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# Tree Crown Condition in Missouri, 2000–2003

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### Abstract

The Forest Service, U.S. Department of Agriculture, Forest Inventory and Analysis (FIA) Program uses visual assessments of tree crown condition to monitor changes and trends in forest health. This report describes three FIA tree crown condition indicators (crown dieback, crown density, and foliage transparency) and sapling crown vigor measured in Missouri between 2000 and 2003. Descriptive statistics are presented for individual species, by FIA species group, and for all trees combined.

**Keywords:** Crown density, crown dieback, FIA, foliage transparency, forest health, sapling vigor.

## Introduction

A tree's crown is its principal engine for energy capture. Trees with full, vigorous crowns generally are associated with more vigorous growth rates due to their increased capacity for photosynthesis. When crowns become degraded, photosynthesis is reduced. Crown characteristics that are less than optimal may indicate one or more underlying stressors (Clinton and others 1993) and, if severe enough, may result in tree mortality (Lawrence and others 2002). Crown degradation is typically the result of past and present stressors such as insects, weather conditions, senescence, and competition or other stand conditions (Kenk 1993).

Forest Inventory and Analysis (FIA) assesses various indicators on the Phase 3 portion of its inventory plots to monitor changes in forest health (U.S. Department of Agriculture 2003a). These forest health indicators include sapling crown vigor and three ocular estimates of individual tree crown condition: crown dieback, crown density, and foliage transparency (U.S. Department of Agriculture 2003a). This report summarizes the crown condition assessments made in Missouri between 2000 and 2003. Our goal is to provide a baseline summary of crown conditions against which future summaries may be compared. We do not present hypothesis tests for significant differences among the species averages because phenological differences among species are expected. Differences within the same species over time and space are more meaningful. Such differences can be determined only after remeasurements are completed.

## What We Found

Across Missouri, 62 tree species were observed on the Phase 3 plots. Two were softwood species, eastern redcedar and shortleaf pine, and the remainder were hardwood species (see Appendix). Species-specific averages for the three tree crown condition indicators were calculated by FIA species group, and also for individual species within each group that were observed at least 20 times. Tabular summary statistics include all observed FIA species groups even though some groups were observed fewer than 20 times, and other groups contained only one species. For example, the loblolly and shortleaf pine group consisted only of shortleaf pine and the other eastern softwoods group included only eastern redcedar (see Appendix). Among hardwoods, the other white oaks, hard maple, sweetgum, tupelo and blackgum, cottonwood and aspen, basswood, and black walnut groups also included only one species (see Appendix). Presentation by FIA species group is made for completeness and to allow flexibility in future reporting. However, discussion of observed tree crown condition is presented at the individual species level for species observed at least 20 times. To maintain reasonable sample sizes, sapling crown vigor was summarized by FIA species group only.

### Crown Dieback

FIA defines crown dieback as recent mortality of branches with fine twigs, which begins at the terminal portion of a branch and proceeds inward toward the trunk (U.S. Department of Agriculture 2003a). Though normal physiological processes may induce some crown dieback, high levels of dieback indicate potentially serious declines in tree health (Millers and others 1992). Hardwood trees may display evidence of dieback even when healthy, whereas conifers generally exhibit dieback only when the trees' root systems are under serious stress (Millers and others 1992). This difference between hardwoods and conifers is exemplified in Missouri where > 5-percent dieback was observed on 13.8 percent of the hardwoods but only 2.8 percent of the softwoods (fig. 1).

Among the individual hardwood species observed at least 20 times, average crown dieback ranged from 1.7 percent

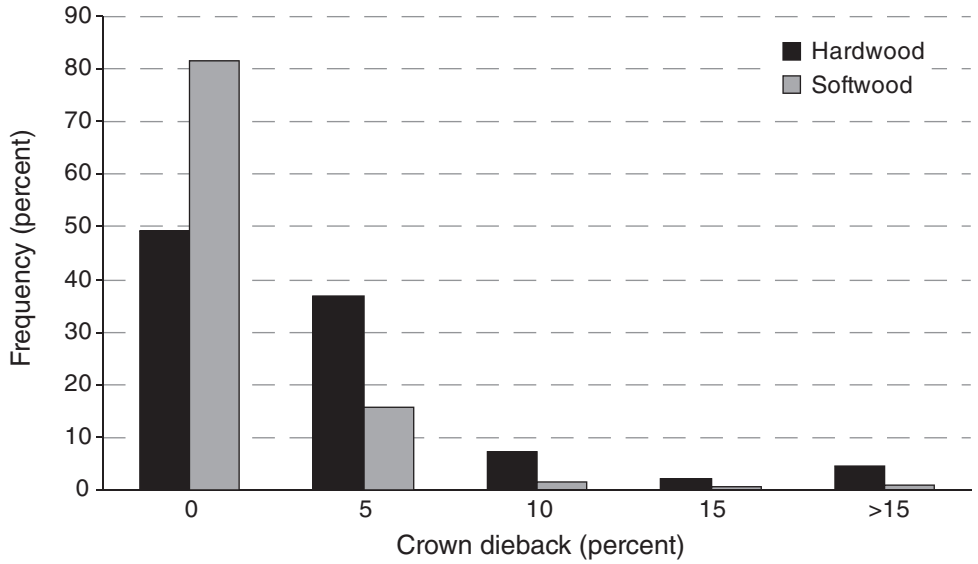


Figure 1—Crown dieback frequency distribution by species group, Missouri, 2000–2003.

for mockernut and bitternut hickory to 11.7 percent for blackjack oak, and was 5.0 percent for all hardwoods combined (table 1). For the softwoods, average crown dieback was higher for shortleaf pine than for eastern redcedar and was 1.2 percent for both species combined (table 1).

During the years of the study, Missouri was just beginning to recover from a severe drought (U.S. Department of Agriculture 2003b). Due to lingering effects of this stress and subsequent insect and disease attacks, the crown dieback averages observed may be higher than those observed in the future.

## Crown Density

Crown density is a measure of the amount of foliage present on the tree and is defined as the amount of crown biomass (i.e., branches, foliage, and reproductive structures) that blocks light visibility through the projected crown outline (U.S. Department of Agriculture 2003a). Within individual species, greater crown densities typically represent healthy trees. Under normal conditions, average crown densities may vary considerably by species due to differences in leaf and branch morphology and underlying shade tolerance.

Most crown densities in Missouri ranged between 30 and 65 percent (fig. 2). Average crown density was 49.5 percent for softwoods and 46.0 percent for hardwoods (table 2). Among the individual hardwood species, average crown density ranged from a low of 38.3 percent for blackjack oak to a high of 53.2 percent for mockernut hickory. Average crown density was 54.0 percent for eastern redcedar and 42.4 percent for shortleaf pine.

## Foliage Transparency

Foliage transparency is an indicator of the amount of foliage present on the tree and is defined as the amount of skylight visible through the live, normally foliated portion of the crown (U.S. Department of Agriculture 2003a). Although foliage transparency and crown density are similar measures they cannot be interpreted as exact inverses. Crown density measures the amount of sunlight blocked by all biomass produced by the tree (both live and dead) in the crown, whereas foliage transparency measures the amount of sunlight penetrating only the live portion of the crown. Deductions are made from the maximum possible crown density for spaces between branches and other large openings in the crown. However, large gaps in the crown where foliage is not expected to occur are excluded from consideration when foliage transparency is rated. Typically, lower foliage transparency ratings indicate healthy trees, and as with crown density, average foliage transparency tends to vary by species.

**Table 1—Mean crown dieback and other statistics[a] for all live trees ≥5.0 inches d.b.h. by species group, Missouri, cycle 5, 2000–2003**

| Species group[b] | Plots | Trees | Mean | SE[c] | 95% confidence Lower | 95% confidence Upper | Min | 90th percentile | Max |
|---|---|---|---|---|---|---|---|---|---|
| | - - number - - | | - - - - - - - - - - - - - - - - - - - - percent - - - - - - - - - - - - - - - - - - - - | | | | | | |
| Softwoods | | | | | | | | | |
| Loblolly and shortleaf pines | 20 | 140 | 1.6 | 0.4 | 0.8 | 2.5 | 0 | 5 | 25 |
| Other eastern softwoods | 36 | 219 | 0.9 | 0.2 | 0.5 | 1.3 | 0 | 5 | 20 |
| All softwoods | 55 | 359 | 1.2 | 0.2 | 0.7 | 1.6 | 0 | 5 | 25 |
| Hardwoods | | | | | | | | | |
| Select white oaks | | | | | | | | | |
| White oak | 80 | 579 | 3.7 | 0.4 | 2.9 | 4.4 | 0 | 5 | 99 |
| Chinkapin oak | 18 | 47 | 3.5 | 0.8 | 2.0 | 5.1 | 0 | 5 | 25 |
| Other select white oaks | 8 | 16 | 1.9 | — | — | — | 0 | 5 | 5 |
| Total | 95 | 642 | 3.6 | 0.4 | 2.9 | 4.3 | 0 | 5 | 99 |
| Select red oaks | | | | | | | | | |
| Northern red oaks | 34 | 85 | 4.6 | 1.4 | 1.8 | 7.4 | 0 | 10 | 95 |
| Other select red oaks | 3 | 8 | 4.4 | — | — | — | 0 | 25 | 25 |
| Total | 37 | 93 | 4.6 | 1.3 | 1.9 | 7.2 | 0 | 10 | 95 |
| Other white oaks | 58 | 316 | 5.8 | 1.0 | 3.9 | 7.8 | 0 | 10 | 99 |
| Other red oaks | | | | | | | | | |
| Scarlet oak | 22 | 71 | 7.2 | 1.5 | 4.3 | 10.1 | 0 | 15 | 70 |
| Shingle oak | 10 | 27 | 5.6 | 2.0 | 1.7 | 9.4 | 0 | 15 | 30 |
| Blackjack oak | 14 | 43 | 11.7 | 3.4 | 5.1 | 18.4 | 0 | 30 | 70 |
| Black oak | 70 | 325 | 7.5 | 1.1 | 5.4 | 9.7 | 0 | 15 | 99 |
| Other red oaks | 8 | 18 | 3.3 | — | — | — | 0 | 10 | 15 |
| Total | 85 | 484 | 7.6 | 0.8 | 5.9 | 9.3 | 0 | 15 | 99 |
| Hickory | | | | | | | | | |
| Bitternut hickory | 15 | 23 | 1.7 | 0.6 | 0.5 | 2.9 | 0 | 5 | 10 |
| Shagbark hickory | 27 | 93 | 1.8 | 0.5 | 0.8 | 2.8 | 0 | 5 | 10 |
| Black hickory | 34 | 73 | 2.8 | 0.5 | 1.9 | 3.7 | 0 | 5 | 15 |
| Mockernut hickory | 30 | 53 | 1.7 | 0.6 | 0.6 | 2.8 | 0 | 5 | 10 |
| Other hickory | 6 | 8 | 1.3 | — | — | — | 0 | 5 | 5 |
| Total | 81 | 250 | 2.0 | 0.3 | 1.5 | 2.6 | 0 | 5 | 15 |
| Hard maple | 9 | 40 | 1.8 | 0.8 | 0.2 | 3.3 | 0 | 5 | 15 |
| Soft maple | 8 | 11 | 15.0 | — | — | — | 0 | 70 | 90 |
| Sweetgum | 1 | 2 | 0.0 | — | — | — | 0 | 0 | 0 |
| Tupelo and blackgum | 15 | 22 | 3.2 | 1.1 | 1.0 | 5.3 | 0 | 10 | 20 |
| Ash | | | | | | | | | |
| White ash | 17 | 42 | 11.0 | 3.5 | 4.1 | 18.0 | 0 | 30 | 99 |
| Other ash | 9 | 15 | 2.3 | — | — | — | 0 | 5 | 5 |
| Total | 23 | 57 | 8.8 | 2.7 | 3.5 | 14.0 | 0 | 20 | 99 |
| Cottonwood and aspen | 1 | 12 | 0.0 | — | — | — | 0 | 0 | 0 |
| Basswood | 4 | 5 | 1.0 | — | — | — | 0 | 5 | 5 |
| Black walnut | 31 | 68 | 4.7 | 1.8 | 1.2 | 8.2 | 0 | 5 | 99 |

*continued*

**Table 1—Mean crown dieback and other statistics[a] for all live trees ≥5.0 inches d.b.h. by species group, Missouri, cycle 5, 2000–2003 (continued)**

| Species group[b] | Plots | Trees | Mean | SE[c] | 95% confidence Lower | 95% confidence Upper | Min | 90th percentile | Max |
|---|---|---|---|---|---|---|---|---|---|
| | - - number - - | | - - - - - - - - - - - - - - - - - - - - percent - - - - - - - - - - - - - - - - - - - - | | | | | | |
| Other eastern soft hardwoods | | | | | | | | | |
| Hackberry | 16 | 28 | 3.0 | 1.0 | 1.1 | 5.0 | 0 | 5 | 30 |
| Black cherry | 10 | 22 | 11.6 | 5.7 | 0.4 | 22.8 | 0 | 20 | 85 |
| American elm | 35 | 64 | 5.9 | 2.2 | 1.6 | 10.1 | 0 | 10 | 90 |
| Slippery elm | 22 | 38 | 5.0 | 1.5 | 2.0 | 8.0 | 0 | 10 | 40 |
| Other eastern soft hardwoods | 30 | 51 | 2.5 | 0.6 | 1.3 | 3.8 | 0 | 5 | 40 |
| Total | 67 | 203 | 5.1 | 1.0 | 3.0 | 7.2 | 0 | 10 | 90 |
| Other eastern hard hardwoods | | | | | | | | | |
| Honeylocust | 14 | 41 | 4.1 | 0.8 | 2.6 | 5.7 | 0 | 5 | 25 |
| Red mulberry | 15 | 22 | 2.3 | 0.7 | 0.8 | 3.7 | 0 | 5 | 10 |
| Other eastern hard hardwoods | 19 | 35 | 5.0 | 1.5 | 1.9 | 8.1 | 0 | 15 | 45 |
| Total | 43 | 98 | 4.0 | 0.7 | 2.6 | 5.4 | 0 | 10 | 45 |
| Eastern noncommercial hardwoods | 14 | 46 | 7.6 | 2.2 | 3.3 | 11.9 | 0 | 15 | 99 |
| All hardwoods | 134 | 2,349 | 5.0 | 0.3 | 4.3 | 5.6 | 0 | 10 | 99 |
| All trees | 135 | 2,708 | 4.5 | 0.3 | 3.8 | 5.1 | 0 | 10 | 99 |

— = not presented due to insufficient sample; SE = standard error.

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

[b] See appendix.

[c] SE and confidence intervals are not presented for species groups with *n* trees < 20.

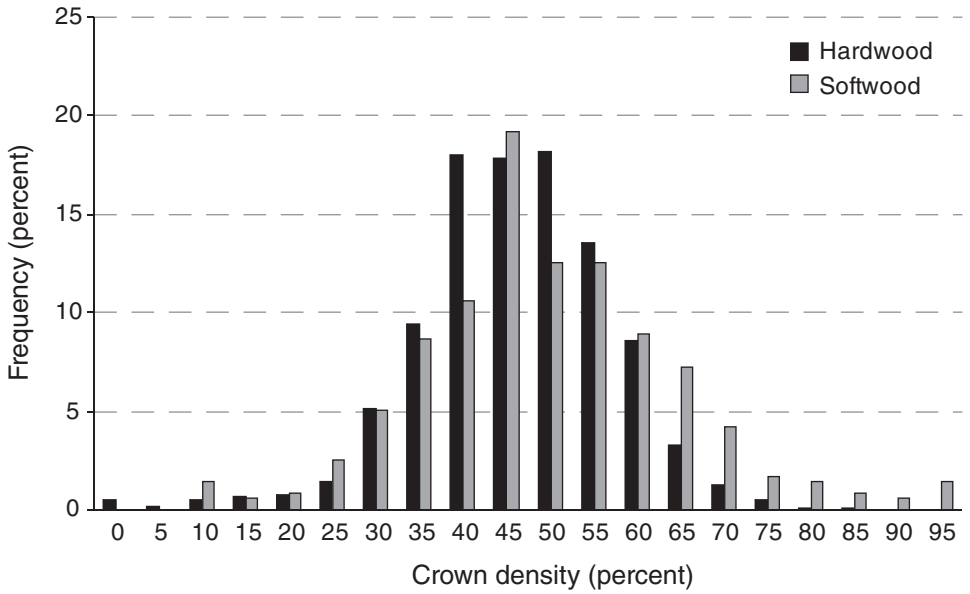


Figure 2—Crown density frequency distribution by species group, Missouri, 2000–2003.

**Table 2—Mean crown density and other statistics[a] for all live trees ≥ 5.0 inches d.b.h. by species group, Missouri, cycle 5, 2000–2003**

| Species group[b] | Plots | Trees | Mean | SE[c] | 95% confidence Lower | 95% confidence Upper | Min | Median | Max |
|---|---|---|---|---|---|---|---|---|---|
| | - - number - - | | - - - - - - - - - - - - - - - - - - - - percent - - - - - - - - - - - - - - - - - - - - | | | | | | |
| Softwoods | | | | | | | | | |
| Loblolly and shortleaf pines | 20 | 140 | 42.4 | 2.7 | 37.0 | 47.8 | 10 | 45 | 70 |
| Other eastern softwoods | 36 | 219 | 54.0 | 2.5 | 49.0 | 59.0 | 10 | 50 | 95 |
| All softwoods | 55 | 359 | 49.5 | 2.0 | 45.6 | 53.3 | 10 | 50 | 95 |
| Hardwoods | | | | | | | | | |
| Select white oaks | | | | | | | | | |
| White oak | 80 | 579 | 47.1 | 0.6 | 45.8 | 48.4 | 0 | 50 | 80 |
| Chinkapin oak | 18 | 47 | 42.8 | 1.6 | 39.7 | 45.9 | 25 | 40 | 65 |
| Other select white oaks | 8 | 16 | 42.8 | — | — | — | 25 | 42.5 | 60 |
| Total | 95 | 642 | 46.7 | 0.6 | 45.5 | 47.9 | 0 | 45 | 80 |
| Select red oaks | | | | | | | | | |
| Northern red oaks | 34 | 85 | 48.0 | 1.4 | 45.2 | 50.8 | 5 | 50 | 75 |
| Other select red oaks | 3 | 8 | 48.8 | — | — | — | 10 | 55 | 60 |
| Total | 37 | 93 | 48.1 | 1.4 | 45.3 | 50.8 | 5 | 50 | 75 |
| Other white oaks | 58 | 316 | 42.2 | 0.9 | 40.5 | 43.9 | 0 | 45 | 70 |
| Other red oaks | | | | | | | | | |
| Scarlet oak | 22 | 71 | 48.0 | 1.4 | 45.1 | 50.8 | 15 | 50 | 65 |
| Shingle oak | 10 | 27 | 46.3 | 2.4 | 41.5 | 51.1 | 25 | 45 | 70 |
| Blackjack oak | 14 | 43 | 38.3 | 2.3 | 33.8 | 42.8 | 15 | 40 | 55 |
| Black oak | 70 | 325 | 45.0 | 1.1 | 42.9 | 47.1 | 0 | 45 | 75 |
| Other red oaks | 8 | 18 | 47.5 | — | — | — | 30 | 47.5 | 75 |
| Total | 85 | 484 | 45.0 | 0.9 | 43.2 | 46.7 | 0 | 45 | 75 |
| Hickory | | | | | | | | | |
| Bitternut hickory | 15 | 23 | 48.0 | 2.1 | 43.9 | 52.2 | 35 | 45 | 75 |
| Shagbark hickory | 27 | 93 | 48.7 | 1.1 | 46.5 | 50.9 | 25 | 50 | 75 |
| Black hickory | 34 | 73 | 52.7 | 1.1 | 50.6 | 54.9 | 30 | 50 | 75 |
| Mockernut hickory | 30 | 53 | 53.2 | 1.4 | 50.4 | 56.1 | 30 | 55 | 70 |
| Other hickory | 6 | 8 | 58.8 | — | — | — | 45 | 57.5 | 80 |
| Total | 81 | 250 | 51.1 | 0.8 | 49.5 | 52.7 | 25 | 50 | 80 |
| Hard maple | 9 | 40 | 51.6 | 2.4 | 46.9 | 56.4 | 30 | 55 | 85 |
| Soft maple | 8 | 11 | 52.7 | — | — | — | 35 | 55 | 70 |
| Sweetgum | 1 | 2 | 35.0 | — | — | — | 30 | 35 | 40 |
| Tupelo and blackgum | 15 | 22 | 45.2 | 2.9 | 39.4 | 51.0 | 20 | 45 | 75 |
| Ash | | | | | | | | | |
| White ash | 17 | 42 | 41.7 | 2.6 | 36.5 | 46.8 | 0 | 45 | 60 |
| Other ash | 9 | 15 | 45.7 | — | — | — | 35 | 45 | 55 |
| Total | 23 | 57 | 42.7 | 1.9 | 38.9 | 46.6 | 0 | 45 | 60 |
| Cottonwood and aspen | 1 | 12 | 55.4 | — | — | — | 45 | 57.5 | 60 |
| Basswood | 4 | 5 | 49.0 | — | — | — | 40 | 45 | 65 |
| Black walnut | 31 | 68 | 45.4 | 1.4 | 42.5 | 48.2 | 0 | 45 | 75 |

*continued*

**Table 2—Mean crown density and other statistics[a] for all live trees ≥ 5.0 inches d.b.h. by species group, Missouri, cycle 5, 2000–2003 (continued)**

| Species group[b] | Plots | Trees | Mean | SE[c] | 95% confidence Lower | 95% confidence Upper | Min | Median | Max |
|---|---|---|---|---|---|---|---|---|---|
| | - - number - - | | - - - - - - - - - - - - - - - - - - - - percent - - - - - - - - - - - - - - - - - - - - | | | | | | |
| Other eastern soft hardwoods | | | | | | | | | |
| Hackberry | 16 | 28 | 48.2 | 2.2 | 43.8 | 52.7 | 30 | 50 | 60 |
| Black cherry | 10 | 22 | 49.3 | 3.5 | 42.4 | 56.2 | 15 | 50 | 75 |
| American elm | 35 | 64 | 44.0 | 1.3 | 41.4 | 46.6 | 10 | 45 | 65 |
| Slippery elm | 22 | 38 | 42.2 | 1.4 | 39.4 | 45.1 | 25 | 40 | 65 |
| Other eastern soft hardwoods | 30 | 51 | 44.6 | 1.9 | 40.8 | 48.5 | 20 | 45 | 85 |
| Total | 67 | 203 | 45.0 | 0.9 | 43.1 | 46.8 | 10 | 45 | 85 |
| Other eastern hard hardwoods | | | | | | | | | |
| Honeylocust | 14 | 41 | 47.6 | 1.9 | 43.8 | 51.3 | 35 | 45 | 75 |
| Red mulberry | 15 | 22 | 48.9 | 2.5 | 44.0 | 53.8 | 25 | 50 | 65 |
| Other eastern hard hardwoods | 19 | 35 | 45.1 | 2.7 | 39.8 | 50.5 | 20 | 45 | 70 |
| Total | 43 | 98 | 47.0 | 1.4 | 44.2 | 49.8 | 20 | 45 | 75 |
| Eastern noncommercial hardwoods | 14 | 46 | 40.9 | 2.3 | 36.4 | 45.4 | 0 | 40 | 65 |
| All hardwoods | 134 | 2,349 | 46.0 | 0.5 | 45.1 | 46.9 | 0 | 45 | 85 |
| All trees | 135 | 2,708 | 46.5 | 0.5 | 45.6 | 47.4 | 0 | 45 | 95 |

— = not presented due to insufficient sample; SE = standard error.

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

[b] See appendix.

[c] SE and confidence intervals are not presented for species groups with *n* trees < 20.

Foliage transparency averaged 23.9 percent for the hardwoods overall, and for individual species observed at least 20 times it ranged from a low of 18.2 percent for black hickory to a high of 28.0 percent for white ash (table 3). Among the softwoods, average foliage transparency was 26.8 percent for eastern redcedar and 24.4 percent for shortleaf pine. The majority of trees had a foliage transparency rating of 15 to 25 percent (fig. 3).

### Sapling Crown Vigor

The crowns of sapling-sized trees are not developed enough for assessing the three crown condition indicators applied to larger trees. Therefore, saplings are categorized based upon the amount and condition of foliage present into three broad vigor classes of good (vigor class 1), fair (vigor class 2), and poor (vigor class 3) (U.S. Department of Agriculture 2003a). Overall, 62.1 percent of the sapling crowns were categorized as good (table 4). Although 6.2 percent of both the hardwoods and softwoods were categorized as poor, 75.4 percent of the softwoods were in the good category, compared to only 60.7 percent of the hardwoods. Among the hardwood species groups with at least 20 observations, the hard maples had the highest percentage of saplings in the good category (85.0 percent); the other red oaks had the lowest percentage of saplings in the good category (45.9 percent); the hickory group had the lowest percentage of trees in the poor category (3.9 percent); and the noncommercial hardwoods had the highest percentage of trees in the poor category (11.4 percent).

## What This Means

Overall, the species averages seem biologically reasonable. For example, blackjack oak's low crown density, high foliage transparency, and high crown dieback averages are consistent with this species' known poor crown form (Carey 1992). Leaf and branch morphological differences among species also are evident. For instance, the different crown structures of eastern redcedar and shortleaf pine are

**Table 3—Mean foliage transparency and other statistics[a] for all live trees ≥5.0 inches d.b.h. by species group, Missouri, cycle 5, 2000–2003**

| Species group[b] | Plots | Trees | Mean | SE[c] | 95% confidence Lower | 95% confidence Upper | Min | Median | Max |
|---|---|---|---|---|---|---|---|---|---|
| | - - number - - | | - - - - - - - - - - - - - - - - - - - - percent - - - - - - - - - - - - - - - - - - - - | | | | | | |
| Softwoods | | | | | | | | | |
| Loblolly and shortleaf pines | 20 | 140 | 24.4 | 3.1 | 18.3 | 30.4 | 0 | 20 | 75 |
| Other eastern softwoods | 36 | 219 | 26.8 | 3.0 | 20.9 | 32.6 | 5 | 25 | 75 |
| All softwoods | 55 | 359 | 25.8 | 2.3 | 21.3 | 30.4 | 0 | 20 | 75 |
| Hardwoods | | | | | | | | | |
| Select white oaks | | | | | | | | | |
| White oak | 80 | 579 | 22.3 | 1.3 | 19.6 | 24.9 | 10 | 20 | 99 |
| Chinkapin oak | 18 | 47 | 25.4 | 2.0 | 21.4 | 29.4 | 10 | 25 | 45 |
| Other select white oaks | 8 | 16 | 25.3 | — | — | — | 15 | 25 | 40 |
| Total | 95 | 642 | 22.6 | 1.2 | 20.2 | 25.0 | 10 | 20 | 99 |
| Select red oaks | | | | | | | | | |
| Northern red oaks | 34 | 85 | 22.0 | 1.4 | 19.3 | 24.7 | 0 | 20 | 60 |
| Other select red oaks | 3 | 8 | 28.8 | — | — | — | 15 | 27.5 | 45 |
| Total | 37 | 93 | 22.6 | 1.3 | 19.9 | 25.2 | 0 | 20 | 60 |
| Other white oaks | 58 | 316 | 26.2 | 1.8 | 22.7 | 29.6 | 0 | 20 | 99 |
| Other red oaks | | | | | | | | | |
| Scarlet oak | 22 | 71 | 23.7 | 1.5 | 20.8 | 26.5 | 10 | 20 | 55 |
| Shingle oak | 10 | 27 | 24.6 | 2.7 | 19.4 | 29.9 | 15 | 20 | 65 |
| Blackjack oak | 14 | 43 | 27.7 | 2.9 | 21.9 | 33.5 | 15 | 25 | 65 |
| Black oak | 70 | 325 | 26.6 | 1.5 | 23.6 | 29.6 | 0 | 25 | 99 |
| Other red oaks | 8 | 18 | 25.6 | — | — | — | 15 | 20 | 60 |
| Total | 85 | 484 | 26.1 | 1.2 | 23.7 | 28.5 | 0 | 20 | 99 |
| Hickory | | | | | | | | | |
| Bitternut hickory | 15 | 23 | 20.0 | 2.4 | 15.2 | 24.8 | 5 | 20 | 40 |
| Shagbark hickory | 27 | 93 | 21.0 | 1.6 | 17.9 | 24.2 | 5 | 20 | 60 |
| Black hickory | 34 | 73 | 18.2 | 1.4 | 15.4 | 20.9 | 10 | 15 | 70 |
| Mockernut hickory | 30 | 53 | 20.2 | 2.3 | 15.5 | 24.8 | 10 | 20 | 60 |
| Other hickory | 6 | 8 | 19.4 | — | — | — | 10 | 15 | 40 |
| Total | 81 | 250 | 19.9 | 1.0 | 17.8 | 21.9 | 5 | 20 | 70 |
| Hard maple | 9 | 40 | 20.1 | 0.6 | 18.9 | 21.4 | 10 | 20 | 30 |
| Soft maple | 8 | 11 | 20.9 | — | — | — | 10 | 20 | 35 |
| Sweetgum | 1 | 2 | 27.5 | — | — | — | 25 | 27.5 | 30 |
| Tupelo and blackgum | 15 | 22 | 20.5 | 1.7 | 17.1 | 23.8 | 10 | 20 | 40 |
| Ash | | | | | | | | | |
| White ash | 17 | 42 | 28.0 | 3.2 | 21.6 | 34.3 | 10 | 20 | 99 |
| Other ash | 9 | 15 | 26.0 | — | — | — | 15 | 25 | 40 |
| Total | 23 | 57 | 27.4 | 2.6 | 22.4 | 32.5 | 10 | 20 | 99 |
| Cottonwood and aspen | 1 | 12 | 21.7 | — | — | — | 20 | 20 | 25 |
| Basswood | 4 | 5 | 19.0 | — | — | — | 15 | 15 | 30 |
| Black walnut | 31 | 68 | 23.4 | 2.2 | 18.9 | 27.8 | 10 | 20 | 99 |

*continued*

**Table 3—Mean foliage transparency and other statistics[a] for all live trees ≥ 5.0 inches d.b.h. by species group, Missouri, cycle 5, 2000–2003 (continued)**

| Species group[b] | Plots | Trees | Mean | SE[c] | 95% confidence | | Min | Median | Max |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Lower | Upper | | | |
| | *- - number - -* | | *- - - - - - - - - - - - - - - - - - - - percent - - - - - - - - - - - - - - - - - - - -* | | | | | | |
| Other eastern soft hardwoods | | | | | | | | | |
| Hackberry | 16 | 28 | 25.9 | 3.0 | 19.9 | 31.8 | 15 | 25 | 55 |
| Black cherry | 10 | 22 | 24.1 | 3.2 | 17.8 | 30.4 | 15 | 20 | 80 |
| American elm | 35 | 64 | 24.1 | 2.4 | 19.4 | 28.7 | 0 | 20 | 80 |
| Slippery elm | 22 | 38 | 25.0 | 2.2 | 20.7 | 29.3 | 10 | 25 | 65 |
| Other eastern soft hardwoods | 30 | 51 | 27.2 | 1.9 | 23.3 | 31.0 | 10 | 25 | 60 |
| Total | 67 | 203 | 25.3 | 1.4 | 22.6 | 27.9 | 0 | 20 | 80 |
| Other eastern hard hardwoods | | | | | | | | | |
| Honeylocust | 14 | 41 | 27.9 | 2.2 | 23.7 | 32.2 | 10 | 25 | 55 |
| Red mulberry | 15 | 22 | 21.6 | 1.4 | 18.7 | 24.5 | 10 | 20 | 35 |
| Other eastern hard hardwoods | 19 | 35 | 25.9 | 3.2 | 19.6 | 32.2 | 10 | 20 | 70 |
| Total | 43 | 98 | 25.8 | 1.4 | 22.9 | 28.6 | 10 | 25 | 70 |
| Eastern noncommercial hardwoods | 14 | 46 | 23.1 | 3.7 | 15.8 | 30.5 | 5 | 22.5 | 99 |
| All hardwoods | 134 | 2,349 | 23.9 | 0.8 | 22.4 | 25.5 | 0 | 20 | 99 |
| All trees | 135 | 2,708 | 24.2 | 0.8 | 22.6 | 25.8 | 0 | 20 | 99 |

— = not presented due to insufficient sample; SE = standard error.

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

[b] See appendix.

[c] SE and confidence intervals are not presented for species groups with *n* trees < 20.

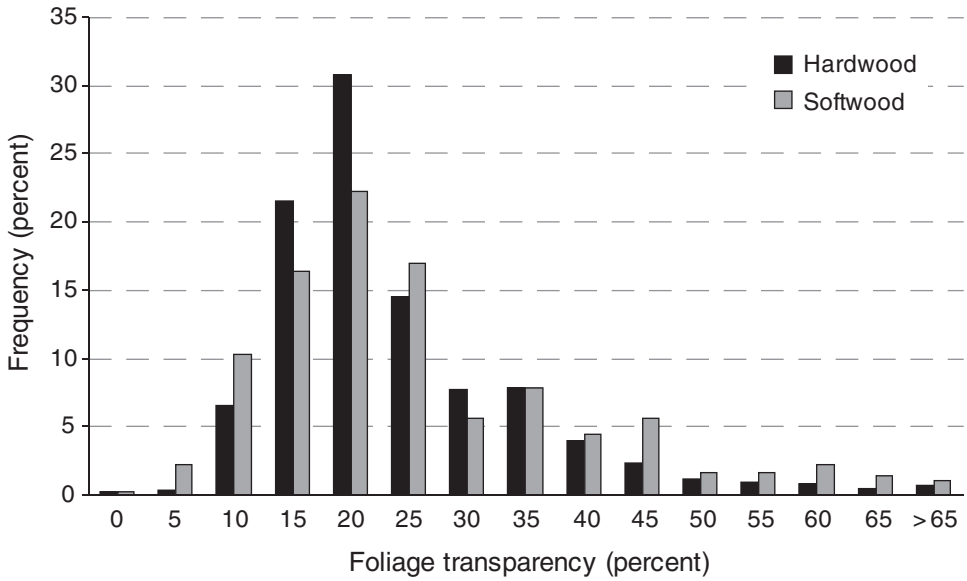


Figure 3—Foliage transparency frequency distribution by species group, Missouri, 2000–2003.

**Table 4—Distribution of sapling crown vigor class for all live saplings 1.0 to < 5.0 inches d.b.h. by species group, Missouri, 2000–2003**

| Species group[a] | Plots | Trees | Crown vigor rating | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Good | | Fair | | Poor | |
| | | | Percent | SE[b] | Percent | SE[b] | Percent | SE[b] |
| | - - number - - | | | | | | | |
| Softwoods | | | | | | | | |
| Loblolly and shortleaf pines | 4 | 6 | 50.0 | — | 50.0 | — | 0.0 | — |
| Other eastern softwoods | 30 | 59 | 78.0 | 5.6 | 15.3 | 5.0 | 6.8 | 3.7 |
| All softwoods | 33 | 65 | 75.4 | 5.7 | 18.5 | 5.4 | 6.2 | 3.4 |
| Hardwoods | | | | | | | | |
| Select white oaks | 28 | 59 | 66.1 | 9.0 | 28.8 | 8.5 | 5.1 | 3.0 |
| Select red oaks | 4 | 6 | 66.7 | — | 33.3 | — | 0.0 | — |
| Other white oaks | 13 | 20 | 40.0 | 13.1 | 50.0 | 15.1 | 10.0 | 6.7 |
| Other red oaks | 22 | 61 | 45.9 | 9.9 | 49.2 | 9.6 | 4.9 | 2.3 |
| Hickory | 49 | 102 | 71.6 | 5.8 | 24.5 | 5.8 | 3.9 | 1.9 |
| Hard maple | 9 | 20 | 85.0 | 6.1 | 15.0 | 6.1 | 0.0 | — |
| Soft maple | 5 | 7 | 42.9 | — | 28.6 | — | 28.6 | — |
| Tupelo and blackgum | 12 | 18 | 72.2 | — | 22.2 | — | 5.6 | — |
| Ash | 21 | 25 | 48.0 | 10.5 | 44.0 | 10.1 | 8.0 | 5.5 |
| Cottonwood and aspen | 1 | 8 | 62.5 | — | 37.5 | — | 0.0 | — |
| Black walnut | 5 | 6 | 83.3 | — | 16.7 | — | 0.0 | — |
| Other eastern soft hardwoods | 53 | 115 | 47.8 | 5.7 | 44.3 | 6.0 | 7.8 | 2.6 |
| Other eastern hard hardwoods | 53 | 116 | 69.8 | 4.9 | 24.1 | 4.5 | 6.0 | 2.6 |
| Noncommercial hardwoods | 18 | 35 | 57.1 | 12.4 | 31.4 | 8.3 | 11.4 | 6.1 |
| All hardwoods | 117 | 598 | 60.7 | 3.3 | 33.1 | 3.0 | 6.2 | 1.2 |
| All trees | 121 | 663 | 62.1 | 3.2 | 31.7 | 2.8 | 6.2 | 1.1 |

— = not presented due to insufficient sample; SE = standard error. (Standard error calculations consider the cluster of trees on plots.)

[a] See appendix.

[b] SE is not presented for species groups with *n* trees < 20.

reflected in the disparity of their average crown densities. Because such differences among species are expected, the most appropriate comparisons of crown condition should be made within individual species across time and space. The crown conditions reported here are the first of their kind in Missouri and will serve as a baseline against which to compare future assessments. Upon remeasurement, calculation of changes in crown measurements will indicate whether crown condition—and, by extension, forest health—is stable, improving, or declining.

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# Appendix

## Species List[a]

| Species group and common name | Scientific name[b] |
|---|---|
| Loblolly and shortleaf pines | |
| Shortleaf pine | *Pinus echinata* Mill. |
| Other eastern softwoods | |
| Eastern redcedar | *Juniperus virginiana* L. |
| Select white oaks | |
| White oak | *Quercus alba* L. |
| Swamp white oak[c] | *Q. bicolor* Willd. |
| Bur oak[c] | *Q. macrocarpa* Michx. |
| Chinkapin oak | *Q. muehlenbergii* Engelm. |
| Select red oaks | |
| Northern red oak | *Q. rubra* L. |
| Shumard oak[c] | *Q. shumardii* Buckl. |
| Other white oaks | |
| Post oak | *Q. stellata* Wangenh. |
| Other red oaks | |
| Scarlet oak | *Q. coccinea* Muenchh. |
| Northern pin oak[c] | *Q. ellipsoidalis* E. J. Hill |
| Southern red oak[c] | *Q. falcata* var. *falcata* |
| Shingle oak | *Q. imbricaria* Michx. |
| Blackjack oak | *Q. marilandica* Muenchh. |
| Pin oak[c] | *Q. palustris* Muenchh. |
| Black oak | *Q. velutina* Lam. |
| Hickory | |
| Bitternut hickory | *Carya cordiformis* (Wangenh.) K. Koch |
| Pignut hickory | *C. glabra* (Mill.) Sweet |
| Pecan | *C. illinoensis* (Wangenh.) K. Koch |
| Shagbark hickory | *C. ovata* (Mill.) K. Koch |
| Black hickory | *C. texana* Buckl. |
| Mockernut hickory | *C. tomentosa* (Poir.) Nutt. |
| Hard maple | |
| Sugar maple | *Acer saccharum* Marsh. |
| Soft maple | |
| Red maple | *A. rubrum* L. |
| Silver maple[c] | *A. saccharinum* L. |
| Sweetgum | |
| Sweetgum[c] | *Liquidambar styraciflua* L. |
| Tupelo and backgum | |
| Blackgum | *Nyssa sylvatica* Marsh. |
| Ash | |
| White ash | *Fraxinus americana* L. |
| Green ash | *F. pennsylvanica* Marsh. |
| Blue ash | *F. quadrangulata* Michx. |
| Cottonwood and aspen | |
| Eastern cottonwood | *Populus deltoides* Bartr. ex. Marsh |
| Basswood | |
| American basswood[c] | *Tilia americana* L. |
| Black walnut | |
| Black walnut | *Juglans nigra* L. |
| Other eastern soft hardwoods | |
| Boxelder[c] | *A. negundo* L. |
| Ohio buckeye[c] | *Aesculus glabra* Willd. |
| River birch[c] | *Betula nigra* L. |
| Sugarberry | *Celtis laevigata* Willd. |
| Hackberry | *C. occidentalis* L. |
| Butternut[c] | *J. cinerea* L. |
| American sycamore | *Platanus occidentalis* L. |
| Black cherry | *Prunus serotina* Ehrh. |
| Black willow[c] | *Salix nigra* Marsh. |
| Sassafras | *Sassafras albidum* (Nutt.) Nees |
| Winged elm | *Ulmus alata* Michx. |
| American elm | *U. americana* L. |
| Slippery elm | *U. rubra* Muhl. |
| Other eastern hard hardwoods | |
| Flowering dogwood | *Cornus florida* L. |
| Common persimmon | *Diospyros virginiana* L. |
| Honeylocust | *Gleditsia triacanthos* L. |
| Mulberry sp. | *Morus* spp. |
| White mulberry[c] | *M. alba* L. |
| Red mulberry | *M. rubra* L. |
| Black locust[c] | *Robinia pseudoacacia* L. |
| Noncommercial hardwoods | |
| Pawpaw[d] | *Asimina triloba* (L.) Dunal |
| American hornbeam, musclewood[d] | *Carpinus caroliniana* Walt. |
| Eastern redbud | *Cercis canadensis* L. |
| American smoketree[d] | *Cotinus obovatus* Raf. |
| Hawthorn sp.[d] | *Crataegus* spp. |
| Osage-orange | *Maclura pomifera* (Raf.) Schneid. |
| Eastern hophornbeam[d] | *Ostrya virginiana* (Mill.) K. Koch |
| Peachleaf willow[c] | *Salix amygdaloides* |
| Gum bumelia, chittamwood | *Sideroxylon lanuginosum* Michx. |

[a] Species group, common, and scientific names of species occurring in the FIA sample as saplings (1.0 to < 5.0 inches d.b.h.) and trees (≥ 5.0 inches d.b.h.) unless otherwise noted by footnote [c] or [d].
[b] Little (1979).
[c] Tree only.
[d] Sapling only.

**Randolph, KaDonna C.; Moser, W. Keith.** 2009. Tree crown condition in Missouri, 2000–2003. Gen. Tech. Rep. SRS–113. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 11 p.

The Forest Service, U.S. Department of Agriculture, Forest Inventory and Analysis (FIA) Program uses visual assessments of tree crown condition to monitor changes and trends in forest health. This report describes three FIA tree crown condition indicators (crown dieback, crown density, and foliage transparency) and sapling crown vigor measured in Missouri between 2000 and 2003. Descriptive statistics are presented for individual species, by FIA species group, and for all trees combined. The crown conditions reported here serve as a baseline against which to compare future assessments. Upon remeasurement, calculation of changes in crown measurements will indicate whether crown condition—and, by extension, forest health—is stable, improving, or declining.

**Keywords:** Crown density, crown dieback, FIA, foliage transparency, forest health, sapling vigor.


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