The Black Walnut Resource in the United States

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ABSTRACT—Between 1989 and 1999 the total volume of black walnut (*Juglans nigra* L.) in the United States increased from 1.6 to 2.4 billion cubic feet. Saw log volume (International ¼-inch scale) increased from 4.3 to 7.2 billion board feet. Increases occurred in most states; however, in Michigan, Ohio, Virginia, Pennsylvania, and Kansas black walnut volumes decreased or remained nearly constant and/or mean tree quality appeared to decrease. National forest inventory data is available online and can readily be queried to summarize and map characteristics of black walnut and other species by individual states, groups of counties, or other geographic areas. The majority of black walnut trees occur in natural stands in association with other fine hardwoods. On average black walnut comprises about 11% of the total volume in stands where it occurs. Thus, opportunities to apply silvicultural treatments to increase walnut volume or value in natural stands usually also provide the option to do the same for other associated hardwood species.

Black walnut (*Juglans nigra* L.) occurs naturally throughout the eastern United States (Williams 1999). Black walnut trees typically occur as scattered individuals or in small clusters; rarely do they comprise a majority of the stand basal area or volume in natural stands. Walnut growth and value increment are closely related to site quality, and, natural stands with high quality walnut trees often contain other valuable hardwoods such as northern red oak (*Q. rubra* L.), white oak (*Quercus alba* L.), white ash (*Fraxinus americana* L.), black cherry (*Prunus serotina* Ehrh), or yellow-poplar (*Liriodendron tulipifera* L.).

The vast majority of black walnut occurs in natural stands. Walnut plantations only cover approximately 13,800 acres in the United States, and plantations (walnut and mixed hardwood plantations) currently include only about 1% of all black walnut cubic foot volume in the United States. In natural stands, management (including harvesting) of black walnut is often carried out as part of prescription applied to a mixture of hardwood tree species (Slusher 1997).

Black walnut is highly valued for lumber and veneer. This fact, coupled with walnut's relative rarity, has resulted in an ongoing interest in inventory data detailing the location, volume, size, and quality of black walnut trees and how those attributes have changed over time (e.g., Quigley and Lindmark 1966, Blythe 1973, Cooper and others 1973, Schmidt and Kingsley 1997).

This paper provides a contemporary overview and update of the status of the black walnut resource. In addition to summarizing current conditions, it presents some large-scale trends in the walnut resource over the last 10 years based on the latest data available from the USDA Forest Service's Forest Inventory and Analysis (FIA) program (Miles 2001, Miles and others 2001). The latest available inventory information (mean inventory year of 1999) is compared to information reported for inventory year 1989 by Schmidt and Kingsley (1997) at the Fifth Black Walnut Symposium (Van Sambeek 1997). The latest inventory data is further analyzed to estimate the relative abundance of hardwood species that frequently occur in association with black walnut.

METHODS

Forest inventory data for black walnut and associated species were derived from data available on the USDA Forest Service FIA Web site (http://www.ncrs2.fs.fed.us/4801/FIADB/index.htm). Most data queries and initial summaries were conducted using the FIA data base (Miles and others 2001)

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coupled with the on-line FIA Mapmaker software (Miles 2001). Additional summaries and analyses were performed using spreadsheet and statistical software.

Except where otherwise noted, results are for timberland. Timberland is forest land that is capable of producing at least 20 cubic feet per acre per year of industrial wood crops and that is not administratively removed from timber utilization (e.g., through park, wilderness, or preserve status). In the eastern United States, 94% of forest land is classified as timberland (Smith and others 2002). Non-timberlands, (e.g., wooded pastures and wooded strips) do, in aggregate, contain significant quantities of black walnut that contribute to timber supply, wildlife values and other benefits. Schmidt and Kingsley (1997) indicate that black walnut on non-timberland has been estimated to range from 5 to 25% of that on timberland.

FIA inventory methods are undergoing a change from periodic statewide inventories at roughly 10-year intervals to on-going annual inventories that survey approximately 20% of a state's timberland each year (McRoberts 2000). Under the annual inventory system it requires approximately 5 years to complete a state inventory that is equivalent to the prior periodic inventories; thereafter the annual inventory system continuously provides current inventory information based on the most recent 5 years of inventory data. Change in some forest attributes can be estimated from as little as 1 to 4 years of annual inventory data, although the precision of estimates decreases with decreasing sample size.

States in the eastern United States are in differing stages of transition from the periodic to the annual inventory methods. The mean year of inventory and type of inventory data analyzed used in this paper are reported in Table 1. The mean inventory year for all states combined was computed as a weighted mean based on black walnut volume per state. The mean inventory year for the most current available data is 1999. This amounts to a mean remeasurement interval of 10 years from results reported by Schmidt and Kingsley (1997) for the black walnut resource in 1989. As noted in Table 1, there was no new inventory data for Kentucky, Louisiana, Mississippi, New York, North Carolina, or Oklahoma since Schmidt and Kingsley's (1997) report.

For reporting purposes some information on associated trees species was grouped into the select white oak group (primarily white oak; bur oak, *Quercus macrocarpa* Michx.; and chinkapin oak, *Quercus muehlenbergii* Engelm.), the select red oak group (primarily northern red oak; and cherrybark oak, *Quercus falcate* var. *pagodifolia* Ell.), the other

Table 1.—Year of most recent inventory, type of inventory, and remeasurement interval used for analysis. Periodic inventories were conducted prior to 2001 and are complete inventories of all timberland in a state. Annual inventories measure approximately 20% of a state's timberland each year on a continuous basis with each year's selection of plots systematically spread across the state. Five years of annual inventory are typically needed to complete a full state inventory cycle; inventories based on fewer than 5 years of data are unbiased but have a higher variance than a full state inventory cycle. The number of annual measurements is shown in parentheses for the annual inventories used in this analysis. The remeasurement interval indicates the number of years between these most current inventories and those reported by Schmidt and Kingsley (1997) which are used to evaluate change. NA indicates that there is no newer information than that reported by Schmidt and Kingsley (1997).

State	Inventory Type	Remeasurement Interval (yrs)
Alabama	2000 periodic	10
Arkansas	2001 annual (2)	13
Delaware	1999 periodic	13
Georgia	1997 periodic	8
Illinois	1998 periodic	13
Indiana	2002 annual (4)	14
Iowa	2001 annual (3)	10
Kansas	2002 annual (2)	20
Kentucky	1988 periodic	NA
Louisiana	1991 periodic	NA
Maryland	1999 periodic	13
Michigan	2001 annual (2)	8
Minnesota	2002 annual (4)	10
Mississippi	1994 periodic	NA
Missouri	2002 annual (4)	11
Nebraska	2002 annual (2)	8
New Jersey	1999 periodic	12
New York	1993 periodic	NA
North Carolina	1990 periodic	NA
Ohio	2001 annual (1)	10
Oklahoma	1993 periodic	NA
Pennsylvania	2002 annual (3)	12
South Carolina	2002 annual (5)	7
Tennessee	1999 periodic	10
Texas	2002 annual (3)	9
Virginia	2001 annual (5)	8
West Virginia	2002 periodic	13
Wisconsin	2001 annual (2)	5
Mean	1999	10

red oak group (primarily black oak, *Quercus velutina* Lam.; pin oak, *Quercus palustris* Muenchh.; and scarlet oak, *Quercus coccinea* Muenchh.), the ash group (*Fraxinus* spp.), the hickory group (*Carya* spp.) and the hard maple group (primarily sugar maple, *Acer saccharu*m Marsh.) (Miles and others 2001).

Trees were classified into four grade classes with grade 1 representing the best quality. Tree grade definitions varied among states, but were most often based upon grading rules by Hanks (1976) and/or by Rast and others (1973). In general, tree grade was determined from the best 12 feet of the lowest 16-foot log or the best 12-foot upper section of the tree if the butt log did not meet minimum grade requirements (e.g., due to rot or defects). Typical minimum DBH limits for grades 1, 2, and 3 were 16 inches, 13 inches, and 11 inches, respectively. Typical minimum scaling diameters inside bark for grades 1, 2, and 3 were 13 inches, 11 inches, and 8 inches, respectively. Additional grading criteria took into account the number of surface defects on logs, and deductions for cull, crook, and/or sweep. The best source of detailed information on grading rules is the appendix of FIA inventory reports for individual states of interest (e.g., Schmidt and others 2000). The most up-to-date source of information on inventory reports is the FIA webpage (http://www.fia.fs.fed.us/).

RESULTS

From 1989 to 1999 the total number of black walnut trees 5 inches DBH and larger increased 23% (162 to 200 million trees) (Fig. 1A). On a percentage basis the greatest increase was in walnut trees > 21 inches DBH; that diameter class increased by 132% (1 million trees) during the inventory interval. However, that increase was on a relatively small initial number of trees. In absolute numbers of trees, the greatest increase (14 million trees) occurred in the 11-inch DBH class (Fig. 1B).

Black walnut volume increased in the 10 states with the greatest current walnut cubic foot volume (Fig. 2). Iowa, with a 13% annual rate of increase (cubic foot basis), had the largest net gain. Virginia and Michigan saw net annual decreases of 3% and 7%, respectively, in black walnut cubic foot volume. Rankings for board foot volume increase and percent volume increase differed slightly from those for cubic volume, but Iowa still had the greatest increase (15% annually) while Virginia and Michigan both declined. The composite category representing "other states" also showed large annual increases in black walnut volume: 10% annual increase for cubic foot volume and 9% annual increase in board foot volume over a 6-year remeasurement interval (Fig. 2). The combined total black walnut cubic foot volume for all states increased from 1.6 to 2.4 billion cubic feet (50% or approximately 4% annually) over the 10-year remeasurement interval (Table 1). Total board foot volume (International ¼-inch scale) increased from 4.3 to 7.2 billion board feet (67% or approximately 6% annually) over the same interval.

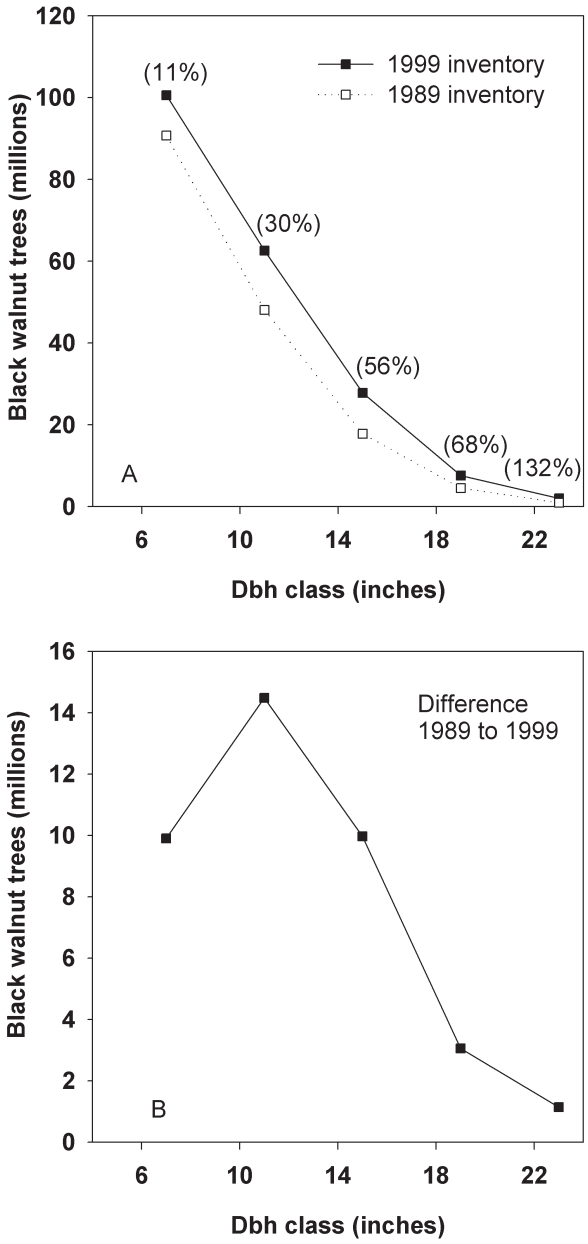

Figure 1.—(A) Number of black walnut trees by DBH class for past (1989) and current (1999) inventories. Inventory dates for individual states are listed in Table 1. Past inventory values are based on Schmidt and Kingsley (1997). Percent increase is shown for individual diameter classes. (B) Net increase by diameter class.

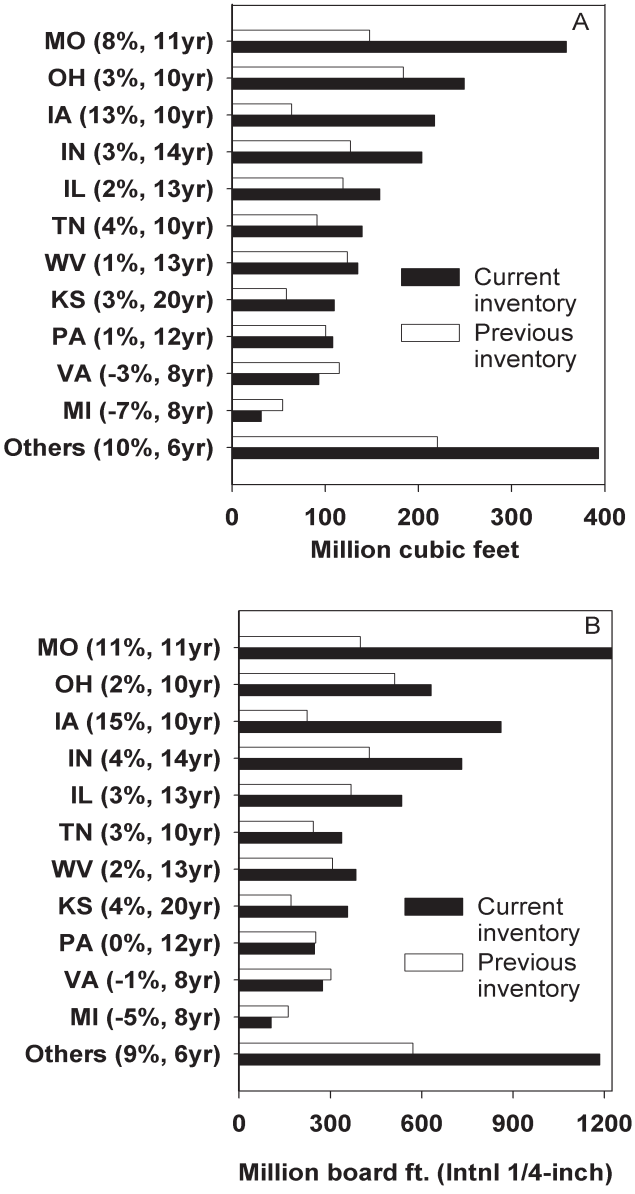

Figure 2.—Volume of black walnut growing stock on timberland. Current values are for the inventory years listed in Table 1; previous values are based on Schmidt and Kingsley (1997). Periodic increase per state is indicated by the difference between bars. State labels show the annual percent change in volume and the remeasurement interval for each state; NA indicates that no remeasured data were available. States are ordered from greatest to least current volume (cubic foot basis). Total cubic foot volume increased from 1.6 to 2.4 billion cubic feet over the period. Total board foot volume (International ¼-inch scale) increased from 4.3 to 7.2 billion board feet (International ¼-inch) over the period.

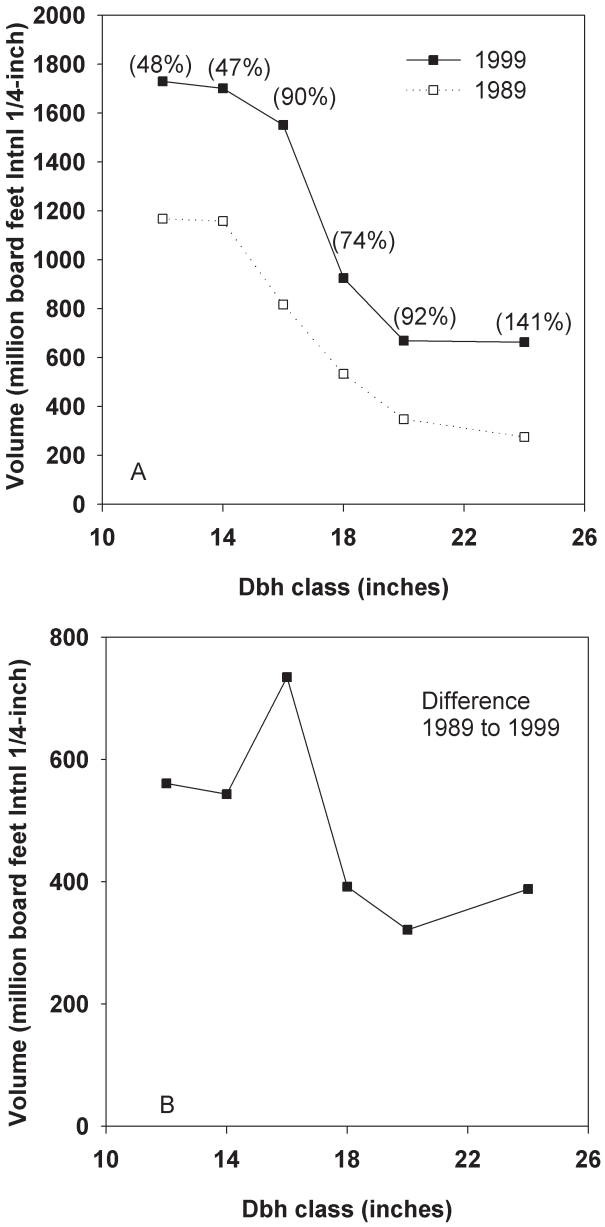

Figure 3.—(A) Black walnut board foot volume by diameter class for past (1989) and current (1999) inventories. Inventory dates for individual states are listed in Table 1. Past inventory values are based on Schmidt and Kingsley (1997). Percent increase is shown for individual diameter classes. (B) Net increase by diameter class over the remeasurement interval of 10 years. Volume increased in all diameter classes with the greatest increases in the 16-inch DBH class.

Across the range of black walnut, the board foot volume of growing stock on timberland increased in all tree diameter classes (Fig. 3). As was observed for the total number of trees, the greatest percentage increase in black walnut volume occurred in the larger diameter classes. Over the 10-year remeasurement period volume increased by more than 90% for black walnut trees > 19 inches DBH. However, on an absolute basis the most volume (735 million board feet) accrued in the 16-inch DBH class.

For all states combined, 16% of black walnut volume was classified as tree grade 1 (best) (Table 2). Tree grades 2 and 3 each included 35% of black walnut board foot volume, and tree grade 4 included the remaining 14%. Michigan and Iowa were on the high end of the quality range for black walnut; they had at least 20% of black walnut volume in tree grade 1. In Michigan, Iowa, Tennessee, Pennsylvania, Indiana, Illinois, and the "Other" group of states at least 50% of black walnut volume was in tree grades 1 and 2. Since the previous measurement, the proportion of volume in tree grades 1 or 2 declined in Ohio, and Kansas. In most other states the proportion of volume in tree grades 3 or 4 decreased while volume in tree grades 1 and 2 increased.

On inventory plots where black walnut occurred, it comprised an average of 11% of the total cubic foot volume (Fig. 4). Iowa and Kansas were at the high end of the range with black walnut comprising 23 and 18%, respectively, of the total volume on sites where walnut occurred. Tennessee was at the low end of the range with an average of 7% black walnut volume on sites where walnut occurred. Across all states black walnut was most commonly found growing in association with select white oaks (10%), yellow-poplar (9%), hickory (9%), other red oaks (8%), ash (7%), select red oaks (5%), and hard maple (4%). Other species comprised the remaining 35% of the volume on plots where black walnut occurred. In most states black walnut comprised the plurality of the volume by species or species groups (Fig. 4) in plots where it occurred. In Missouri and Illinois the total volume of the select white oak group exceed the total walnut volume on plots where walnut occurred. Similarly the total volume of yellow-poplar volume exceeded black walnut volume on plots in Kentucky, Tennessee, West Virginia, and the group of "other" states.

DISCUSSION

In the 10 years since the last comprehensive inventory and summary of the black walnut resource in the eastern United States (Schmidt and Kingsley 1997), the number and volume of black walnut trees has increased (Figs. 1, 3). This continues a trend that goes back to at least 1966 (Quigley and Lindmark 1966). Thus, across the region there is little reason to be concerned that the black walnut is being depleted at current rates of

Table 2.—Black walnut sawtimber volume by state and tree grade, 1999. Percent change from previous inventory as reported by Schmidt and Kingsley (1997) is shown in italics. State entries are ordered from best (lowest) to worst (highest) average tree grade. Tree grade definitions differ among some states as described in the text. Statistics showing change over time within a given state are based on a consistent set of tree grade definitions.

State	Remeas. Interval	Grade 1		Grade 2		Grade 3		Grade 4	
		Current	Change	Current	Change	Current	Change	Current	Change
MI	8	28	*8*	41	*-5*	31	*0*	0	*-3*
IL	13	16	*3*	48	*10*	33	*-8*	3	*-5*
IA	10	20	*8*	42	*8*	29	*-21*	9	*5*
Others		17	*7*	42	*15*	32	*-21*	9	*-1*
PA	12	18	*15*	36	*11*	34	*-12*	11	*-15*
TN	10	19	*14*	31	*13*	42	*-21*	8	*-6*
IN	14	17	*6*	36	*6*	27	*-23*	19	*10*
MO	11	15	*10*	31	*12*	38	*-7*	15	*-16*
WV	13	15	*2*	32	*1*	34	*-4*	19	*1*
KS	20	5	*-19*	41	*4*	44	*5*	10	*10*
VA	8	8	*4*	32	*2*	41	*-14*	19	*8*
OH	10	16	*7*	15	*-7*	42	*-21*	28	*21*
All states	10	**16**	*6*	**35**	*7*	**35**	*-16*	**14**	*3*

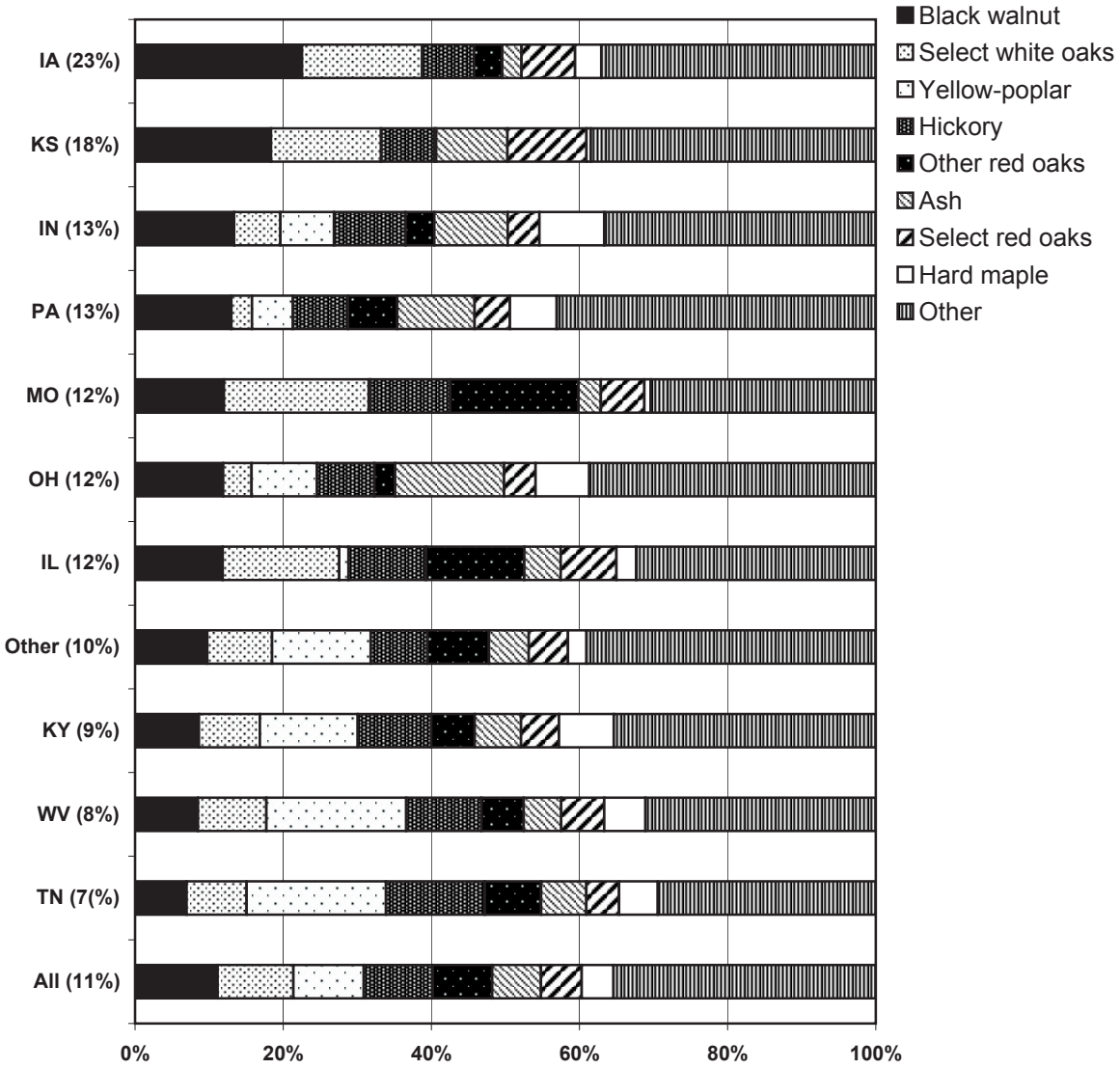

Figure 4.—Proportion of volume by species or species groups for inventory plots that contain black walnut. Proportions are based on total cubic feet of growing stock volume on timberland. The total proportion of black walnut volume is listed with the state name. Across all states, black walnut comprises 11% of the volume where it occurs.

harvest and natural mortality. However, the walnut resources merit continued scrutiny in Michigan, Virginia, and Pennsylvania where walnut volume is flat or decreasing. The shift to annual (continuous) FIA inventories (McRoberts 2000) provides an excellent mechanism to monitor the black walnut resource on a continuing basis.

The composite reverse-J-shaped diameter distribution for black walnut trees in the region (Fig. 1A) is expected for any species that has experienced decades of successful reproduction and growth in the absence of excessive depletion by insects, disease, harvesting or other disturbance factors. What is puzzling about this pattern is that the greatest absolute increase in walnut abundance is in the 11-inch DBH class and not in smaller (7-inch) DBH class (Fig. 1B). This could be a natural consequence of an abundance of well-stocked, maturing forests that provide fewer opportunities for walnut regeneration than in the past. Over the long term this pattern bears watching regionally and locally to ascertain whether or not fewer black walnut trees will be moving into the 11-inch DBH class in coming decades. In the short term the fact that the largest percentage increases in the number and volume of black walnut trees has occurred in the largest diameter classes bodes well for those interested in an abundance of large, black walnut trees for products or other values.

Percentage increases in board foot volume were high in the larger diameter classes (Fig. 3), but the absolute increase in board foot volume peaked in the 16-inch diameter class (735 million board feet). The overall increase in walnut volume was substantial (nearly 3 billion board feet over the remeasurement interval), but states did not share equally in the increase. Although most states registered net increases in black walnut board foot volume (2% to 15% annually) (Fig. 2), volume in Pennsylvania remained virtually unchanged and decreased in Virginia (-1%) and Michigan (-5%). This highlights the fact that broad regional trends tell only part of the story. Local patterns may differ from regional trends due to a whole host of factors.

The availability of web-based tools for summarizing FIA data makes it relatively easy to explore trends for individual states, ecoregions, groups of counties, or even circular areas around a specific point (e.g., the procurement zone around a sawmill) (Miles 2001, Miles and others 2001). Data presented in Table 2 and Figures 1-4 were summarized from retrievals made from the FIA web-based retrieval system. Individuals with interest in a smaller geographic region can summarize similar statistics specific to that area. Web-based mapping tools provide opportunities to display spatial patterns of resource data for counties or larger areas. A web browser and internet access are all that is required to access these data. Spreadsheet software is usually a helpful addition for summarizing and graphing results.

Black walnut lumber and veneer value is greatly affected by log grade. FIA inventories use tree grade as an indicator of quality and value. The proportion of black walnut volume in the two best quality classes increased in most states. This can partially be attributed to the overall increase in the mean diameter of black walnut trees in the sawlog size class during the remeasurement interval. Other factors being equal, tree grade increases when trees increase in scaling diameter to exceed specific merchantability limits (e.g., 8, 11, or 13 inches). Other factors related to tree quality may also be involved in the observed increase in tree grade, but it is difficult to evaluate them separately. As described in the Methods section, grading rules differed among some states. However, the percent changes in tree grade for an individual state (Table 2) for are based on a consistent set of grade definitions.

Ohio, Virginia, Michigan, and Kansas stand out as states that have (1) modest or negative total volume change, (2) decreases in the proportion of volume in tree grades 1 and 2, and (3) increases in the proportion of volume in tree grades 3 and 4. Those states are worthy of closer monitoring as new inventories are completed in coming years.

Black walnut rarely occurs in pure or nearly pure stands. However it often occurs on good sites in association with other valuable hardwoods. Across all plots where black walnut occurred, it comprised an average of 11% of the board foot volume—more than any other individual species. Select white oaks, yellow-poplar and hickories had slightly less volume, followed by other red oak, ash, select red oaks, and hard maples. Other species comprised the remainder, an average of 35% of the saw log volume. Consequently, black walnut growing in natural stands usually provides the opportunity to simultaneously manage a suite of hardwood species with the potential to produce high-valued timber and often to produce abundant mast as well.

There was considerable variation among states in the relative abundance of black walnut sawtimber volume on plots where black walnut occurred. For individual states black walnut had the plurality of board foot volume in only five: Iowa (23%), Kansas (18%), Indiana (13%), Pennsylvania (13%), and Ohio (12%). In Tennessee, West Virginia, and the group of “other” states the volume of yellow-poplar exceeded walnut volume on those plots where walnut occurred. For Illinois and Missouri the volume of select white oaks exceeded the volume of walnut on plots where walnut occurred. Thus, black walnut management opportunities are most often found in mixed hardwood stands where general hardwood management guides (e.g., Sander 1977, Clark and Hutchinson 1998, Perkey and others 1993, Johnson and others 2002) apply. For best results with black walnut, however, hardwood management guides should be modified with guidelines specific to black walnut (e.g., Schlesinger 1977, Burde 1988, Van Sambeek 1997).

CONCLUSIONS

The number, volume, and general quality of black walnut trees in the eastern Unites States has increased since conditions were last reported by Schmidt and Kingsley (1997) at the Fifth Black Walnut Symposium. These increases continue a trend dating to 1966 (Quigley and Lindmark 1966). Across the region increases in black walnut abundance were observed for a wide range of diameter classes. The number of black walnut trees between 5 and 9 inches DBH (the smallest DBH class examined) increased, but at a rate less than or equal to some larger diameter classes. This pattern should be monitored as new inventory information becomes available.

All states did not fair equally in the generally rosy outlook for the black walnut resource. Michigan, Ohio, Virginia, Pennsylvania, and Kansas stand out as states where black walnut volume is low or declining and/or where overall tree quality appeared to decrease. This too should be monitored in subsequent inventories.

Some excellent tools are available to query FIA databases for specific information about forest resources in individual states, groups of counties, or mill procurement zones. These web-based tools can be accessed at http://www.ncrs2.fs.fed.us/4801/FIADB/index.htm

The vast majority of black walnut volume is found in natural stands in association with other hardwoods, many of which are valuable or potentially so. In stands where black walnut occurs, it is often the species with the greatest volume per acre, but on average it comprises only about 11% of the total volume. Thus, opportunities to increase walnut volume or value generally provide opportunities to do the same for other hardwood species.

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