback and other statistics[a] for all live trees > 4.9 inches d.b.h. by species, Kentucky, 2000 to 2002

Species	Plots	Trees	Mean	SE[b]	Minimum	Median	Maximum
	- - number - -				*- - - - - - - - percent - - - - - - - -*		
Softwoods							
Eastern redcedar	8	59	1	1	0	0	5
Shortleaf pine	1	1	0	—	0	0	0
Loblolly pine	1	1	0	—	0	0	0
Virginia pine	7	18	4	—	0	0	15
Other softwoods	3	6	5	—	0	5	10
All softwoods	18	85	2	1	0	0	15
Hardwoods							
White oaks	50	235	2	0	0	0	40
Red oaks	41	120	2	1	0	0	60
Maple	51	247	2	0	0	0	55
Yellow-poplar	28	86	4	2	0	0	80
Blackgum	26	42	1	1	0	0	40
Hickory	43	133	1	0	0	0	15
Ash	26	53	2	1	0	0	10
Elm	17	26	4	1	0	3	20
Other hardwoods	62	282	2	1	0	0	50
All hardwoods	72	1,224	2	0	0	0	80
All trees	72	1,309	2	0	0	0	80

SE = standard error; — = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] The mean, SE, and median calculations consider the clustering of trees on plots.
[b] SEs are not presented for species groups with n trees < 20.

Overall, average crown conditions in Kentucky are not outside the expected range for trees in the South and may be considered representative of healthy and productive trees.

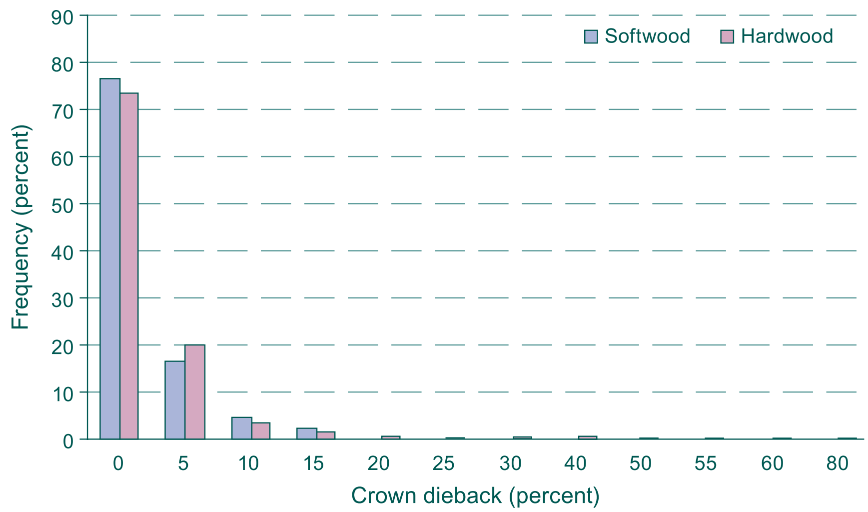

Figure 32—Crown dieback frequency for all live trees > 4.9 inches d.b.h. by species group, Kentucky, 2000 to 2002.

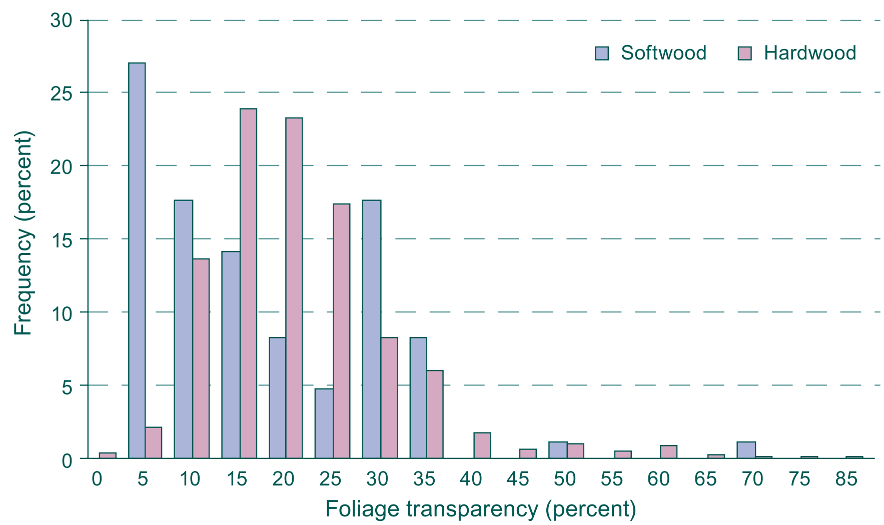

Figure 33—Foliage transparency frequency for all live trees > 4.9 inches d.b.h. by species group, Kentucky, 2000 to 2002.

Soil Characteristics

Forest soils in southern and eastern Kentucky are primarily classified as Ultisols, while soils in the north and west are primarily classified as Alfisols (fig. 34). Formed on geologically old, unglaciated landscapes in temperate, humid areas, Ultisols are highly leached and lower in nutrients than some younger soil orders (Buol and others 1997). Ultisols are often too nutrient-poor to sustain agricultural production, but are well suited for forestry because this soil type relies on nutrient input through leaf litter and woody detritus for continued soil fertility (Buol and others 1997). Alfisols are highly fertile, naturally forested soils formed on stable landscapes in temperate and subtropical climate zones (Buol and others 1997). Alfisols are often cultivated for agriculture but also support broadleaf deciduous and mixed evergreen forests.

Soil characteristics substantially influence the productivity of forest land in a given region. Tree growth and development is partially dependent on the amount of water and nutrients available to the tree in the surrounding soil matrix. FIA collects soil data on P3 plots to assess erosion potential, soil compaction, the availability of water and nutrients to plant species, the amount of carbon present in soil organic matter, pollution, and acidification.

FIA collects soil data to assess erosion potential, soil compaction, the availability of water and nutrients to plant species, the amount of carbon present in soil organic matter, pollution, and acidification.

FIA assesses the chemical properties of the soils of Kentucky's forest lands by collecting and testing soil samples in the 0- to 10-cm and 10- to 20-cm soil horizons. Chemical properties of soils are best portrayed either spatially, or in conjunction with other forest characteristics, as the chemical properties of soils can vary widely within one soil type depending on vegetation cover, terrain, and local climate. FIA began collecting soil information only in 2001. For this reason soil chemical analyses are available only for 2001 to 2003 and sample sizes are very small. The data that are presented here describe conditions on a very broad scale.

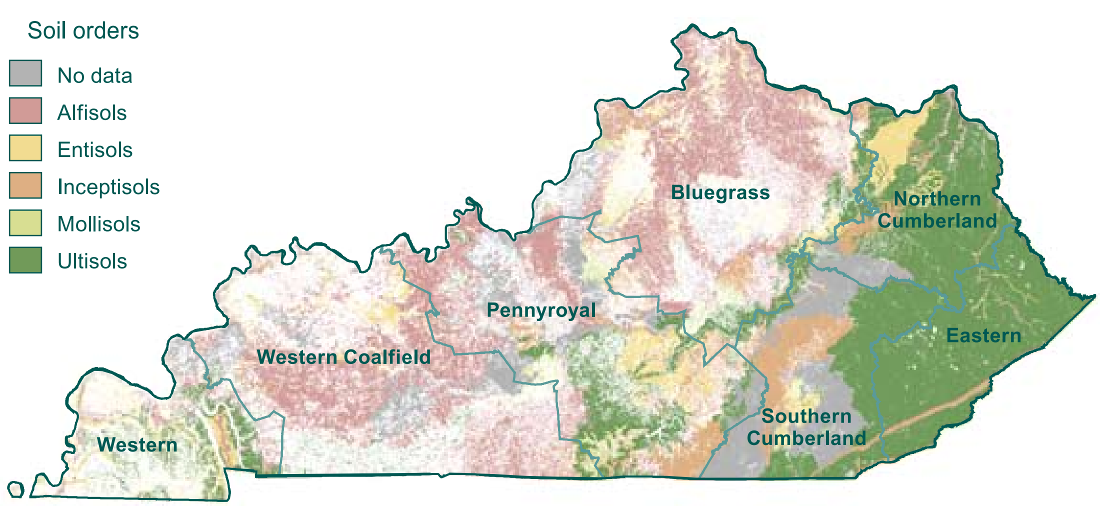

Figure 34—Soil orders of Kentucky. Data from STATSGO. http://soildatamart.nrcs.usda.gov.

A fuller range of information will be available for analysis when a complete 5-year cycle of data has been collected.

Bulk density—The bulk density (mass per unit volume) of soil is an indication of the pore space available in the soil for the transport of air and water. High bulk densities may interfere with root growth and exchange of water and air. Lower bulk densities allow for easier root penetration and more efficient air and water exchange. Soil bulk density tends to increase with soil depth as organic matter content decreases and coarse particulates such as rocks increase. For 2001 to 2003 the mean bulk density of Kentucky soils in the 0- to 10-cm horizon was 1.12 g/cm^3 (table A.38), with a median value of 1.15 and a range of 0.54 to 1.54, suggesting that most soils sampled were fairly compacted. Mean bulk density of soils in the 10- to 20-cm horizon was higher at 1.46 (table A.38), with a median value of 1.49 and a range of 1.00 to 1.82.

Total carbon and macronutrients—Soil carbon is of importance for its contribution to global carbon sequestration—a topic of concern in forest and global environmental health. FIA measures total, inorganic, and organic soil carbon values on P3 plots across the United States. In Kentucky, organic soil carbon values in the 0- to 10-cm mineral soil layer averaged 2.6 percent (±0.2) (table A.39), with a median value of 2.4 percent. Organic carbon values in the 10- to 20-cm mineral soil layer averaged 1.08 percent (±0.1) (table A.39), with a median value of 0.86 percent.

Information about the chemical composition of soils allows managers to better understand potential limitations to growth, and to identify potential problems like soil acidification. The roles of key nutrients in plant growth and development are stated in table 24. Effective cation exchange capacity (ECEC) tended to be highest in the nutrient-rich soils of the Bluegrass and Pennyroyal regions and lowest in the Western and Western Coalfield regions. Similarly, extractable cation content tended to be higher in the Bluegrass region than in others, while extractable cation content tended to be lowest in the Western region (table A.39). Readers are cautioned against applying these lab results until they have been confirmed by local testing, because sample sizes were small and because soil nutrient levels tend to fluctuate widely in response to local precipitation events and other local influences.

Table 24—Soil macronutrients collected by FIA and implications for vegetation

Soil attribute	Implications for vegetation [a]
Aluminum	Toxic to plants in high doses, stunts growth
Calcium	Aids in root, leaf, cell wall development
Carbon	Increases the water holding capacity of the soil
Cation exchange capacity	Index of the ability of soil to hold nutrients
Magnesium	Aids in photosynthesis, metabolism, respiration
Nitrogen	Aids in leaf development and plant metabolism
Phosphorus	Aids in metabolic processes and cell development
Potassium	Facilitates gas exchange, disease resistance, drought protection
Sodium	May be detrimental in high concentrations
Sulfur	Aids in protein formation but toxic at high levels

[a] Amacher and others (2007).

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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. and larger that died from natural causes during the intersurvey period.

Average annual removals. Average annual volume of trees 5.0 inches d.b.h. and larger 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. and larger 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. and larger 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 under 0.5 inch in diameter at the point of occurrence on sapling-size trees is included but is excluded on poletimber and sawtimber-size trees.

Blind check. A reinstallation done by a qualified inspection crew without production crew data on hand; a full reinstallation of the plot is recommended for the purpose of obtaining a measure of data quality. If a full plot reinstallation 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. and larger.

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

Coarse woody debris or coarse woody material. Down pieces of wood leaning more than 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 QC 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.

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 and 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./drc.

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 as part of crown dieback, unless there is continuous dieback from the upper and outer crown down to those branches.

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

Decay class. Qualitative assessment of stage of decay (five 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 through 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 take 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. and larger 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 at least 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 or less, 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.

Lichen. An organism generally appearing to be a single small leafy, tufted or crustlike 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 four 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: (1) a statement of the tolerance and (2) a percentage of time when the collected data are required to be within tolerance. MQOs can only be assigned where standard methods of sampling or field measurements exist, or where experience has established upper or lower bounds on precision or bias. MQOs can be set for measured data elements, observed data elements, and derived data elements.

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 at least 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.

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 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 or more.

Ozone (O_3). A regional, 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.

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 P2 plots. Additional attributes related to forest health are measured on P3 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.

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. QA 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 QC 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. QC 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 or longer, 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 or longer, 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 at least 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 larger and hardwoods 11.0 inches d.b.h. and larger.

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.

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 centimeter 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 s oil 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.

Sawtimber stands. Stands at least 10 percent stocked with live trees, with half or more of total stocking in sawtimber and poletimber trees, and with sawtimber stocking at least equal to poletimber stocking.

Poletimber stands. Stands at least 10 percent stocked with live trees, with half or more of total stocking in poletimber and sawtimber trees, and with poletimber stocking exceeding sawtimber stocking.

Sapling-seedling stands. Stands at least 10 percent stocked with live trees, in which saplings and seedlings account for more than 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 (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 at least 3 inches d.b.h., a more or less definitely formed crown of foliage, and a height of at least 13 feet (at maturity).

Tree grade. A classification of the saw-log portion of sawtimber 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 sawtimber 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 at least 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 sawtimber trees. The cubic-foot volume of sound wood in the saw-log portion of sawtimber trees. Volume is the net result after deductions for rot, sweep, and other defects that affect use for lumber.

Oak plantation. (photo by Christopher M. Oswalt)

The current inventory is a three-phase 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 (Bechtold and Patterson 2005). There are 25 P1 points for every P2 plot. There are 16 P2 plots for every P3 plot. P1 points and P2 and P3 plots represent about 236 acres, 6,000 acres, and 96,000 acres each, respectively.

The inventory design and methodology used to collect and process the information needed to derive the current forest resource estimates for the 2004 survey of Kentucky have undergone substantial change since the previous survey conducted in 1988. The current survey's sample design has changed in three major ways from the previous inventory of Kentucky [see Bechtold and Patterson (2005) for a detailed discussion of the FIA design]. The first change was in the method of collecting forest area estimation based on aerial photos. The second was switching from a five-point cluster ground plot that was a mixture of fixed- and variable-radius points to a four-point fixed-radius ground sample. The third was switching from periodic to annual collection of ground samples. There are also changes in volume equations, variable definitions, processing methodology, and algorithms. While all of these changes alone or in combination weaken comparisons among surveys, they are necessary to improve survey accuracy and allow comparisons with other surveys throughout the region.

Data is collected by Kentucky Division of Forestry foresters in forests across the Commonwealth. (photo by Ray D. Campbell)

Sample Design Phases

Previous P1: forest area estimates—The previous forest area estimate was based on a grid of 16 points placed over the center of each aerial photo. In the previous inventory, over 69,500 points were classified into forest and nonforest land uses, with each point representing about 360 acres. Forested points were further classified into eight different volume classes. The number of points that fell into each volume class was used to stratify the forested P2 ground plots at the county level. However, forest area estimates were only developed for each county that had >60,000 acres of timberland. Counties that did not meet that criterion were grouped with a neighboring county or counties to form a larger sampling base.

Current P1: forest area estimates—For the 2004 inventory of Kentucky the P1 forest area estimate was based on a grid of 25 points that was placed over the quadrant of an aerial photo where a P2 sample plot was located. There were over 105,000 points, and these represented about 236 acres each. A photointerpreter classified each point as forest or nonforest and a percentage for each class was derived for each county. The forest area for each county was then determined by multiplying the percentage of forested points by the U.S. Census Bureau's estimate of all land for each respective county (U.S. Bureau of the Census 2002). Ground truths were done at each P2 sample location and one additional location by field personnel. Where a classification was found to be incorrect, a correction factor was calculated and the forest percentage that was derived from the original P1 dot count estimate was adjusted. These correction factors adjust for possible misinterpretation of aerial photos and for real changes which may have occurred since the date of the aerial photography. Plot-level expansion factors were determined by dividing the number of forested plots into the total forest land.

The increase in the number of photopoints classified increased the precision of the forest land area estimate from ±0.8 percent to ±0.4 percent at the State level. Expansion factors were derived only from the classifications of P1 points into forest and nonforest categories and did not apply to volume estimation. Furthermore, forest land area is estimated for each county in the 2004 inventory. Counties with < 60,000 acres of timberland were not grouped with an adjacent county or counties. However, users should be aware that individual county estimates have unacceptably larger error percentages than unit and State level estimates. County data are provided in the Forest Inventory and Analysis Database (FIADB) so that users can group counties into their own defined areas of interest, but they are not valid for county level analysis.

Previous P2: forest inventory—The previous plot design was a five-point cluster design (fig. A.1) with one center point and four satellite points located 98.4 feet north, east, south, and west. The center point consisted of four concentric fixed-radius plots: (1) a reproduction plot, (2) a vegetation plot, (3) a poletimber plot, and (4) a sawtimber plot. Trees 1.0 to 4.9 inches in d.b.h. and seedlings (trees <1.0 inches in d.b.h.) were measured on the reproduction plot, which had a 3.7-foot radius and an

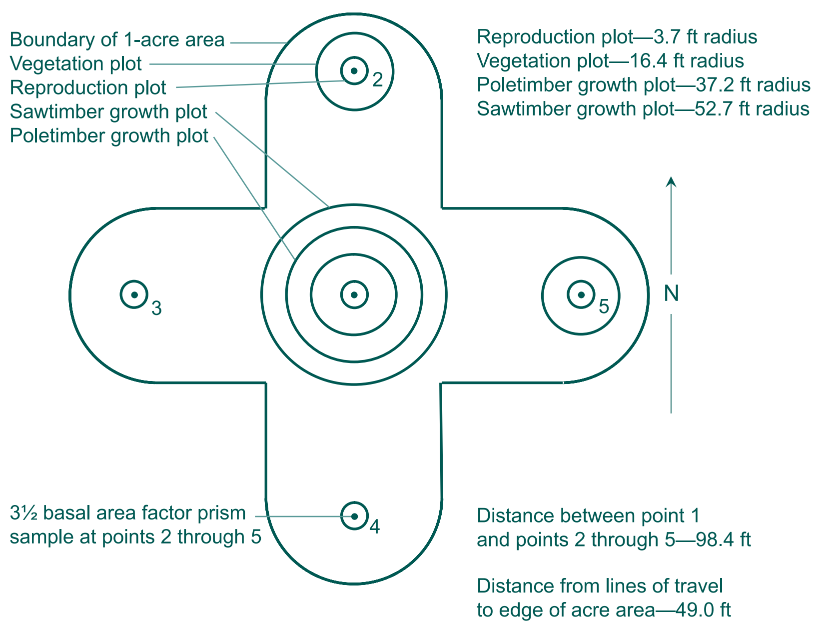

Figure A.1—Pattern of five-point prism plot used in Kentucky.

area of about 1/1000 of an acre. Vegetation characteristics were measured within a plot with a radius of 16.4 feet and an area of about 1/50 of an acre. Trees ≥ 5.0 inches d.b.h. were measured on the poletimber plot, which had a radius of 37.2 feet and an area of about 1/10 of an acre. Softwood tree species ≥ 9.0 inches d.b.h. and hardwood tree species ≥ 11.0 inches d.b.h. were measured on the sawtimber plot, which had a radius of 52.7 feet and an area of about 1/5 of an acre. The four satellite points served as centers of variable radius plots; at each of these points, a 37.5-basal-area-factor prism was used to select trees with d.b.h. ≥ 5.0 inches. The reproduction and vegetation plots were also located at all four satellite points. Finally, the entire sawtimber plot and the four satellite points were relocated in some cases so that they all were in the same land use (U.S. Department of Agriculture 1987).

The ground samples established in 1988 were located independently from the plots that were established in the 1975 inventory and from those established in the 2004 inventory. Data from the remeasured plots were collected from 1999 to 2002 and are only used to calculate growth, removals, and mortality volume estimates for the Commonwealth.

Current P2: forest inventory—The current plot design employs a fixed plot composed of four subplots spaced 120 feet apart (fig. A.2). The sample area of these four subplots totals approximately 1/6 of an acre, while the footprint of the cluster is about 1 acre. Trees ≥ 5.0 inches in d.b.h. are measured on each subplot, which has a 24-foot radius and an area of about 1/24 of an acre. Trees 1.0 to 4.9 inches in d.b.h. and seedlings (trees <1.0 inch in d.b.h.) are measured on a microplot, which has a radius of 6.8 feet and an area of 1/300 acre, in each of the four subplots.

Because the plots are placed on the ground without bias, i.e., systematically but at a scale large enough so that their placement can be considered random, there is a probability that the plot cluster will straddle more than one type of land use or forest condition. Furthermore, the four subplots are not relocated into the same land use. When a plot straddled multiple land uses or forest conditions the crew identified and mapped 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 and mapping differing conditions

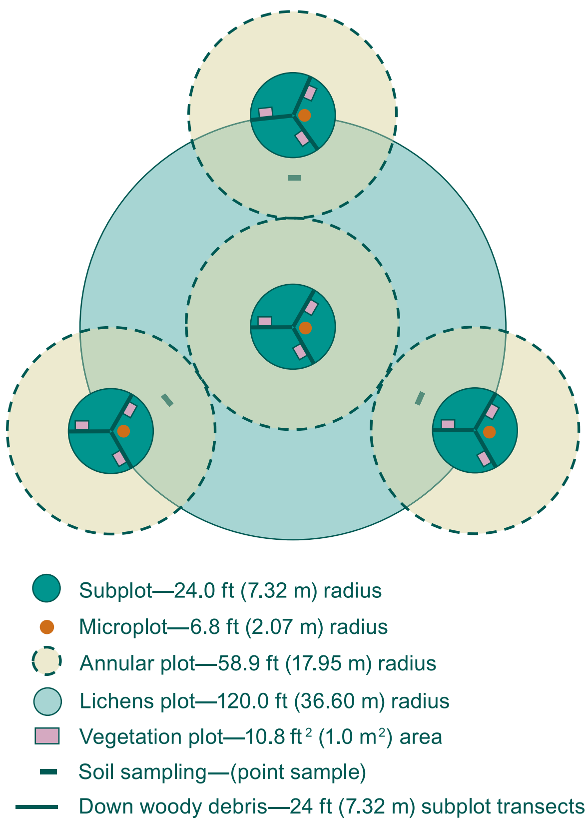

Figure A.2—Layout of fixed-radius plot.

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.

The new subplots were not installed in the same places where the remeasured plots were established. All of the current forest land area characteristics, e.g., stand size, ownership, forest type, stand age, and volume, are derived from data from the new subplots.

P3: forest health—Forest health data (P3 data) were collected on about 1/16th 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 data was not collected in Kentucky until 2000 so there is no previous methodology to compare and contrast.

P3 data include data related to tree crown health, dead woody material (DWM), foliar ozone injury, lichen diversity, and soil composition. Tree crown health, DWM, and soil composition measurements were collected using the same plot design used during P2 data collection, while lichen data were collected within a 120-foot radius circle centered on subplot 1 of each FIA P3 field plot (fig. A.2).

Biomonitoring sites for ozone data collection were located 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 a minimum number of plants of at least two identified bioindicator species (Smith and others, in press). 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

Previous surveys of Kentucky were done in a periodic fashion; all of the plots were measured in 1 to 2 years, and the remeasurement interval averaged 13 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 Commonwealth 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, so 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. In actuality, the 2004 cycle took 6 years to complete.

After field measurements are completed, a cycle of data (consisting of the data for five panels of plots) is then available for discussion in a 5-year report. This dataset consists of data of differing collection dates and ages: 20 percent of the data would be <1 year old, 20 percent >1 but <2 years old, and so on.

One major effect of the switch to the annual inventory design is that the length of the data collection period, which used to be 1 or 2 years, has increased to 5 years. Data collected over a longer period of time has a higher probability of sampling a specific event, e.g., a hurricane or fire, but only in a small proportion of the sample. However, data collected over a shorter time span may miss an event entirely until the next periodic measurement takes place, at which time all of the sample plots reflect the event.

Moreover, the elapsed time between an event and plot remeasurement may erase significant evidence that the event occurred.

Volume Estimation

Nonlinear regression was used to estimate tree volumes in the previous inventory (Scott 1979, 1981). Tree volumes in the 2004 Kentucky inventory were computed using a simple linear regression model of the form:

$$V = \alpha + \beta\,(dbh^2 * Ht) + \varepsilon$$

where

V = volume
α and β = parameters
dbh = diameter at breast height
Ht = height
ε = error

This equation estimated gross cubic-foot volume from a 1-foot stump to a 4-inch upper diameter for each sample tree. Separate equation coefficients for 77 species or species groupings were used. Net cubic-foot volume was derived by subtracting the estimate of rotten or missing wood for each sample tree. Volume of the saw-log portion (expressed in International ¼-inch board feet) of sample trees was derived by using board foot-to-cubic foot ratio equations. All equations and coefficients were developed from standing and felled tree volume studies conducted across several Southern States.

Growth, Removals, and Mortality Estimation

Previous—Estimates of growth, removals, and mortality in the 1988 inventory were based on data obtained by remeasuring 1,283 sample plots that were established in 1975. BAF 37.5 prisms were used to remeasure the 10-point variable-radius prism plots.

Current—Estimates of growth, removals, and mortality for the 2004 inventory were determined on the basis of remeasurement data for 1,751 sample plots established in the 1988 inventory. This was accomplished by remeasuring the trees on the poletimber and sawtimber plots at point center of the previous plot design. The reproduction plots at point center and the four satellite points were not remeasured. Differences between the volume equations used in this inventory and those used previously have already been described, and these differences affected growth, removal, and mortality volume estimates.

Changes in Methods Used to Assess Attributes

The methods used to assess various attributes have changed in some cases and this may affect trend analysis. In 1988, field personnel evaluated the forested area of the plot as a single stand, using the plurality of stocking as the basis of assessing most of the stand variables. The current procedures required mapping of divergent forest conditions across the plot, and then recording the differences in stand characteristics. Thus, the size and homogeneity of the assessment areas changed from one inventory to the next. There are also some differences between the 1988 algorithms employed by the Northeastern Research Station and the current algorithms used to compute stocking, stand size, and forest type. However, the forest-type data for the 2004 inventory reflect only the field crew's forest-type determination; no forest-type algorithm was employed. As FIA standardizes these algorithms nationally, region-to-region differences in methodology will diminish.

Change in Assessing Area of National Forest and Reserved Lands

Previous—In the 1988 Kentucky inventory, all national forest and public agency forest lands (timberland and reserved) plus forest industry timberland in each county were enumerated. The enumerated or known acreages were taken from public agency reports and other public domain documents at the Commonwealth and county levels. For each county, the known forest area in each enumerated ownership class was divided by the number of sample locations for that ownership class to produce an expansion factor. Also for each county, the total known forest area in enumerated ownership classes was subtracted from the county's total forest area (obtained from P1), and the result was divided by the number of sample locations on land that was not in enumerated ownership classes. The latter operations yielded expansion factors for the nonenumerated ownerships. In addition, supplemental plots were installed to account for small parcels of land where a FIA plot did not fall.

Current—Estimates of area for all lands and ownership classes were based on the probability of selection of P2 plot locations. Information about the area of land in various ownership classes was not used to determine area and plot expansion factors. As a result, known forest land area will not always agree closely with area estimates derived by means of probability of selection for all ownerships. For example, the known acreage of national forests, published by the National Forest System, will not agree exactly with FIA's statistically derived estimates of national forest land area. These numbers could differ substantially when areas are smaller, as at the county level.

Privacy Laws

It is important that forest land owners and FIA data users be aware that Federal law requires that private ownership information collected by FIA shall not be made available for public distribution. Federal law also requires that the exact locations of FIA plots shall not be made public, as this information could be used to determine who owns the land on which plots are sited. This resource bulletin summarizes FIA data by ownership class at the multicounty unit and State levels. FIA reports characterize ownership at the county level only as public or private, and FIA does not make more detailed county-level ownership information available, even on the FIADB Web site.

Summary

Users who wish to make rigorous comparisons between data from different surveys should be aware that plot designs and methods for assessing variables have changed over time. If there is no bias in plot selection or maintenance of plot integrity, the most valuable and powerful trend information is produced when the same plots are visited from one survey to the next and measured in the same way. This is also the only method that yields reliable components of change estimation (growth, removals, and mortality). This approach reduces the data noise that is present in natural forest stands and makes for a higher level of confidence in assessing trends. However, if sample designs change, there can never be a high level of certainty whether the trends in the data are real or due to procedural changes. Even though both designs may be judged statistically valid, the naturally occurring noise in the data hinders confident and rigorous assessments of trend over time. Data produced by different sample designs can have different degrees of strength in trend, depending on what is being compared. Defining the confidence and strength of trend over time is difficult or impossible when sample methodology differs.

A measure of reliability of inventory statistics is provided by sampling errors. Sampling errors (in percent) and confidence intervals for estimates of timberland area and inventory volumes are presented in the following tabulation. For each estimate in this tabulation, there is a two-out-of-three chance that the true population value is within the confidence interval indicated.

Sampling error (in percent) is calculated by dividing the square root of an estimate's variance by the estimate and multiplying the result by 100. The relative sizes of sampling errors (in percent) associated with estimates of different items indicate the relative reliability of those estimates.

FIA inventories supported by the full complement of sample plots are designed to achieve reliable statistics at the survey unit and State levels. 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. Statistical confidence may be

Item	Sample estimate and confidence interval	Sampling error
		percent
Timberland (1,000 acres)	11,647.9 ± 46.1	0.40
All live (million cubic feet)		
Inventory	21,187.9 ± 304.9	1.44
Net annual growth	565.0 ± 13.3	2.35
Annual removals	319.5 ± 25.4	7.96
Annual mortality	204.1 ± 13.9	6.80
Growing stock (million cubic feet)		
Inventory	18,217.4 ± 294.2	1.61
Net annual growth	470.0 ± 13.8	2.93
Annual removals	311.8 ± 25.1	8.04
Annual mortality	182.7 ± 12.0	6.58
Sawtimber (million board feet[a])		
Inventory	60,382.8 ± 1,358.8	2.25
Net annual growth	2,181.4 ± 81.4	3.73
Annual removals	1,166.3 ± 103.2	8.85
Annual mortality	478.2 ± 55.0	11.5

[a] International ¼-inch rule.

computed for any subdivision of State totals using the following formula.

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

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

Sampling errors obtained by this method are only approximations of reliability because this process assumes constant variance across all subdivisions of totals.

For example, the number of acres of timberland owned by forestry industry is estimated at 278.8 thousand acres. The estimate of sampling error for this example is computed as:

$$SE_s = 0.40 \frac{\sqrt{11,647.9}}{\sqrt{278.8}} = 2.59$$

Thus, the sampling error is 2.59 percent, and the resulting confidence interval of one standard error (two times out of three) for area of timberland owned by forest industry is 278.8±7.2 thousand acres. To achieve the 95-percent confidence interval, the standard error is multiplied by 1.96 or 278.8±14.1 thousand acres.

Precautions

The accuracy of small subsets of population totals is highly variable. Therefore, it is strongly recommended that users who are summarizing statistics from the FIADB avoid using data for any subdivision below the survey unit level. All published FIA reports include a chapter that explains sampling errors and provides cautions about the reliability of statistics for subpopulations, such as county-level statistics. Users should familiarize themselves with the procedures for computing sampling error, which are outlined above.

Species List[a]

Common name	Scientific name[b]	Common name	Scientific name[b]
Softwoods		Hardwoods (continued)	
Eastern redcedar	*Juniperus virginiana* L.	Black walnut	*Juglans nigra* L.
Shortleaf pine	*Pinus echinata* Mill.	Sweetgum	*Liquidambar styraciflua* L.
Table Mt. pine	*P. pungens* Lamb.	Yellow-poplar	*Liriodendron tulipifera* L.
Eastern white pine	*P. strobus* L.	Osage-orange	*Maclura pomifera* (Raf.) Schneid.
Loblolly pine	*P. taeda* L.	Cucumbertree	*Magnolia acuminata* L.
Virginia pine	*P. virginiana* Mill.	Southern magnolia	*M. grandiflora* L.
Baldcypress	*Taxodium distichum* (L.) Rich.	Bigleaf magnolia	*M. macrophylla* Michx.
Eastern hemlock	*Tsuga canadensis* (L.) Carr.	Apple	*Malus* spp. Mill.
		Chinaberry	*Melia azedarach* L.
Hardwoods		White mulberry	*Morus alba* L.
Boxelder	*Acer negundo* L.	Red mulberry	*M. rubra* L.
Red maple	*A. rubrum* L.	Water tupelo	*Nyssa aquatica* L.
Silver maple	*A. saccharinum* L.	Blackgum	*N. sylvatica* Marsh.
Sugar maple	*A. saccharum* Marsh.	Swamp tupelo	*N. sylvatica* var. *biflora* (Walt.) Sarg.
Buckeye	*Aesculus* spp. L.		
Ohio buckeye	*A. glabra* Willd.	Eastern hophornbeam	*Ostrya virginiana* (Mill.) K. Koch
Ailanthus	*Ailanthus altissima* (Mill.) Swingle	Sourwood	*Oxydendrum arboreum* (L.) DC.
Serviceberry	*Amelanchier* spp. Medic.	American sycamore	*Platanus occidentalis* L.
Yellow birch	*Betula alleghaniensis* Britton	Cottonwood	*Populus* spp. L.
River birch	*Betula nigra* L.	Black cherry	*Prunus serotina* Ehrh.
American hornbeam	*Carpinus caroliniana* Walt.	White oak	*Quercus alba* L.
Hickory	*Carya* spp. Nutt.	Scarlet oak	*Q. coccinea* Muenchh.
Water hickory	*C. aquatica* (Michx. f.) Nutt.	Durand oak	*Q. durandii* Buckl.
Bitternut hickory	*C. cordiformis* (Wangenh.) K. Koch	Southern red oak	*Q. falcata* Michx.
Pignut hickory	*C. glabra* (Mill.) Sweet	Cherrybark oak	*Q. falcata* var. *pagodifolia* Ell.
Pecan	*C. illinoensis* (Wangenh.) K. Koch	Overcup oak	*Q. lyrata* Walt.
Shellbark hickory	*C. laciniosa* (Michx. f.) Loud.	Swamp chestnut oak	*Q. michauxii* Nutt.
Nutmeg hickory	*C. myristiciformis* (Mich. f.) Nutt.	Chinkapin oak	*Q. muehlenbergii* Engelm.
Shagbark hickory	*C. ovata* (Mill.) K. Koch	Water oak	*Q. nigra* L.
Black hickory	*C. texana* Buckl.	Nuttall oak	*Q. nuttallii* Palmer
Mockernut hickory	*C. tomentosa* (Poir.) Nutt.	Pin oak	*Q. palustris* Muenchh.
Allegheny chinkapin	*Castanea pumila* Mill.	Willow oak	*Q. phellos* L.
Chinkapin	*Castanopsis* (D. Don) Spach	Chestnut oak	*Q. prinus* L.
Catalpa	*Catalpa* spp. Scop.	Northern red oak	*Q. rubra* L.
Sugarberry	*Celtis laevigata* Willd.	Shumard oak	*Q. shumardii* Buckl.
Hackberry	*C. occidentalis* L.	Post oak	*Q. stellata* Wangenh.
Eastern redbud	*Cercis canadensis* L.	Black oak	*Q. velutina* Lam.
Flowering dogwood	*Cornus florida* L.	Black locust	*Robinia pseudoacacia* L.
Hawthorn	*Crataegus* spp. L.	Willow	*Salix* spp. L.
Common persimmon	*Diospyros virginiana* L.	Sassafras	*Sassafras albidum* (Nutt.) Nees
American beech	*Fagus grandifolia* Ehrh.	American basswood	*Tilia americana* L.
White ash	*Fraxinus americana* L.	White basswood	*T. heterophylla* Vent.
Pumpkin ash	*F. profunda* (Bush) Bush	Winged elm	*Ulmus alata* Michx.
Blue ash	*F. quadrangulata* Michx.	American elm	*U. americana* L.
Waterlocust	*Gleditsia aquatica* Marsh.	Cedar elm	*U. crassifolia* Nutt.
Honeylocust	*G. triacanthos* L.	Slippery elm	*U. rubra* Muhl.
Kentucky coffeetree	*Gymnocladus dioicus* (L.) K. Koch	September elm	*U. serotina* Sarg.
American holly	*Ilex opaca* Ait.	Rock elm	*U. thomasii* Sarg.

[a] Common and scientific names of tree species > 1.0 inch d.b.h. occurring in the FIA sample.
[b] Little (1979).

Table A.1—Land area by survey unit and land class, Kentucky, 2004

Survey unit	Total land area [a]	Forest land: Total forest	Forest land: Timber-land	Forest land: Productive reserved	Forest land: Other	Other land [b]
	thousand acres					
Eastern	2,123.1	1,838.8	1,794.6	32.0	12.1	284.2
Northern Cumberland	2,492.1	1,909.6	1,884.6	21.9	3.1	582.6
Southern Cumberland	2,780.1	2,197.2	2,063.2	127.4	6.7	582.8
Bluegrass	5,617.2	1,559.2	1,550.5	8.7	—	4,058.0
Pennyroyal	4,818.1	2,080.2	2,041.6	33.1	5.4	2,737.9
Western Coalfield	5,438.8	1,686.8	1,644.5	31.8	10.5	3,752.0
Western	2,156.6	698.6	668.9	29.7	—	1,458.0
All units	25,425.9	11,970.4	11,647.9	284.7	37.8	13,455.5

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.
[a] From the U.S. Bureau of the Census (2000).
[b] Includes 138.84 thousand acres classified as land by the Bureau of the Census and as water by Forest Inventory and Analysis.

Table A.2—Area of timberland by survey unit and ownership class, Kentucky, 2004

Survey unit	All classes	Ownership class: National forest	Ownership class: Other public	Ownership class: Forest industry	Ownership class: Nonindustrial private
	thousand acres				
Eastern	1,794.6	71.3	39.5	24.6	1,659.2
Northern Cumberland	1,884.6	127.3	83.8	56.5	1,616.9
Southern Cumberland	2,063.2	319.5	43.8	49.3	1,650.6
Bluegrass	1,550.5	16.8	36.8	15.9	1,481.0
Pennyroyal	2,041.6	23.7	75.4	52.5	1,890.0
Western Coalfield	1,644.5	—	77.9	23.0	1,543.7
Western	668.9	31.5	82.7	57.0	497.7
All units	11,647.9	590.3	439.7	278.8	10,339.1

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.

Table A.3—Area of timberland by survey unit and forest-type group, Kentucky, 2004

Survey unit	All groups	Forest-type group: White-red-jack pine	Loblolly-shortleaf	Pinyon-juniper[a]	Oak-pine	Oak-hickory	Oak-gum-cypress	Elm-ash-cottonwood	Maple-beech-birch	Aspen-birch	Non-stocked
	thousand acres										
Eastern	1,794.6	37.5	16.3	—	29.3	1,407.3	—	34.5	263.2	—	6.6
Northern Cumberland	1,884.6	68.6	37.1	10.3	109.1	1,585.7	—	10.7	57.6	4.1	1.5
Southern Cumberland	2,063.2	44.7	114.9	—	112.6	1,659.3	1.6	29.2	96.0	—	4.9
Bluegrass	1,550.5	—	7.0	85.5	360.6	753.0	—	202.5	126.8	—	15.0
Pennyroyal	2,041.6	5.9	42.5	54.5	284.6	1,408.6	—	84.9	150.7	—	9.9
Western Coalfield	1,644.5	—	20.0	20.1	151.9	1,173.2	21.8	171.7	64.8	—	21.2
Western	668.9	—	6.5	—	30.6	449.3	56.6	111.9	10.2	—	3.7
All units	11,647.9	156.8	244.2	170.3	1,078.7	8,436.3	80.0	645.4	769.3	4.1	62.8

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.
Forest-type groups are based on field estimates.
[a] Includes eastern redcedar forest type.

Table A.4—Area of timberland by survey unit and stand-size class, Kentucky, 2004

Survey unit	All classes	Stand-size class: Saw-timber	Pole-timber	Sapling-seedling	Non-stocked
	thousand acres				
Eastern	1,794.6	1,374.5	270.8	142.7	6.6
Northern Cumberland	1,884.6	1,301.3	411.1	170.6	1.5
Southern Cumberland	2,063.2	1,424.6	400.4	233.4	4.9
Bluegrass	1,550.5	786.1	558.8	190.6	15.0
Pennyroyal	2,041.6	1,312.8	501.6	217.4	9.9
Western Coalfield	1,644.5	1,002.7	486.7	133.9	21.2
Western	668.9	403.5	192.2	69.4	3.7
All units	11,647.9	7,605.4	2,821.6	1,158.0	62.8

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

Table A.5—Area of timberland by forest-type group, stand origin, and ownership class, Kentucky, 2004

Forest-type group and stand origin	All classes	Ownership class: National forest	Other public	Forest industry	Nonindustrial private
	thousand acres				
Softwood types					
White-red-jack pine					
Planted	16.7	9.0	—	—	7.7
Natural	140.1	23.7	3.5	—	112.9
Total	156.8	32.7	3.5	—	120.6
Loblolly-shortleaf					
Planted	31.2	—	—	2.3	28.9
Natural	213.0	13.4	1.7	—	197.8
Total	244.2	13.4	1.7	2.3	226.7
Pinyon-juniper [a]	170.3	—	9.8	—	160.5
Total softwoods	571.3	46.1	15.0	2.3	507.8
Hardwood types					
Oak-pine					
Planted	21.3	—	9.5	6.0	5.8
Natural	1,057.3	46.5	50.5	6.5	953.9
Total	1,078.7	46.5	60.0	12.5	959.7
Oak-hickory	8,436.3	481.4	292.4	216.9	7,445.7
Oak-gum-cypress	80.0	—	14.4	17.3	48.2
Elm-ash-cottonwood	645.4	—	38.2	5.6	601.6
Maple-beech-birch	769.3	16.3	15.1	24.1	713.8
Aspen-birch	4.1	—	—	—	4.1
Total hardwoods	11,013.8	544.1	420.1	276.5	9,773.1
Nonstocked	62.8	—	4.6	—	58.2
All groups	11,647.9	590.3	439.7	278.8	10,339.1

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.
Forest-type groups are based on field estimates.
[a] Includes eastern redcedar forest type.

Table A.6—Number of live trees on timberland by species group and diameter class, Kentucky, 2004

Species group	All classes	1.0–2.9	3.0–4.9	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
		Diameter class (*inches at breast height*)											
		thousand trees											
Softwood													
Yellow pine	172,310	73,967	32,623	20,492	15,977	11,981	8,208	4,548	2,845	891	467	310	—
Other softwoods	396,096	199,166	107,744	46,569	22,896	10,093	4,341	2,241	1,007	733	419	812	74
All softwoods	568,406	273,133	140,367	67,061	38,874	22,074	12,550	6,789	3,852	1,624	886	1,122	74
Hardwood													
Soft hardwood	2,588,641	1,642,030	446,929	195,699	114,205	68,985	46,753	30,900	19,905	10,681	5,153	6,378	1,022
Hard hardwood	3,312,096	1,876,406	558,724	267,596	181,792	136,213	100,176	74,693	48,544	29,822	16,405	19,444	2,282
All hardwoods	5,900,736	3,518,436	1,005,653	463,295	295,996	205,198	146,929	105,594	68,450	40,503	21,558	25,822	3,304
All species	6,469,142	3,791,569	1,146,020	530,355	334,870	227,272	159,479	112,382	72,302	42,127	22,444	26,944	3,378

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.

Table A.7—Number of growing-stock trees on timberland by species group and diameter class, Kentucky, 2004

Species group	All classes	Diameter class (*inches at breast height*) 1.0–2.9	3.0–4.9	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
	thousand trees												
Softwood													
Yellow pine	90,215	15,541	17,179	17,633	13,791	10,703	7,587	3,957	2,459	763	325	277	—
Other softwoods	149,158	54,034	42,000	26,607	14,617	5,576	2,531	1,482	602	618	246	772	74
All softwoods	239,373	69,576	59,178	44,239	28,408	16,280	10,118	5,439	3,062	1,381	571	1,048	74
Hardwood													
Soft hardwood	863,322	293,255	197,035	130,534	84,850	55,330	38,669	26,610	17,531	9,130	4,542	5,214	622
Hard hardwood	1,132,124	248,788	201,260	175,149	141,603	114,872	86,018	65,738	42,714	26,234	14,175	14,485	1,086
All hardwoods	1,995,446	542,043	398,295	305,683	226,454	170,202	124,687	92,348	60,244	35,364	18,718	19,700	1,708
All species	2,234,819	611,619	457,473	349,922	254,861	186,482	134,805	97,786	63,306	36,745	19,289	20,748	1,782

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.

Table A.8—Volume of live trees on timberland by species group and diameter class, Kentucky, 2004

Species group	All classes	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
		Diameter class (*inches at breast height*)									
	million cubic feet										
Softwood											
Yellow pine	852.0	59.5	110.8	150.8	167.6	135.3	122.6	49.2	31.8	24.5	—
Other softwoods	597.9	98.8	112.5	89.3	61.8	49.5	29.0	32.5	22.5	84.9	17.0
All softwoods	1,449.9	158.3	223.2	240.1	229.4	184.9	151.6	81.7	54.3	109.3	17.0
Hardwood											
Soft hardwood	6,248.5	535.2	717.8	803.6	873.5	865.8	772.0	533.7	340.7	602.4	203.9
Hard hardwood	13,489.6	718.4	1,131.3	1,576.9	1,845.4	2,007.1	1,810.3	1,432.1	987.4	1,624.9	355.8
All hardwoods	19,738.1	1,253.5	1,849.1	2,380.5	2,718.9	2,872.9	2,582.3	1,965.8	1,328.1	2,227.2	559.7
All species	21,187.9	1,411.8	2,072.3	2,620.7	2,948.2	3,057.8	2,733.9	2,047.5	1,382.4	2,336.6	576.7

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.

Table A.9—Volume of growing-stock trees on timberland by species group and diameter class, Kentucky, 2004

Species group	All classes	5.0–6.9	7.0–8.9	9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
		Diameter class (*inches at breast height*)									
	million cubic feet										
Softwood											
Yellow pine	763.4	53.7	99.0	138.1	156.6	119.4	106.7	43.5	24.1	22.3	—
Other softwoods	419.0	60.4	75.8	51.0	38.1	34.8	17.9	28.8	13.8	81.5	17.0
All softwoods	1,182.4	114.1	174.8	189.1	194.7	154.2	124.6	72.3	37.9	103.7	17.0
Hardwood											
Soft hardwood	5,355.0	386.6	571.2	679.4	762.6	775.7	709.3	483.1	310.1	525.8	151.2
Hard hardwood	11,680.0	511.6	929.4	1,382.8	1,646.4	1,814.3	1,648.8	1,312.2	889.5	1,335.4	209.5
All hardwoods	17,035.0	898.2	1,500.6	2,062.2	2,409.0	2,590.0	2,358.1	1,795.4	1,199.6	1,861.2	360.7
All species	18,217.4	1,012.3	1,675.4	2,251.3	2,603.7	2,744.1	2,482.7	1,867.7	1,237.5	1,964.9	377.7

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.

Table A.10—Volume of sawtimber on timberland by species group and diameter class, Kentucky, 2004

Species group	All classes	Diameter class (*inches at breast height*) 9.0–10.9	11.0–12.9	13.0–14.9	15.0–16.9	17.0–18.9	19.0–20.9	21.0–28.9	29.0 and larger
	million board feet [a]								
Softwood									
Yellow pine	2,873.3	502.3	686.4	585.4	572.0	248.0	141.6	137.6	—
Other softwoods	1,464.9	199.9	171.0	172.0	95.7	156.2	77.9	483.7	108.6
All softwoods	4,338.2	702.2	857.4	757.3	667.7	404.2	219.4	621.3	108.6
Hardwood									
Soft hardwood	17,391.7	—	2,635.1	3,205.9	3,333.9	2,450.4	1,671.8	3,086.7	1,007.8
Hard hardwood	38,653.0	—	5,674.0	7,191.0	7,197.2	6,117.6	4,328.1	6,967.9	1,177.2
All hardwoods	56,044.6	—	8,309.1	10,396.9	10,531.1	8,568.1	5,999.9	10,054.6	2,184.9
All species	60,382.8	702.2	9,166.6	11,154.3	11,198.9	8,972.3	6,219.3	10,675.8	2,293.6

— = no sample for the cell.
Numbers in rows and columns may not sum to totals due to rounding.
[a] International ¼-inch rule.

Table A.11—Volume of live trees on timberland by survey unit and species group, Kentucky, 2004

Survey unit	All species	Softwoods: All softwood	Yellow pine	Other softwood	Hardwoods: All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Eastern	3,627.5	117.6	74.7	42.9	3,509.9	1,365.6	2,144.3
Northern Cumberland	3,519.3	267.4	205.5	61.9	3,251.9	870.3	2,381.6
Southern Cumberland	3,936.1	318.7	260.8	57.9	3,617.4	1,195.5	2,421.9
Bluegrass	2,299.2	197.5	21.6	176.0	2,101.6	583.2	1,518.4
Pennyroyal	3,654.9	284.9	170.5	114.4	3,370.0	888.5	2,481.5
Western Coalfield	2,878.1	155.6	99.2	56.5	2,722.5	905.7	1,816.8
Western	1,272.8	108.0	19.7	88.3	1,164.8	439.6	725.2
All units	21,187.9	1,449.9	852.0	597.9	19,738.1	6,248.5	13,489.6

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

Table A.12—Volume of growing stock on timberland by survey unit and species group, Kentucky, 2004

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Eastern	3,054.3	98.3	68.6	29.7	2,956.0	1,205.9	1,750.2
Northern Cumberland	3,176.3	248.4	189.6	58.8	2,927.9	775.6	2,152.3
Southern Cumberland	3,483.3	288.5	239.9	48.6	3,194.8	1,052.4	2,142.4
Bluegrass	1,791.6	123.3	18.9	104.4	1,668.3	440.2	1,228.1
Pennyroyal	3,142.3	208.9	145.7	63.1	2,933.4	734.6	2,198.8
Western Coalfield	2,443.8	111.8	81.7	30.0	2,332.1	771.2	1,560.9
Western	1,125.7	103.3	18.9	84.4	1,022.4	375.1	647.3
All units	18,217.4	1,182.4	763.4	419.0	17,035.0	5,355.0	11,680.0

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

Table A.13—Volume of sawtimber on timberland by survey unit and species group, Kentucky, 2004

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million board feet [a]						
Eastern	10,428.2	421.3	294.7	126.7	10,006.9	4,039.8	5,967.1
Northern Cumberland	10,145.4	975.0	702.7	272.3	9,170.4	2,208.4	6,962.0
Southern Cumberland	11,594.5	1,054.4	872.9	181.4	10,540.1	3,219.6	7,320.5
Bluegrass	5,646.7	292.0	62.5	229.5	5,354.7	1,512.2	3,842.5
Pennyroyal	10,210.0	653.1	530.8	122.3	9,556.8	2,349.6	7,207.2
Western Coalfield	8,054.8	437.3	367.7	69.6	7,617.5	2,455.4	5,162.1
Western	4,303.3	505.0	41.9	463.1	3,798.3	1,606.8	2,191.5
All units	60,382.8	4,338.2	2,873.3	1,464.9	56,044.6	17,391.7	38,653.0

Numbers in rows and columns may not sum to totals due to rounding.
[a] International ¼-inch rule.

Table A.14—Volume of live trees and growing stock on timberland by ownership class and species group, Kentucky, 2004

Ownership class	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
Live trees (*million cubic feet*)							
National forest	1,398.2	157.2	106.0	51.2	1,241.0	286.9	954.1
Other public	980.9	119.6	65.5	54.0	861.3	247.0	614.3
Forest industry	576.2	75.1	16.1	59.0	501.1	188.5	312.5
Nonindustrial private	18,232.7	1,098.0	664.4	433.6	17,134.7	5,526.0	11,608.7
All classes	21,187.9	1,449.9	852.0	597.9	19,738.1	6,248.5	13,489.6
Growing-stock trees (*million cubic feet*)							
National forest	1,297.6	151.2	104.0	47.2	1,146.4	263.7	882.7
Other public	848.8	93.6	49.1	44.5	755.2	209.8	545.4
Forest industry	525.9	73.7	15.9	57.8	452.2	178.7	273.4
Nonindustrial private	15,545.1	863.9	594.4	269.5	14,681.2	4,702.8	9,978.4
All classes	18,217.4	1,182.4	763.4	419.0	17,035.0	5,355.0	11,680.0

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

Table A.15—Volume of sawtimber on timberland by ownership class and species group, Kentucky, 2004

Ownership class	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
All size classes (*million board feet*[a])							
National forest	4,767.3	659.9	452.2	207.6	4,107.4	835.1	3,272.3
Other public	3,164.6	413.8	220.0	193.8	2,750.8	771.8	1,979.1
Forest industry	2,043.6	348.5	18.5	330.0	1,695.1	789.0	906.1
Nonindustrial private	50,407.4	2,916.1	2,182.5	733.6	47,491.3	14,995.8	32,495.5
All classes	60,382.8	4,338.2	2,873.3	1,464.9	56,044.6	17,391.7	38,653.0
Trees ≥ 15.0 inches d.b.h. (*million board feet*[a])							
National forest	3,410.8	370.2	208.4	161.8	3,040.5	589.3	2,451.2
Other public	2,296.3	258.1	115.1	143.0	2,038.2	585.5	1,452.7
Forest industry	1,659.1	316.2	2.9	313.3	1,342.9	682.5	660.4
Nonindustrial private	31,993.7	1,076.8	772.8	304.0	30,917.0	9,693.3	21,223.6
All classes	39,359.9	2,021.3	1,099.2	922.1	37,338.6	11,550.6	25,788.0

Numbers in rows and columns may not sum to totals due to rounding.
[a] International ¼-inch rule.

Table A.16—Volume of growing stock on timberland by forest-type group, stand origin, and species group, Kentucky, 2004

		Softwoods			Hardwoods		
Forest-type group and stand origin	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	33.3	31.0	30.9	0.1	2.3	1.4	1.0
Natural	249.3	97.4	20.5	76.9	151.9	60.6	91.3
Total	282.7	128.4	51.5	76.9	154.3	62.0	92.3
Loblolly-shortleaf							
Planted	54.0	50.2	50.1	0.1	3.9	2.4	1.5
Natural	251.2	158.0	154.6	3.4	93.2	36.0	57.2
Total	305.3	208.2	204.7	3.5	97.1	38.4	58.7
Pinyon-juniper [a]	65.5	36.9	6.8	30.0	28.7	8.6	20.1
Total softwoods	653.5	373.4	263.0	110.4	280.1	109.0	171.1
Hardwood types							
Oak-pine							
Planted	19.1	16.7	16.7	—	2.5	2.1	0.4
Natural	1,009.9	348.5	220.5	128.1	661.4	197.0	464.4
Total	1,029.0	365.2	237.1	128.1	663.8	199.1	464.7
Oak-hickory	14,190.0	352.0	261.1	90.9	13,838.0	3,964.1	9,874.0
Oak-gum-cypress	289.2	80.1	—	80.1	209.1	121.3	87.8
Elm-ash-cottonwood	868.0	2.5	0.0	2.5	865.5	532.1	333.5
Maple-beech-birch	1,186.3	9.2	2.2	7.1	1,177.0	428.2	748.8
Total hardwoods	17,562.5	809.0	500.4	308.6	16,753.5	5,244.8	11,508.8
Nonstocked	1.4	—	—	—	1.4	1.2	0.1
All groups	18,217.4	1,182.4	763.4	419.0	17,035.0	5,355.0	11,680.0

— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
Numbers in rows and columns may not sum to totals due to rounding.
Forest-type groups are based on field estimates.
[a] Includes eastern redcedar forest type.

Table A.17—Average net annual growth of live trees on timberland by survey unit and species group, Kentucky, 1988 to 2003

Survey unit	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Eastern	74.9	3.6	2.8	0.8	71.3	30.2	41.1
Northern Cumberland	80.0	2.6	1.7	0.9	77.3	26.3	51.1
Southern Cumberland	100.4	8.9	6.0	2.9	91.5	39.6	51.9
Bluegrass	63.1	7.8	0.0	7.8	55.3	12.9	42.4
Pennyroyal	109.8	8.9	3.9	5.0	100.9	35.1	65.8
Western Coalfield	94.6	6.0	4.0	2.0	88.7	34.1	54.6
Western	42.1	1.9	1.7	0.3	40.2	15.0	25.2
All units	565.0	39.8	20.2	19.6	525.2	193.2	332.0

Numbers in rows and columns may not sum to totals due to rounding.
0.0 = a value of > 0.0 but < 0.05 for the cell.

Table A.18—Average net annual growth of growing stock on timberland by survey unit and species group, Kentucky, 1988 to 2003

Survey unit	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Eastern	62.2	3.3	2.5	0.8	58.9	25.2	33.7
Northern Cumberland	70.9	2.2	1.4	0.9	68.7	23.0	45.7
Southern Cumberland	87.8	7.0	4.5	2.5	80.8	34.6	46.2
Bluegrass	43.6	5.4	0.2	5.2	38.2	8.4	29.8
Pennyroyal	93.2	5.1	2.5	2.6	88.1	29.8	58.3
Western Coalfield	75.4	3.1	2.7	0.3	72.4	26.9	45.5
Western	36.8	1.4	1.4	-0.0	35.4	12.7	22.7
All units	470.0	27.5	15.2	12.2	442.5	160.7	281.8

Numbers in rows and columns may not sum to totals due to rounding.
-0.0 = a value of < 0.0 but > -0.5 for the cell.

Table A.19—Average net annual growth of sawtimber on timberland by survey unit and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million board feet [a]			
Eastern	290.8	16.3	12.0	4.3	274.5	105.8	168.7
Northern Cumberland	333.5	23.6	20.0	3.7	309.8	104.7	205.1
Southern Cumberland	423.5	54.3	43.2	11.1	369.2	145.4	223.8
Bluegrass	171.2	14.2	0.7	13.5	157.0	36.0	121.0
Pennyroyal	455.9	25.0	17.9	7.2	430.9	145.0	286.0
Western Coalfield	331.6	17.5	15.6	1.9	314.1	112.0	202.1
Western	174.9	5.9	6.5	-0.6	169.0	61.8	107.2
All units	2,181.4	156.8	115.8	41.0	2,024.6	710.6	1,314.0

Numbers in rows and columns may not sum to totals due to rounding.
[a] International ¼-inch rule.

Table A.20—Average annual removals of live trees on timberland by survey unit and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million cubic feet			
Eastern	42.1	1.0	0.4	0.6	41.1	13.9	27.2
Northern Cumberland	49.1	0.7	0.7	—	48.4	12.5	35.9
Southern Cumberland	39.2	5.0	4.8	0.2	34.2	14.4	19.8
Bluegrass	30.8	6.1	0.1	6.0	24.7	9.8	14.9
Pennyroyal	66.9	9.7	7.2	2.4	57.2	17.7	39.5
Western Coalfield	63.2	0.6	0.3	0.3	62.6	17.0	45.6
Western	28.1	0.2	0.0	0.1	28.0	11.0	17.0
All units	319.5	23.3	13.6	9.7	296.3	96.4	199.9

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.

Table A.21—Average annual removals of growing stock on timberland by survey unit and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million cubic feet			
Eastern	40.6	1.0	0.4	0.6	39.6	13.1	26.5
Northern Cumberland	48.6	0.7	0.7	—	47.9	12.3	35.6
Southern Cumberland	38.4	5.0	4.8	0.2	33.4	13.8	19.6
Bluegrass	29.2	5.9	0.1	5.7	23.3	9.4	13.9
Pennyroyal	65.7	9.5	7.2	2.2	56.3	17.1	39.2
Western Coalfield	62.7	0.6	0.3	0.3	62.1	16.7	45.4
Western	26.6	0.2	0.0	0.1	26.5	10.2	16.3
All units	311.8	22.7	13.6	9.1	289.0	92.6	196.4

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.

Table A.22—Average annual removals of sawtimber on timberland by survey unit and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Survey unit	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				million board feet [a]			
Eastern	163.2	4.8	1.9	2.9	158.5	55.2	103.3
Northern Cumberland	181.8	2.8	2.8	—	179.0	52.9	126.1
Southern Cumberland	157.7	16.2	15.5	0.7	141.5	61.3	80.2
Bluegrass	88.7	12.2	0.5	11.7	76.5	35.9	40.6
Pennyroyal	261.8	41.3	34.6	6.7	220.5	74.5	146.0
Western Coalfield	232.1	0.6	—	0.6	231.6	58.5	173.1
Western	80.9	0.5	0.0	0.5	80.4	18.2	62.2
All units	1,166.3	78.3	55.3	23.1	1,088.0	356.5	731.5

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] International ¼-inch rule.

Table A.23—Average net annual growth and average annual removals of live trees, growing stock, and sawtimber on timberland by species group, Kentucky, 1988 to 2003

Species group	Live trees		Growing stock		Sawtimber	
	Net annual growth	Annual removals	Net annual growth	Annual removals	Net annual growth	Annual removals
	- - - - - - - - million cubic feet - - - - - - - -				*million board feet* [a]	
Softwood						
Yellow pine	20.2	13.6	15.2	13.6	115.8	55.3
Other softwoods	19.6	9.7	12.2	9.1	41.0	23.1
All softwoods	39.8	23.3	27.5	22.7	156.8	78.3
Hardwood						
Soft hardwood	193.2	96.4	160.7	92.6	710.6	356.5
Hard hardwood	332.0	199.9	281.8	196.4	1,314.0	731.5
All hardwoods	525.2	296.3	442.5	289.0	2,024.6	1,088.0
All species	565.0	319.5	470.0	311.8	2,181.4	1,166.3

Numbers in rows and columns may not sum to totals due to rounding.
[a] International ¼-inch rule.

Table A.24—Average annual mortality of live trees, growing stock, and sawtimber on timberland by species group, Kentucky, 1988 to 2003

Species group	Live trees	Growing stock	Saw-timber
	million cubic feet		*mmbf* [a]
Softwood			
Yellow pine	24.3	24.0	67.4
Other softwoods	3.2	3.1	4.3
All softwoods	27.5	27.0	71.7
Hardwood			
Soft hardwood	54.6	48.9	109.1
Hard hardwood	122.1	106.7	297.4
All hardwoods	176.6	155.7	406.5
All species	204.1	182.7	478.2

Numbers in columns may not sum to totals due to rounding.
[a] International ¼-inch rule.

Table A.25—Average net annual growth and average annual removals of live trees on timberland by ownership class and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Ownership class	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
				Average net annual growth (*million cubic feet*)			
National forest	27.7	3.4	1.5	1.9	24.3	9.0	15.2
Other public	23.5	1.9	1.0	0.9	21.6	9.2	12.3
Forest industry	10.1	0.9	0.8	0.1	9.2	3.7	5.5
Nonindustrial private	503.7	33.6	16.9	16.7	470.1	171.2	298.9
All classes	565.0	39.8	20.2	19.6	525.2	193.2	332.0
				Average annual removals (*million cubic feet*)			
National forest	4.3	0.2	0.2	—	4.1	1.3	2.8
Other public	3.0	0.0	0.0	—	2.9	0.7	2.3
Forest industry	6.6	0.2	0.2	—	6.4	1.9	4.6
Nonindustrial private	305.6	22.8	13.1	9.7	282.8	92.6	190.2
All classes	319.5	23.3	13.6	9.7	296.3	96.4	199.9

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.

Table A.26—Average net annual growth and average annual removals of growing stock on timberland by ownership class and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Ownership class	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	Average net annual growth (*million cubic feet*)						
National forest	24.4	3.3	1.4	1.8	21.2	7.6	13.5
Other public	18.8	-0.4	-0.6	0.2	19.2	8.0	11.2
Forest industry	9.1	0.6	0.6	—	8.5	3.2	5.3
Nonindustrial private	417.7	24.0	13.8	10.2	393.7	141.9	251.8
All classes	470.0	27.5	15.2	12.2	442.5	160.7	281.8
	Average annual removals (*million cubic feet*)						
National forest	4.3	0.2	0.2	—	4.1	1.3	2.8
Other public	2.8	0.0	0.0	—	2.8	0.6	2.2
Forest industry	6.3	0.2	0.2	—	6.1	1.6	4.5
Nonindustrial private	298.3	22.3	13.1	9.1	276.0	89.2	186.8
All classes	311.8	22.7	13.6	9.1	289.0	92.6	196.4

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.

Table A.27—Average net annual growth and average annual removals of sawtimber on timberland by ownership class and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Ownership class	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	Average net annual growth (*million board feet*[a])						
National forest	127.4	20.8	12.6	8.2	106.6	34.0	72.6
Other public	99.7	4.4	3.9	0.5	95.3	32.9	62.4
Forest industry	33.1	-0.0	-0.0	—	33.1	6.7	26.4
Nonindustrial private	1,921.3	131.6	99.3	32.3	1,789.6	637.0	1,152.6
All classes	2,181.4	156.8	115.8	41.0	2,024.6	710.6	1,314.0
	Average annual removals (*million board feet*[a])						
National forest	12.2	—	—	—	12.2	3.0	9.2
Other public	10.1	—	—	—	10.1	1.6	8.5
Forest industry	29.4	1.0	1.0	—	28.4	8.8	19.6
Nonindustrial private	1,114.6	77.3	54.2	23.1	1,037.3	343.1	694.2
All classes	1,166.3	78.3	55.3	23.1	1,088.0	356.5	731.5

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; -0.0 = a value of < 0.0 but > -0.5 for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] International ¼-inch rule.

Table A.28—Average net annual growth of growing stock on timberland by forest-type group, stand origin, and species group, Kentucky, 1988 to 2003

		Softwoods			Hardwoods		
Forest-type group [a] and stand origin [b]	All species	All softwood	Yellow pine	Other softwood	All hardwood	Soft hardwood	Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	—	—	—	—	—	—	—
Natural	2.2	1.7	0.8	0.8	0.5	0.6	-0.1
Total	2.2	1.7	0.8	0.8	0.5	0.6	-0.1
Loblolly-shortleaf pine							
Planted	2.2	1.8	1.8	—	0.4	0.3	0.1
Natural	17.4	9.8	9.2	0.6	7.6	3.7	3.8
Total	19.6	11.6	11.0	0.6	7.9	4.0	3.9
Pinyon-juniper [c]	5.9	3.1	0.3	2.8	2.7	0.6	2.1
Total softwoods	27.7	16.4	12.1	4.2	11.1	5.2	5.9
Hardwood types							
Oak-pine							
Planted	—	—	—	—	—	—	—
Natural	26.6	3.3	0.4	2.9	23.2	10.0	13.2
Total	26.6	3.3	0.4	2.9	23.2	10.0	13.2
Oak-hickory	366.1	7.1	2.6	4.5	358.9	120.7	238.3
Oak-gum-cypress	1.8	0.0	—	0.0	1.8	0.5	1.3
Elm-ash-cottonwood	23.4	0.3	—	0.3	23.1	17.0	6.1
Maple-beech-birch	24.5	0.2	0.1	0.2	24.2	7.3	17.0
Aspen-birch	—	—	—	—	—	—	—
Total hardwoods	442.4	10.9	3.1	7.9	431.2	155.5	275.9
Nonstocked	—	—	—	—	—	—	—
All groups	470.0	27.5	15.2	12.1	442.5	160.7	281.8

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] Forest-type groups are based on field estimates. Forest types calculated by an algorithm from the tree tally are not yet available.
[b] Classification at the beginning of the remeasurement period.
[c] Includes eastern redcedar forest type.

Table A.29—Average annual removals of growing stock on timberland by forest-type group, stand origin, and species group, Kentucky, 1988 to 2003

Forest-type group [a] and stand origin [b]	All species	Softwoods: All softwood	Softwoods: Yellow pine	Softwoods: Other softwood	Hardwoods: All hardwood	Hardwoods: Soft hardwood	Hardwoods: Hard hardwood
	million cubic feet						
Softwood types							
White-red-jack pine							
Planted	—	—	—	—	—	—	—
Natural	0.4	0.4	—	0.4	0.1	—	0.1
Total	0.4	0.4	—	0.4	0.1	—	0.1
Loblolly-shortleaf pine							
Planted	0.3	0.3	0.3	—	—	—	—
Natural	11.4	10.3	10.0	0.3	1.1	0.7	0.4
Total	11.7	10.6	10.3	0.3	1.1	0.7	0.4
Pinyon-juniper [c]	2.0	2.0	—	2.0	—	—	—
Total softwoods	14.1	13.0	10.3	2.7	1.2	0.7	0.5
Hardwood types							
Oak-pine							
Planted	—	—	—	—	—	—	—
Natural	9.8	6.1	2.0	4.1	3.6	1.4	2.3
Total	9.8	6.1	2.0	4.1	3.6	1.4	2.3
Oak-hickory	245.9	2.8	1.4	1.5	243.1	72.9	170.1
Oak-gum-cypress	1.7	0.0	—	0.0	1.6	0.2	1.5
Elm-ash-cottonwood	13.1	0.8	—	0.8	12.3	11.0	1.3
Maple-beech-birch	27.2	0.0	—	0.0	27.2	6.4	20.8
Aspen-birch	—	—	—	—	—	—	—
Total hardwoods	297.7	9.8	3.4	6.4	287.9	91.9	196.0
Nonstocked	—	—	—	—	—	—	—
All groups	311.8	22.7	13.7	9.1	289.0	92.6	196.5

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] Forest-type groups are based on field estimates. Forest types calculated by an algorithm from the tree tally are not yet available.
[b] Classification at the beginning of the remeasurement period.
[c] Includes eastern redcedar forest type.

Table A.30—Area of timberland treated or disturbed annually and retained in timberland by treatment or disturbance and ownership class, Kentucky, 1988 to 2003

Treatment or disturbance [a]	All classes	Ownership class: Public	Forest industry	Private
	thousand acres			
Final harvest	28.1	1.3	4.1	22.7
Partial harvest [b]	282.0	7.4	11.2	263.4
Seed tree/shelterwood	9.5	0.3	1.2	8.1
Commercial thinning	9.4	0.3	3.7	5.4
Other stand improvement	4.5	2.6	—	2.0
Site preparation	4.1	—	—	4.1
Artificial regeneration [c]	0.3	0.0	0.0	0.3
Natural regeneration [c]	79.1	6.0	5.4	67.8
Other cutting	—	—	—	—
Natural disturbance				
Insects	29.0	7.4	1.4	20.2
Disease	3.1	—	—	3.1
Weather				
Ice	14.8	4.7	—	10.1
Wind	7.3	1.3	—	6.0
Flood	34.1	3.1	3.8	27.2
Drought	—	—	—	—
Weather - other	64.4	14.8	2.9	46.6
Total	120.6	23.8	6.8	90.0
Fire				
Ground	37.3	5.0	1.2	31.1
Crown	—	—	—	—
Fire - other	53.2	7.0	—	46.2
Total	90.5	12.0	1.2	77.3
Animals				
Beaver	5.2	—	1.4	3.8
Porcupine	—	—	—	—
Deer/ungulate	2.3	1.2	—	1.1
Bear	—	—	—	—
Rabbit	—	—	—	—
Animals - other	6.9	0.9	1.0	5.0
Total	14.4	2.1	2.4	9.8
Other disturbances				
Grazing	84.5	—	—	84.5
Other human-caused disturbance	101.6	4.5	2.8	94.3
Other naturally caused disturbance	8.1	1.0	—	7.2

Since some acres experience more than one treatment or disturbance, there are no column totals.
Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] Previous established plots record treatment and disturbance since last inventory. New plots record treatment and disturbance only if it occurred within the last 5 years.
[b] Includes high-grading and some selective cutting.
[c] Includes establishment of trees for timber production on forest and nonforest land.

Table A.31—Average annual output of timber products by product, species group, and type of material, Kentucky, 1988 to 2003

Product and species group	Total output	Round-wood products	Plant byproducts
	million cubic feet		
Saw logs			
Softwood	5.6	5.6	—
Hardwood	155.0	154.9	0.1
Total	160.6	160.5	0.1
Veneer logs			
Softwood	0.1	0.1	—
Hardwood	5.5	5.5	—
Total	5.5	5.5	—
Pulpwood [a]			
Softwood	2.8	2.4	0.4
Hardwood	49.8	16.6	33.2
Total	52.6	19.0	33.6
Composite panels			
Softwood	0.5	0.5	0.0
Hardwood	5.6	4.2	1.4
Total	6.1	4.7	1.5
Other industrial [b]			
Softwood	4.3	1.9	2.5
Hardwood	40.4	5.0	35.4
Total	44.8	6.9	37.9
Total industrial products			
Softwood	13.4	10.5	2.9
Hardwood	256.3	186.1	70.2
Total	269.7	196.6	73.1
Fuelwood [c]			
Softwood	0.1	0.1	0.0
Hardwood	17.1	16.8	0.3
Total	17.2	16.9	0.3
All products			
Softwood	13.5	10.6	2.9
Hardwood	273.3	202.9	70.4
Total	286.8	213.5	73.4

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

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

[a] Roundwood figures include an estimated 1.43 million cubic feet of roundwood chipped at other primary wood-using plants.

[b] Includes litter, mulch, particleboard, charcoal, and other specialty products.

[c] Excludes approximately 18.3 million cubic feet of wood residues and 7.3 million cubic feet of bark used for industrial fuel.

Table A.32—Average annual output of roundwood products by product, species group, and source of material, Kentucky, 1988 to 2003

Product and species group	All sources	Growing-stock trees[a] Total	Saw-timber	Pole-timber	Other sources[b]
	million cubic feet				
Saw logs					
Softwood	5.6	5.4	5.3	0.1	0.2
Hardwood	154.9	131.3	126.7	4.6	23.5
Total	160.5	136.7	132.1	4.7	23.7
Veneer logs					
Softwood	0.1	0.1	0.1	0.0	0.0
Hardwood	5.5	5.3	5.1	0.1	0.2
Total	5.5	5.3	5.2	0.1	0.2
Pulpwood					
Softwood	2.4	2.2	1.5	0.7	0.2
Hardwood	16.6	15.5	5.5	9.9	1.2
Total	19.0	17.7	7.0	10.6	1.4
Composite panels					
Softwood	0.5	0.5	0.3	0.1	0.0
Hardwood	4.2	3.9	1.4	2.5	0.2
Total	4.7	4.4	1.7	2.7	0.3
Other industrial					
Softwood	1.9	1.7	1.2	0.5	0.1
Hardwood	5.0	4.8	2.6	2.1	0.2
Total	6.9	6.5	3.9	2.6	0.4
Total industrial products					
Softwood	10.5	9.9	8.4	1.4	0.6
Hardwood	186.1	160.8	141.4	19.3	25.4
Total	196.6	170.6	149.9	20.8	25.9
Fuelwood					
Softwood	0.1	0.1	0.1	0.0	0.0
Hardwood	16.8	15.3	15.1	0.2	1.5
Total	16.9	15.4	15.2	0.2	1.5
All products					
Softwood	10.6	10.0	8.5	1.4	0.6
Hardwood	202.9	176.1	156.6	19.5	26.8
Total	213.5	186.0	165.1	20.9	27.5

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] On timberland.
[b] Includes trees < 5.0 inches in diameter, tree tops and limbs from timberland, or material from other forest land or nonforest land such as fence rows or suburban areas.

Table A.33—Average annual timber removals from growing stock on timberland by item, softwood, and hardwood, Kentucky, 1988 to 2003

Item	All species	Soft-wood	Hard-wood
	million cubic feet		
Roundwood products			
Saw logs	136.7	5.4	131.3
Veneer logs and bolts	5.3	0.1	5.3
Pulpwood	17.7	2.2	15.5
Composite panels	4.4	0.5	3.9
Other	6.5	1.7	4.8
Fuelwood	15.4	0.1	15.3
All products	186.0	10.0	176.1
Logging residues	46.0	1.6	44.4
Other removals	79.7	11.1	68.6
Total removals	311.8	22.7	289.1

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

Table A.34—Disposal of average annual volume of residue at primary wood-using plants by product, species group, and type of residue, Kentucky, 1988 to 2003

Product and species group	All types	Bark	Coarse[a]	Fine[b]
	million cubic feet			
Fiber products				
Softwood	0.4	—	0.4	0.0
Hardwood	33.2	0.1	32.4	0.7
Total	33.6	0.1	32.8	0.7
Particleboard				
Softwood	0.0	0.0	0.0	0.0
Hardwood	1.4	0.1	1.1	0.3
Total	1.5	0.1	1.1	0.3
Sawn products				
Softwood	—	—	—	—
Hardwood	0.1	—	0.1	—
Total	0.1	—	0.1	—
Industrial fuel				
Softwood	0.6	0.4	0.1	0.1
Hardwood	25.3	6.9	3.1	15.3
Total	25.9	7.3	3.2	15.4
Charcoal				
Softwood	0.2	0.0	0.0	0.1
Hardwood	8.4	0.4	1.7	6.3
Total	8.6	0.4	1.7	6.4
Miscellaneous				
Softwood	2.3	0.5	1.1	0.8
Hardwood	27.0	14.2	3.8	9.0
Total	29.4	14.7	4.9	9.8
Not used				
Softwood	0.4	0.1	0.2	0.2
Hardwood	5.0	1.3	1.7	1.9
Total	5.4	1.4	1.9	2.0
All products				
Softwood	3.9	0.9	1.9	1.2
Hardwood	100.4	23.0	43.9	33.5
Total	104.3	23.9	45.7	34.7

Numbers in rows and columns may not sum to totals due to rounding.
— = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] Material such as slabs and edgings.
[b] Material such as sawdust and shavings.

Table A.35—Carbon estimates and coarse woody material attributes by forest-type group, size class, and decay class, Kentucky

Forest-type group or nonstocked	Sample size	Fine woody debris carbon	Coarse woody debris carbon	Coarse woody debris	Size class[a] (inches) 3.0–7.9	8.0–12.9	13.0–17.9	18.0 and larger	Decay class[b] 1	2	3	4	5
	number	*mg/ha*	*mg/ha*	*ft*^{3}*/ac*	*pieces per acre*								
Loblolly-shortleaf	2	8.98	2.23	252.06	51.36	3.03	2.02	—	—	—	47.32	9.08	—
Oak-pine	6	2.87	3.06	272.31	70.36	8.82	—	—	4.11	37.40	33.97	2.67	1.04
Oak-hickory	59	4.32	2.47	230.02	69.94	10.17	0.80	—	1.76	24.12	46.84	8.08	0.12
Elm-ash-cottonwood	7	3.87	1.48	155.78	55.21	10.36	—	—	—	—	62.45	3.12	—
Maple-beech-birch	1	2.36	0.96	113.65	3.46	6.91	—	—	—	—	10.37	—	—
Nonstocked	1	7.81	0.90	87.12	162.33	—	—	—	—	—	162.33	—	—

— = no sample for the cell.

[a] Diameters collected at transect crossing.

[b] 1 = sound, freshly fallen, intact logs; 2 = sound; 3 = heartwood sound; piece supports its own weight; 4 = heartwood rotten; piece does not support its own weight, but maintains its shape; 5 = none, piece no longer maintains its shape, it spreads out on ground.

Table A.36—Down woody material attributes by forest-type group and fuel type, Kentucky

Forest-type group or nonstocked	Samples	Fuel type 1-hr	10-hr	100-hr	1,000-hr	Duff	Litter	All fuels
	number	*- - - - - - - - - - - - - - - -*			*tons per acre*			*- - - - - - - - - - - - - - - -*
Loblolly-shortleaf	2	0.11	1.55	6.27	1.97	7.84	4.23	21.96
Oak-pine	6	0.16	0.98	1.39	2.70	6.34	1.02	12.58
Oak-hickory	59	0.12	0.83	2.85	2.18	5.47	1.96	13.41
Elm-ash-cottonwood	7	0.15	0.63	2.64	1.30	2.38	0.53	7.62
Maple-beech-birch	1	0.17	0.36	1.55	0.84	11.47	3.32	17.71
Nonstocked	1	0.14	2.71	4.05	0.79	3.76	1.97	13.42

All estimates are tons per acre unless otherwise indicated.

Table A.37—Soil physical properties averaged by soil layer and reporting unit, Kentucky

Soil layer	Reporting unit	Samples	Moisture content	Coarse fragments	Bulk density
		number	*ovendry weight*	*percent*	*g/cm³*
Mineral soil (0 to 10 cm)	Eastern	8	213.69	25.86	1.21
	Northern Cumberland	9	202.80	22.95	1.12
	Southern Cumberland	19	187.76	16.60	1.07
	Bluegrass	12	202.88	11.50	1.12
	Pennyroyal	13	206.29	10.03	1.14
	Western Coalfield	8	209.78	9.17	1.16
	Western	7	201.33	9.86	1.12
	All units	76	201.40	15.00	1.12
Mineral soil (10 to 20 cm)	Eastern	8	254.68	25.16	1.38
	Northern Cumberland	9	268.80	20.75	1.49
	Southern Cumberland	19	269.24	14.87	1.50
	Bluegrass	12	254.26	9.77	1.41
	Pennyroyal	13	263.07	19.31	1.45
	Western Coalfield	8	261.45	14.36	1.45
	Western	7	271.23	12.71	1.50
	All units	76	263.60	16.35	1.46

Table A.38—Soil chemical properties averaged by soil layer and reporting unit, Kentucky

Soil layer	Reporting unit	Samples	pH		Organic carbon	Inorganic carbon	Total nitrogen	Extractable phosphorus	Extractable cations					
			H_2O	$CaCl_2$					Na	K	Mg	Ca	Al	ECEC
		number			*- - - - - - - percent - - - - - - -*			*mg/kg*	*- - - - - - - - - - - - - - cmolc/kg - - - - - - - - - - - - - -*					
Mineral soil (0 to 10 cm)	Eastern	8	5.35	4.99	2.61	0.00	0.20	4.93	2.50	150.81	183.71	931.91	76.66	7.41
	Northern Cumberland	9	5.29	4.84	2.50	0.01	0.17	4.87	5.14	95.95	99.66	1132.51	123.77	8.12
	Southern Cumberland	19	5.06	4.50	2.81	0.01	0.17	4.34	4.34	113.85	165.32	684.60	147.44	6.73
	Bluegrass	12	6.07	5.51	3.35	0.00	0.24	11.92	7.36	155.30	324.75	2891.86	104.69	18.69
	Pennyroyal	13	5.00	4.29	2.81	0.01	0.16	10.28	5.01	97.19	137.11	1221.24	129.05	8.93
	Western Coalfield	8	5.15	4.64	1.90	0.01	0.14	5.68	5.79	84.14	120.24	726.78	50.46	5.42
	Western	7	4.99	4.45	1.75	0.00	0.11	8.09	12.77	68.29	103.76	456.88	120.08	4.70
	All units	76	5.27	4.74	2.64	0.01	0.17	7.03	5.76	111.99	169.41	1187.45	114.56	8.90
Mineral soil (10 to 20 cm)	Eastern	8	5.23	4.81	1.71	0.00	0.11	3.19	2.50	87.81	121.66	549.25	92.78	5.01
	Northern Cumberland	9	5.30	4.74	0.89	0.00	0.05	2.31	5.30	67.38	57.09	886.36	136.11	6.60
	Southern Cumberland	19	4.98	4.44	1.15	0.00	0.09	2.73	3.10	68.66	83.38	249.08	141.51	3.69
	Bluegrass	12	6.08	5.66	1.17	0.05	0.08	5.95	8.12	104.37	304.54	2482.34	155.47	16.92
	Pennyroyal	13	5.04	4.44	1.09	0.01	0.14	6.67	5.94	74.56	104.06	870.00	175.27	7.36
	Western Coalfield	8	4.85	4.28	0.71	0.01	0.05	2.00	6.80	54.33	81.60	169.33	125.76	3.08
	Western	7	4.85	4.28	0.63	0.00	0.05	5.87	12.94	53.86	141.46	233.12	233.43	5.12
	All units	76	5.20	4.68	1.08	0.01	0.09	4.02	5.86	74.57	128.53	813.58	150.86	7.01

ECEC = extractable cation exchange capacity.

Table A.39—Mean crown density and other statistics [a] for all live trees > 4.9 inches d.b.h. by species, Kentucky, 2000 to 2002

Species	Plots	Trees	Mean	SE [b]	Minimum	Median	Maximum
	- - *number* - -				- - - - - - - - *percent* - - - - - - - -		
Softwoods							
Eastern redcedar	8	59	54	4	5	60	80
Shortleaf pine	1	1	10	—	10	10	10
Loblolly pine	1	1	60	—	60	60	60
Virginia pine	7	18	43	—	30	40	70
Other softwoods	3	6	47	—	30	48	65
All softwoods	18	85	50	3	5	50	80
Hardwoods							
White oaks	50	235	42	1	20	40	65
Red oaks	41	120	40	1	10	40	65
Maple	51	247	42	1	15	40	75
Yellow-poplar	28	86	42	1	10	40	60
Blackgum	26	42	41	1	25	40	60
Hickory	43	133	43	1	20	40	65
Ash	26	53	41	2	20	40	65
Elm	17	26	40	2	20	40	65
Other hardwoods	62	282	41	1	10	40	70
All hardwoods	72	1,224	42	0	10	40	75
All trees	72	1,309	42	1	5	40	80

SE = standard error; — = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.
[a] The mean, SE, and median calculations consider the clustering of trees on plots.
[b] SEs are not presented for species groups with n trees < 20.

Table A.40—Mean foliage transparency and other statistics [a] for all live trees > 4.9 inches d.b.h. by species, Kentucky, 2000 to 2002

Species	Plots	Trees	Mean	SE [b]	Minimum	Median	Maximum
	- - *number* - -				- - - - - - - - *percent* - - - - - - - -		
Softwoods							
Eastern redcedar	8	59	15	4	5	10	70
Shortleaf pine	1	1	35	—	35	35	35
Loblolly pine	1	1	15	—	15	15	15
Virginia pine	7	18	24	—	5	25	35
Other softwoods	3	6	20	—	15	20	25
All softwoods	18	85	18	3	5	15	70
Hardwoods							
White oaks	50	235	21	1	0	20	60
Red oaks	41	120	22	2	10	20	60
Maple	51	247	23	2	5	20	75
Yellow-poplar	28	86	20	2	5	20	40
Blackgum	26	42	23	2	0	20	50
Hickory	43	133	19	1	5	20	60
Ash	26	53	21	2	10	20	40
Elm	17	26	18	2	0	20	30
Other hardwoods	62	282	22	1	5	20	85
All hardwoods	72	1,224	21	1	0	20	85
All trees	72	1,309	21	1	0	20	85

SE = standard error; — = no sample for the cell; 0.0 = a value of > 0.0 but < 0.05 for the cell.

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

[b] SEs are not presented for species groups with n trees < 20.

Turner, Jeffery A.; Oswalt, Christopher M.; Chamberlain, James L. [and others]. 2008. Kentucky's Forests, 2004. Resour. Bull. SRS–129. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 101 p.

Forest land area in the Commonwealth of Kentucky amounted to 11.97 million acres, including 11.6 million acres of timberland. Over 110 different species, mostly hardwoods, account for an estimated 21.2 billion cubic feet of all live tree volume. Hardwood forest types occupy 85 percent of Kentucky's timberland, and oak-hickory is the dominant forest-type group accounting for about 8.4 million acres. About 78 percent of timberland in Kentucky is owned by nonindustrial private forest land owners. Forest industry owns about 2 percent of the timberland in the Commonwealth, while Federal, State, and local government agencies manage about 11 percent or 1.03 million acres. In 2003 more than 21,500 individuals were directly employed at wood-processing mills with a total annual payroll of over 700 million dollars. Many nontimber forest products are harvested in Kentucky, which ranks second in the Southern region in terms of the number of nontimber forest product enterprises.

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

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Commonwealth of Kentucky State Facts

Capital City: Frankfort

Location: 38.19077 N, 084.86520 W

Population: 3,908,124; 24th - 7-97

Geology:
Land Area: 39,674 sq. mi.; 37th
Highest Point: Black Mtn.; 4145 feet
Inland Water: 740 sq. mi.
Largest City: Louisville
Lowest Point: Mississippi River; 257 feet

Border States: Illinois, Indiana, Missouri, Ohio, Tennessee, Virginia, West Virginia

Constitution: 15th State

Statehood: June 1, 1792

Bird: Cardinal—The pleasant melodies of this red-crested song bird are heard year round in Kentucky. The male boasts a vivid red plumage; the female is light brown with red highlights.

Industry: Transportation equipment, chemical products, electric equipment, machinery, food processing, tobacco products, coal, tourism.

Agriculture: Agriculture: horses, cattle, tobacco, dairy products, hogs, soybeans, corn.

Natural Resources: The numerous rivers and water impoundments provide 1,100 commercially navigable miles (1,770 km). Kentucky ranks third among hardwood producing States. The main species of trees are white oak, red oak, walnut, yellow poplar, beech, sugar maple, white ash and hickory. Principal minerals and by products produced in order of value are coal, crushed stone, natural gas and petroleum.

Flag: The State seal imprinted on a field of navy blue was approved by the General Assembly in 1928. The original flag is displayed in Frankfort at the Kentucky History Museum.

Tree: Sometimes called the tulip poplar, this tree is not a poplar at all, but a member of the magnolia family. It can grow to 145 feet and live for 200 years. It blossoms in May with yellow-green flowers resembling tulips.

Nickname: Bluegrass State—Bluegrass is not really blue—it's green—but in the spring, bluegrass produces bluish-purple buds that when seen in large fields give a rich blue cast to the grass. Early pioneers found bluegrass growing on Kentucky's rich limestone soil, and traders began asking for the seed of the "blue grass from Kentucky." The name stuck and today Kentucky is known as the Bluegrass State.

Song: "My Old Kentucky Home" by Stephen Collins Foster—1853

The sun shines bright on my old Kentucky home,
'Tis summer, the people are gay;
The corn top's ripe and the meadow's in the bloom,
While the birds make music all the day.

The young folks roll on the little cabin floor,
All merry, all happy and bright;
By 'n by hard times comes a-knockin' at the door,
Then my old Kentucky home, good-night!

Weep no more, my lady!
Oh weep no more today.
We will sing one song for my old Kentucky home,
For my old Kentucky home, far away.

Flower: Goldenrod, *Solidago altissima*—The golden plumes of this wildflower line Kentucky's roadsides in the fall. Native to all of Kentucky, 30 of nearly 100 species of this herb are found here.

Presidental Birthplace:
Abraham Lincoln, 16th President of the United States (March 4, 1861 to April 15, 1865)
Nicknames: "Honest Abe"; "Illinois rail-splitter"
Born: February 12, 1809, in Hardin (now Larue) County, KY
Died: April 15, 1865, at Petersen's boarding house in Washington, DC.

Motto: United we stand, divided we fall.

Origin of Commonwealth: Commonwealth of Kentucky—Kentucky is one of four States to call itself a "commonwealth." In 1792 when Kentucky became the 15th State—the first on the western frontier—both "commonwealth" and "State" were used. Commonwealth, meaning government based on the common consent of the people, dates to the time of Oliver Cromwell's England in the mid-1600s. The other U.S. commonwealths, Massachusetts, Pennsylvania, and Virginia, were originally British colonies. Kentucky, once part of Virginia, chose to remain a commonwealth when it separated from Virginia.

Information courtesy of The World Factbook, www.cia.gov/library/publications/the-world-factbook; www.travel.ky.gov/about/facts/facts.



Kentucky's
Forests, 2004

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