# PART 1

# THE HISTORY OF THE EASTERN BLACK WALNUT SPECIES

# Black Walnut In The United States

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ABSTRACT: -- The current situation of black walnut (Juglans nigra L.) in the United States related to area, volume, growth, mortality, and removals is presented. As of the most recent inventories, there were more than 15 million acres of timberland with black walnut present, 95 percent of which is privately owned. The majority of the black walnut timberland was classed as sawtimber. Growing-stock and sawtimber volume almost doubled between 1963 and 1989. The long-term future for black walnut appears bright due to favorable growth to removal ratios. Aspects of black walnut nut production in relation to the resource are presented.

## GROWER RECOMMENDATIONS

Currently, nut production is a secondary consideration of most timberlands with black walnut (Juglans nigra L.) present. Plantations represent only one percent of the total black walnut resource throughout the Nation. Black walnut plantations specifically designed for nut production represent only a fraction of the total black walnut plantations. While the black walnut resource is growing, there has not been a focus on managing this resource for nut production. Demand for black walnut nuts has consistently met or exceeded supply due to the consistently growing demand and inconsistent availability of the nuts produced.

The supply of black walnut nuts and timber would be enhanced if establishment and management were focused on sites with high potential productivity. With the majority of black walnut timberlands owned by non-industrial private landowners, the future supply is dependent on land management goals that include nut and timber production. Private landowners own land for many purposes, if improving the quantity of both black walnut nuts and wood fiber is of high priority, public agencies could target these landowners for increased management, technical assistance, and cost-share programs.

Tree distribution records of state forestry agencies show that more than 3 million black walnut seedlings have been annually distributed throughout the eastern United States in 1990's (Johnson 1995). In addition, there are many private nurseries that distribute black walnut seedlings. To date, plantations have not made a significant impact on the supply of black walnut nuts or timber. However, if this level of planting continues, if the plantations are adequately managed, and if they are planted on productive sites, plantations have the potential to improve the future supply of black walnut nuts and wood fiber. The number of black walnut trees has consistently increased, growing-stock volume has consistently risen, the number of plantations has increased, and demand for nuts and fiber has consistently risen. If this growing resource is adequately managed, questions about the long-term supply of black walnut for both nuts and timber will be answered.

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## INTRODUCTION

Black walnut, one of the most highly valued hardwood species, is found throughout most of the eastern half of the United States (Harlow and Harrar 1969). The species is not dominant in most forests, but rather is generally found as scattered single trees or as small isolated groups within hardwood stands (Fischer 1982). Black walnut has a large geographical range but a narrow range of suitable sites where it can grow at an adequate rate.

Since the late 1800's, the supply of black walnut has been a topic of concern. The concern for black walnut has been centered on high quality, large diameter trees but the supply of black walnut nuts has also received attention. In 1880, a Purdue University professor reported that about 85 percent of the black walnut resource in Indiana had been disposed of (Frye 1982). Foresters concerned about the supply of black walnut have historically urged an increase in the management and planting of black walnut (Quigley and Lindmark 1966, Adams 1981). In an address to the Third Black Walnut Symposium, R. Max Petersen recognized that while, for most hardwoods, growth significantly exceeded demand, the situation was quite the opposite for black walnut (Petersen 1982). He estimated that demand for black walnut had been greater than supply for many years and that the gap between demand and supply was projected to widen at an ever increasing rate. From a nut production perspective, demand has consistently met or exceeded supply.

Inventory results from the 1970's seemed to confirm the concerns expressed by forest industries, foresters, and landowners. For example, in Missouri black walnut growing stock decreased from 100 million cubic feet in 1959 to 97 million cubic feet in 1972, and sawtimber decreased from 238 million board feet to 217 million board feet in the same time period (Spencer and Essex 1976). In Iowa, black walnut growing-stock volume decreased by more than a third from 1954 to 1974, going from about 52 million cubic feet to about 32 million cubic feet (Spencer and Jakes 1980). Similar examples of decreasing black walnut volumes in the 1960's and 1970's could be provided for many other states.

Plantations have been viewed as a means to increase the supply of black walnut. While black walnut plantations have not met the expectations of either the producing landowners or the utilizing industries from a timber production standpoint (Schmidt and Kingsley 1997), they do hold great promise for increasing nut production. In light of the many concerns about black walnut, it is important to understand and evaluate black walnut's current status.

## METHODS

Data for this paper are from the USDA Forest Service, Forest Inventory and Analysis' (FIA) Eastwide Data Base (EWDB) which contains the most recent statewide forest inventory for each state (Hansen et al. 1992). Data presented pertain only to timberland, however, more than 95 percent of the forest land in the United States is classified as timberland (Powell et al. 1993). Timberland is forest land capable of producing more than 20 cubic feet per acre per year of industrial wood crops under natural conditions and not withdrawn from timber utilization. There are other classifications of forest land that contain black walnut, including reserved forest land, narrow planted and natural wooded strips, and pasture land with trees that do not meet the timberland definition. Significant amounts of black walnut occur on these non-timberlands and they make important contributions to not only the nut and timber supply of black walnut, but also to other forest related benefits. It has been estimated that the majority of the harvested black walnut

nuts come from either open-grown forests, pastures with black walnut present, or plantations. The amount of black walnut on non-timberland has been estimated to range from 5 to 25 percent of that found on timberlands. Until recently, FIA did not install field plots on these other lands and, as a result, data are very limited for forestland classifications other than timberlands.

Black walnut is not a recognized forest type but is included within several forest types. Black walnut is a common associate of five forest cover types and is also found as an occasional associated species in four other forest cover types recognized by the Society of American Foresters (Williams 1990). Area data are generated from FIA tree-level records and are based on the existence of at least one 5 inch d.b.h. (diameter at breast height) or larger black walnut within an established FIA field plot. Area data for each state in the black walnut range are generated by this method for ownership, stand-size class, and site productivity class. For stand-size class determinations, sawtimber sized stands are stands with half or more of the total live tree stocking in trees that are at least 11 inches d.b.h. Growing-stock volume is the net volume in cubic feet of growing-stock trees 5.0 inches d.b.h. and over, from 1 foot above the ground to a minimum 4 inch top diameter outside bark (d.o.b.) or to the point where the central stem breaks into limbs. Sawtimber volume, a subset of growing-stock volume, is the net volume in board feet (International 1/4 inch rule) of the saw-log portion of live sawtimber sized trees from 1 foot above ground to a minimum 9 inches top d.o.b.

Dates of the most recent statewide inventories range from 1981 in Kansas to 1993 in Michigan. To determine the average most recent FIA inventory date for black walnut, the inventory year for each state was multiplied by the percent of the total national growing-stock volume represented by each state. This resulted in an average inventory date of 1989. By comparison, Quigley and Lindmark referenced the 1962 appraisal of the timber resources of the United States. Thus, comparisons over time are based on average inventory dates of 1962 and 1989, a 27-year time span.

To estimate the volume of timber produced from timberland, FIA units conduct direct mail canvasses of the mills that process the timber. There are two sources of black walnut timber products: those from timberland and those from lands not considered timberland such as nonforest area with trees, fence rows, and other lands. Thus, it is conceivable that the total volume of products removed can exceed the total volume of growing stock removed. If the total volume harvested was significantly greater than the growing-stock volume removed, it can be assumed that a significant volume was produced from non-growing stock sources (as is often the case).

## RESULTS

### Area

The most recent inventories indicate more than 15.4 million acres of timberland with black walnut present (Table 1). Of these acres, 99 percent occurred in natural stands and 1 percent was in plantations. Black walnut plantations generally are small, scattered acreages. While the majority of the black walnut plantations were located in Ohio, Kentucky, and Illinois, several additional states have plantations specifically designed for nut production.

Table 1.--Area of timberland with black walnut by ownership class.

| Most Recent | Ownership class | | | | | |
|---|---|---|---|---|---|---|
| | National | Misc. | Other | Forest | Private | Private |

| State | Inventory | Total | forest | federal | Public | Industry | individual | corporation |
|---|---|---|---|---|---|---|---|---|
| | | | | | (Thousand acres) | | | |
| Missouri | 1989 | 2,569.7 | 101.1 | 76.0 | 50.9 | 8.3 | 2,124.3 | 209.1 |
| Kentucky | 1988 | 1,971.2 | 46.1 | - | 15.5 | 10.3 | 1,770.3 | 129.0 |
| Ohio | 1991 | 1,759.8 | 26.8 | - | 46.6 | 19.0 | 1,532.3 | 135.1 |
| West Virginia | 1989 | 1,357.8 | 4.6 | 7.2 | 22.1 | 54.9 | 1,103.7 | 165.3 |
| Tennessee | 1989 | 1,234.6 | 7.7 | 36.2 | 11.5 | 59.7 | 1,088.3 | 31.2 |
| Indiana | 1986 | 1,064.2 | 12.9 | 31.4 | 27.5 | 1.9 | 907.6 | 82.9 |
| Illinois | 1985 | 941.5 | 20.1 | - | 15.8 | 4.0 | 853.1 | 48.5 |
| Pennsylvania | 1989 | 708.7 | - | 5.3 | 5.8 | 5.5 | 636.0 | 56.1 |
| Virginia | 1991 | 577.5 | 15.8 | 13.5 | 10.8 | 15.2 | 461.4 | 60.8 |
| Iowa | 1990 | 536.0 | - | 6.1 | 17.9 | - | 484.5 | 27.5 |
| Kansas | 1981 | 472.7 | - | 15.3 | 1.0 | 3.4 | 427.3 | 25.7 |
| Arkansas | 1988 | 451.4 | 52.0 | 6.3 | 6.2 | 9.7 | 343.8 | 33.4 |
| 18 other states | | 1,769.7 | 6.6 | 38.1 | 82.2 | 69.3 | 1,468.3 | 105.2 |
| Total all states | | 15,414.8 | 293.7 | 235.4 | 313.8 | 261.2 | 13,200.9 | 1,109.8 |

There are 30 states with naturally occurring black walnut, however, the walnut resource is not evenly distributed across the Nation. For example, 50 percent of the total timberland area in the United States with black walnut occurred in only 4 states--Missouri, Kentucky, Ohio, and West Virginia (Fig. 1). Twelve states, mostly in the Central Hardwood Region, accounted for almost 90 percent of the total area of timberland with black walnut present.

Comparing the area of timberland with black walnut present to the total area of timberland, Kansas ranks first with almost 40 percent of its timberland having black walnut present. Other states with high percentages of timberlands with black walnut present include Iowa, Indiana, Illinois, Ohio, Missouri, Kentucky, West Virginia, and Nebraska. In these states, at least 10 percent of the total timberland area contain black walnut. By comparison, Pennsylvania was 8th in total area of timberland with black walnut (709 thousand acres) but this was less than 5 percent of their total timberland area (15.9 million acres).

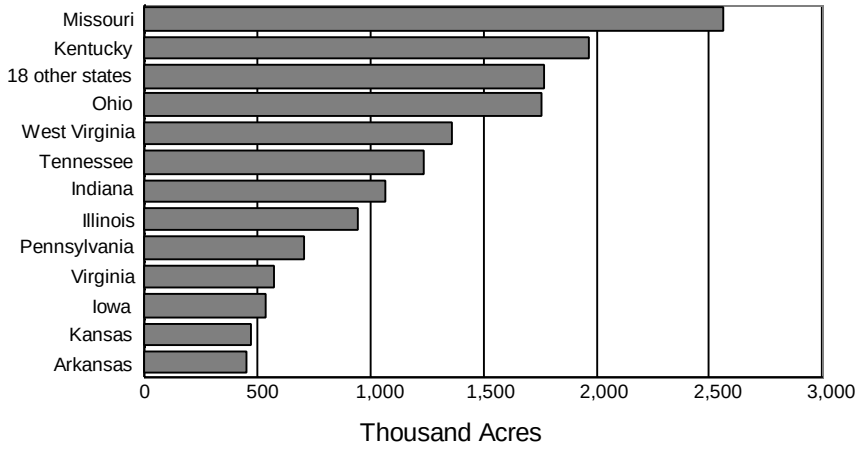


Figure 1. Area of timberland with black walnut present from most recent inventories, by state.

In the most recent inventories, 58 percent of the timberland with black walnut was in sawtimber-sized stands, 28 percent was in poletimber-sized stands, and 14 percent was in sapling-seedling sized stands (Fig. 2). All thirty of the states had the most timberland area with black walnut present in the sawtimber-size class (Table 2). These data represent the average stand size determined from the dominant trees in the stand, black walnut might or might not have been the dominant trees. However, since black walnut seedlings are intolerant of shade and are seldom found under dense tree canopies (Williams 1990), the black walnut size class should be similar to that of the overall stand.

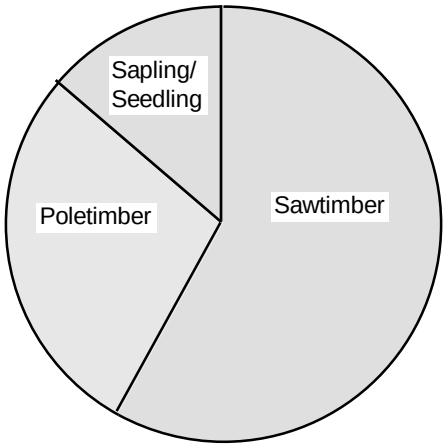


Figure 2. Size class distribution of timberland area with black walnut present.

Table 2.— Area of timberland with black walnut by stand-size class.

| | | Stand-size class | | |
|---|---|---|---|---|
| State | Total | Sawtimber | Poletimber | Sapling-seedling |
| | | (Thousand acres) | | |
| Missouri | 2,569.7 | 1,293.8 | 875.4 | 400.5 |
| Kentucky | 1,971.2 | 1,041.4 | 648.6 | 281.2 |
| Ohio | 1,759.8 | 1,012.3 | 420.1 | 327.4 |
| West Virginia | 1,357.8 | 774.1 | 442.8 | 140.9 |
| Tennessee | 1,234.6 | 659.8 | 401.3 | 173.5 |
| Indiana | 1,064.2 | 749.7 | 176.2 | 138.3 |
| Illinois | 941.5 | 668.0 | 173.1 | 100.4 |
| Pennsylvania | 708.7 | 400.1 | 236.4 | 72.2 |
| Virginia | 577.5 | 389.5 | 143.0 | 45.0 |
| Iowa | 536.0 | 390.1 | 107.7 | 38.2 |
| Kansas | 472.7 | 234.2 | 113.4 | 125.1 |
| Arkansas | 451.4 | 196.5 | 186.6 | 68.3 |
| 18 other states | 1,769.7 | 1,130.9 | 437.7 | 201.1 |
| Total all states | 15,414.8 | 8,940.4 | 4,362.3 | 2,112.1 |

Almost 70 percent of the black walnut timberland acreage were located on the two lowest productivity classes (Table 3). Less than 10 percent of the black walnut timberland was classified as being on sites with very high to excellent productivity potential (120 + cubic feet of growth per acre

per year). However, there were a few states with significant acreages of black walnut timberland on the higher productivity sites. For example, more than 60 percent of the black walnut timberland in Indiana was located on sites with a potential productivity of at least 85 cubic feet per acre per year. From a nut production perspective, it is critical that plantations be located on the highest productivity sites possible.

Table 3.--Area of timberland with black walnut by site productivity class.

| | | Productivity class (cubic feet of growth per acre per year) | | | | |
|---|---|---|---|---|---|---|
| State | Total | 165+ | 120 -164 | 85 -119 | 50 -84 | 20 -49 |
| | | | (Thousand acres) | | | |
| Missouri | 2,569.7 | 15.4 | 28.9 | 207.9 | 1,289.0 | 1,028.5 |
| Kentucky | 1,971.2 | - | 149.9 | 353.6 | 605.8 | 861.9 |
| Ohio | 1,759.8 | - | 58.9 | 159.9 | 405.5 | 1,135.5 |
| West Virginia | 1,357.8 | - | 139.3 | 404.3 | 362.6 | 451.6 |
| Tennessee | 1,234.6 | 52.3 | 184.0 | 316.6 | 485.1 | 196.6 |
| Indiana | 1,064.2 | - | 206.1 | 449.6 | 298.4 | 110.1 |
| Illinois | 941.5 | - | 47.5 | 382.8 | 408.5 | 102.7 |
| Pennsylvania | 708.7 | - | 65.7 | 107.9 | 198.4 | 336.7 |
| Virginia | 577.5 | 4.6 | 15.1 | 158.4 | 356.3 | 43.1 |
| Iowa | 536.0 | 3.2 | 5.8 | 181.1 | 260.6 | 85.3 |
| Kansas | 472.7 | - | 2.1 | 67.4 | 220.5 | 182.7 |
| Arkansas | 451.4 | 4.8 | 0.0 | 40.0 | 280.3 | 126.3 |
| 18 other states | 1,769.7 | 117.2 | 183.5 | 539.6 | 670.4 | 259.0 |
| Total all states | 15,414.8 | 197.5 | 1,086.8 | 3,369.1 | 5,841.4 | 4,920.0 |

## Number of Trees

In the most recent inventories, there were almost 500 million black walnut growing-stock trees in the United States (Table 4). More than 90 percent of these trees were located in twelve states. Of the half billion black walnut growing-stock trees, two-thirds were less than 5 inches d.b.h. In the most recent inventories, only 8 percent of the total number of black walnut growing-stock trees were larger than 11 inches d.b.h., considered the minimum size necessary for being classified as sawtimber. Only one percent (5.4 million) of all of the black walnut growing-stock trees in the United States were larger than 17 inches d.b.h.

Table 4.– Number of black walnut growing-stock trees by diameter class.

Diameter class (inches d.b.h.)

| State | Total | 1.0 -4.9 | 5.0 - 8.9 | 9.0 - 12.9 | 13.0 - 16.9 | 17.0 - 20.9 | 21.0 + |
|---|---|---|---|---|---|---|---|
| | | | | (Thousand trees) | | | |
| Kentucky | 94,453 | 70,875 | 14,854 | 6,507 | 1,732 | 410 | 75 |
| Ohio | 76,552 | 58,244 | 9,770 | 5,386 | 2,408 | 669 | 76 |
| West Virginia | 63,123 | 50,553 | 7,020 | 3,541 | 1,544 | 394 | 71 |
| Pennsylvania | 57,385 | 46,210 | 7,051 | 2,528 | 1,221 | 297 | 77 |
| Missouri | 50,936 | 33,580 | 9,860 | 5,417 | 1,668 | 376 | 36 |
| Illinois | 26,397 | 14,548 | 7,339 | 2,904 | 1,240 | 270 | 97 |
| Indiana | 22,715 | 11,900 | 5,686 | 3,208 | 1,489 | 375 | 56 |
| Kansas | 20,969 | 13,163 | 4,430 | 2,406 | 756 | 173 | 41 |
| Iowa | 13,677 | 8,238 | 2,351 | 1,920 | 867 | 272 | 29 |
| Virginia | 11,413 | 3,254 | 3,501 | 3,000 | 1,233 | 335 | 90 |
| Tennessee | 10,732 | 1,669 | 4,532 | 3,242 | 1,065 | 194 | 30 |
| Michigan | 7,968 | 3,470 | 2,494 | 1,343 | 468 | 160 | 34 |
| 18 other states | 43,306 | 22,064 | 11,769 | 6,670 | 2,083 | 566 | 154 |
| Total all states | 499,625 | 337,768 | 90,657 | 48,071 | 17,773 | 4,491 | 865 |

In addition to the half billion black walnut growing-stock trees, there were 91 million non growing-stock black walnut trees (typically rough or rotten trees classified as cull) on timberland in the most recent inventories. Estimates of the number of black walnut trees on non-timberland run as high as an additional 125 million trees. These trees represent an important source of nuts. Black walnut trees in these more "open-grown" conditions tend to have a higher nut production level when compared to trees growing in the more heavily stocked timberland situations. Kentucky, with almost 95 million trees, had the greatest number of black walnut growing-stock trees, almost 20 percent of the total number of black walnut growing-stock trees in the Nation. Ohio, West Virginia, Missouri, and Pennsylvania all had more than 50 million black walnut growing-stock trees.

The number of black walnut trees has been increasing. In Missouri, the number of black walnut trees increased from about 21 million in 1972 to more than 50 million in 1989. In Iowa, the number of black walnut trees doubled from 1974 to 1990, increasing from 7 million to almost 14 million. Similar increases occurred in most of the other states. Although increases occurred in all diameter classes, the majority of the increase in number of black walnut trees was in the smaller diameter classes.

**Volume**

In 1962, there were more than 1 billion cubic feet of black walnut growing-stock volume on timberland in the United States, 41 percent of which was sawtimber volume (Quigley and Lindmark 1966). In the most recent inventories, there were almost 1.6 billion cubic feet of black walnut growing-stock volume, 41 percent of which was sawtimber (Table 5). This was a 60 percent increase in total volume from 1962 to 1989, representing an average increase of about 22 million cubic feet per year. Interestingly, the ratio of sawtimber volume to growing-stock volume remained about the same between the two time periods.

In addition to the black walnut volume found on timberlands, there are large quantities growing in pastures, narrow wooded strips, and other areas not classified as timberland. As previously

mentioned, these areas are not included in the volume estimates but they do contribute to the overall supply of black walnut nuts and wood fiber in the United States.

Table 5.--Volume of black walnut growing stock by diameter class.

| | | Diameter class (inches d.b.h.) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| State | Total | 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+ |
| | | (Million cubic feet) | | | | | | | | |
| Ohio | 183.6 | 13.5 | 21.2 | 29.1 | 36.0 | 36.4 | 18.0 | 15.4 | 10.0 | 4.2 |
| Kentucky | 183.3 | 19.6 | 33.2 | 42.7 | 27.4 | 22.8 | 17.5 | 11.7 | 3.6 | 5.0 |
| Missouri | 147.5 | 11.9 | 22.4 | 29.6 | 26.6 | 24.5 | 14.4 | 11.1 | 4.8 | 2.3 |
| Indiana | 127.2 | 7.4 | 17.1 | 19.0 | 23.0 | 19.8 | 21.3 | 10.2 | 5.9 | 3.5 |
| West Virginia | 123.7 | 9.7 | 16.7 | 22.4 | 19.9 | 23.2 | 13.5 | 9.8 | 4.5 | 4.0 |
| Illinois | 119.1 | 11.5 | 18.5 | 16.7 | 22.7 | 20.7 | 11.7 | 7.9 | 3.7 | 5.7 |
| Virginia | 115.2 | 4.1 | 10.0 | 21.1 | 18.3 | 23.2 | 11.4 | 6.3 | 12.5 | 8.3 |
| Pennsylvania | 100.5 | 9.5 | 16.5 | 13.9 | 16.1 | 17.3 | 10.6 | 7.2 | 4.7 | 4.8 |
| Tennessee | 91.3 | 6.2 | 11.4 | 19.3 | 17.8 | 14.9 | 11.3 | 4.2 | 3.8 | 2.3 |
| Iowa | 63.8 | 2.9 | 4.6 | 9.4 | 12.0 | 13.0 | 7.7 | 6.2 | 5.9 | 2.2 |
| Kansas | 58.4 | 7.9 | 6.0 | 9.6 | 11.0 | 8.0 | 5.9 | 4.6 | 2.0 | 3.4 |
| Michigan | 54.4 | 4.4 | 6.4 | 9.4 | 9.5 | 8.4 | 5.7 | 5 | 2.9 | 2.9 |
| 18 other states | 220.1 | 14.6 | 31.3 | 42.4 | 40.3 | 29.3 | 28.3 | 14.5 | 9.6 | 9.7 |
| Total all states | 1,588.1 | 123.2 | 215.3 | 284.6 | 280.6 | 261.4 | 177.2 | 114.0 | 73.7 | 58.1 |

Only 8 percent of the total growing-stock volume in the United States was in diameter classes larger than 19 inches d.b.h. The majority of the growing-stock volume was in diameter classes from 9 to 15 inches d.b.h., reflecting a resource that has the potential to greatly expand its volume, assuming these medium sized trees continue to mature (Fig. 3). If market pressures increase to where smaller sized sawtimber trees are harvested, the potential for greatly increasing the volume will be diminished.

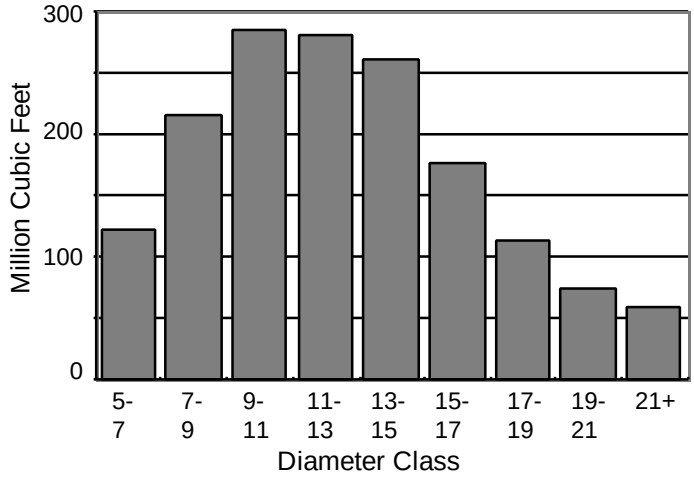


Figure 3. Black walnut growing-stock volume by diameter class.

Ohio and Kentucky had the most black walnut growing-stock volume, each with about 183 million cubic feet (Table 5). These two states accounted for almost one-fourth of the total black walnut growing-stock volume in the United States. While these two states had similar totals, they differed in diameter class distribution. Ohio tended to have more volume in trees 11 inches d.b.h. and greater while Kentucky had more volume in trees less than 11 inches d.b.h.

In 1962, there were an estimated 2.7 billion board feet of black walnut sawtimber (Quigley and Lindmark 1966). As of 1989, there were 4.3 billion board feet of black walnut sawtimber (Table 6). Over the 27-year period between the two estimates, black walnut sawtimber volume increased by almost 70 percent, averaging an increase of about 59 million board feet per year.

Table 6.— Volume of black walnut sawtimber by diameter class.

| | | Diameter class (inches d.b.h.) | | | | | |
|---|---|---|---|---|---|---|---|
| State | Total | 11.0-12.9 | 13.0-14.9 | 15.0-16.9 | 17.0-18.9 | 19.0-20.9 | 21+ |
| | | (Thousand board feet [1]) | | | | | |
| Ohio | 510,820 | 143,700 | 155,297 | 82,845 | 65,743 | 43,858 | 19,377 |
| Indiana | 427,500 | 113,062 | 101,737 | 111,392 | 53,600 | 30,390 | 17,320 |
| Missouri | 398,063 | 127,338 | 117,467 | 68,453 | 52,050 | 22,325 | 10,430 |
| Illinois | 368,033 | 111,592 | 106,211 | 61,051 | 41,740 | 19,171 | 28,269 |
| Kentucky | 363,548 | 98,539 | 90,715 | 76,189 | 54,308 | 18,874 | 24,924 |
| West Virginia | 306,088 | 71,492 | 92,027 | 58,740 | 40,756 | 21,305 | 21,769 |
| Virginia | 301,859 | 62,459 | 84,257 | 43,205 | 25,101 | 51,009 | 35,828 |
| Pennsylvania | 251,310 | 59,690 | 71,349 | 45,508 | 31,511 | 21,880 | 21,372 |
| Tennessee | 244,059 | 69,949 | 69,431 | 54,150 | 21,012 | 19,161 | 10,357 |
| Iowa | 223,198 | 57,822 | 62,394 | 36,931 | 29,077 | 27,230 | 9,745 |
| Kansas | 170,256 | 52,427 | 40,291 | 30,144 | 23,267 | 9,463 | 14,665 |
| Michigan | 160,997 | 41,073 | 39,127 | 27,372 | 24,518 | 14,321 | 14,586 |
| 18 other states | 570,843 | 158,613 | 126,882 | 120,821 | 69,986 | 48,505 | 46,035 |
| Total all states | 4,296,573 | 1,167,755 | 1,157,184 | 816,799 | 532,668 | 347,492 | 274,675 |

[1] International 1/4 inch rule.

In addition to the sawtimber volume, there are many black walnut trees that are considered "short-log" trees and are not included in the sawtimber volume estimates. To be included in sawtimber volume estimates, a minimum of one 12-foot, or two non-contiguous 8-foot, sawlogs is required. In western portions of the black walnut range, trees often do not reach sufficient height to contain the minimum sawlog requirement. However, industry will use smaller length logs if they meet other quality and size standards. For example, in Nebraska short-log black walnut trees represent an additional 7 percent of the total black walnut sawtimber volume in the state. Many of these trees are of the highest quality and are marketed worldwide. In addition, log-length does not impact the potential nut production capability.

Considering only large trees (>21 inches d.b.h.), Virginia had the most volume followed by Illinois, Kentucky, West Virginia, and Pennsylvania. All five of these states had at least 20 million board feet of sawtimber in the largest diameter class. In Virginia, 29 percent of the total black walnut sawtimber volume in the state was in trees at least 19 inches d.b.h., compared to a national average

of 14 percent. Virginia alone accounts for 14 percent of the black walnut sawtimber volume larger than 19 inches d.b.h. in the Nation. As one compares the sawtimber volumes for smaller diameter classes, other states begin to dominate but Virginia is the current king of large diameter black walnut sawtimber.

## Growth, Mortality, and Removals

Black walnut growing stock averaged 55 million cubic feet of gross growth and about 11 million cubic feet of mortality each year across the country in the most recent inventories (Table 7). The result was an average annual net growth rate of 44 million cubic feet, 2.7 percent of the Nation's total growing-stock volume. This annual net growth would provide enough wood to make almost a million desks completely out of black walnut or make a stack of black walnut wood four feet high and four feet wide that would stretch from Springfield, Missouri to Richmond, Virginia.

States with above average annual net growth rates when compared to total growing-stock volume include Kansas, Pennsylvania, Illinois, Iowa, Michigan, and Indiana. Kansas and Pennsylvania led all states, each averaging annual net growth rates that were 3.7 percent of their total growing-stock volume. Missouri and Virginia show the lowest percent of growing-stock growth to total volume ratio in the United States, both having a net growth rate of less than 2 percent. Missouri's lower net growth rate was in-part due to higher than average mortality rates.

Average annual mortality was estimated to be 0.7 percent of the Nation's total black walnut growing-stock volume. Of the known causes of black walnut mortality as identified by FIA field crews, weather related factors and diseases were most commonly reported. Tennessee and Missouri had the highest average annual mortality rates, both being about 1.2 percent of total volume. States with low mortality rates included Iowa, Michigan, Pennsylvania, West Virginia, and Kansas. Iowa's black walnut average annual mortality rate was a mere 0.2 percent of its total growing-stock volume.

Table 7.--Black walnut growing-stock volume and average annual growth, mortality, and removals.

| | Growing stock | | | | | |
|---|---|---|---|---|---|---|
| State | Volume | gross growth | Mortality | net growth | removals | net gain /loss |
| | (Thousand cubic feet) | | | | | |
| Ohio | 183,618 | 5,751 | 1,049 | 4,702 | 2,635 | 2,067 |
| Kentucky | 183,349 | 5,521 | 1,454 | 4,067 | 2,279 | 1,788 |
| Missouri | 147,480 | 4,120 | 1,789 | 2,331 | 2,103 | 228 |
| Indiana | 127,223 | 5,309 | 1,335 | 3,974 | 1,978 | 1,996 |
| West Virginia | 123,743 | 4,063 | 604 | 3,459 | 1,086 | 2,373 |
| Illinois | 119,080 | 5,335 | 1,186 | 4,149 | 875 | 3,274 |
| Virginia | 115,219 | 2,723 | 636 | 2,087 | 2,746 | -659 |
| Pennsylvania | 100,498 | 4,068 | 359 | 3,709 | 449 | 3,260 |
| Tennessee | 91,251 | 3,556 | 1,312 | 2,244 | 865 | 1,379 |
| Iowa | 63,757 | 2,372 | 159 | 2,213 | 699 | 1,514 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Kansas | 58,370 | 2,480 | 305 | 2,175 | 485 | 1,690 |
| Michigan | 54,447 | 1,939 | 181 | 1,758 | 474 | 1,284 |
| 18 other states | 220,107 | 8,895 | 1,070 | 7,825 | 2,699 | 5,126 |
| Total | 1,588,142 | 55,182 | 11,534 | 43,648 | 19,373 | 24,275 |

Growing-stock average annual removals averaged 19 million cubic feet per year, about 1.2 percent of the total volume. Most states had statistically similar growing-stock removal rates, although Virginia reported a removal rate (2.4 percent of its total growing-stock volume) that was double the national average. Even though Virginia has only 63 percent of the growing-stock volume of Ohio, it has a higher removal rate. The high removal rates in Virginia probably could be attributed to harvesting and urban/suburban sprawl pressures. In the long-term, this high removal rate will impact the potential nut production.

If mortality and removals are subtracted from total gross growth, the net result is an increase of 24 million cubic feet of black walnut wood each year in the United States. This compares to the average annual increase of 22 million cubic feet of black walnut that was calculated based on comparing 1962 total growing stock with 1989 total growing stock (see discussion in volume section). Thus, the average annual increase in growing stock is probably between 22 and 24 million cubic feet. Comparing average net growing-stock growth to removals shows a ratio of 2.25/1.0, reflecting a growing resource with long-term sustainability.

The national average net annual gain in volume of black walnut of between 22 and 24 million cubic feet represents about 1.5 percent of the Nation's total black walnut growing-stock volume. The net annual increase in growing-stock volume as a percentage of the state's total growing-stock volume was largest in Pennsylvania, Kansas, and Illinois. Each of these states have a net annual increase of at least 2.5 percent of their total growing-stock volume. Missouri, with a net annual gain of 228 thousand cubic feet or 0.1 percent, is nearly static in terms of annual changes in total growing-stock volume. This is primarily due to above average mortality and removal rates. The current condition in Virginia is different than in any other state in the entire range of black walnut, primarily due to its large volume of sawtimber-sized trees. Virginia is experiencing an annual decrease of 659 thousand cubic feet. If current conditions continue in Virginia, the black walnut resource will dwindle, which will have adverse impacts on both the potential nut production and forest industry.

## Sawtimber Quality

Black walnut sawtimber removals have a direct relationship to the quality of the trees available. Therefore, discussions concerning resource quality must precede discussions of the utilization of the resource. In 1965, approximately 45 percent of the volume in walnut sawtimber in Illinois, Kentucky, and Missouri was in grades 1 and 2 (Quigley and Lindmark 1965). As a comparison, 38 percent of the black walnut sawtimber in the most recent inventories were grade 1 or 2 (Table 8).

Many field foresters, log-buyers, and industry officials feel that the decrease in quality was partially the result of a decrease in the size of the timber available for harvest. However, a comparison of sawtimber volume by diameter classes between 1962 and 1989 show that, in fact, the average

diameter of sawtimber trees in the United States has been increasing. The percent of black walnut sawtimber in the largest diameter classes, above 19 inches d.b.h., actually increased from 10 percent in 1962 to 14 percent in 1989.

Table 8.— Percent of black walnut sawtimber by grade.

| State | Grade 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | (Percent) | | | |
| Ohio | 9 | 22 | 63 | 7 |
| Indiana | 11 | 30 | 50 | 9 |
| Missouri | 5 | 19 | 45 | 31 |
| Illinois | 13 | 38 | 41 | 8 |
| Kentucky | 12 | 34 | 50 | 4 |
| West Virginia | 13 | 31 | 38 | 18 |
| Virginia | 4 | 30 | 55 | 11 |
| Pennsylvania | 3 | 25 | 46 | 26 |
| Tennessee | 5 | 18 | 63 | 14 |
| Iowa | 12 | 34 | 50 | 4 |
| Kansas | 24 | 37 | 39 | 0 |
| Michigan | 20 | 46 | 31 | 3 |
| 18 other states | 10 | 27 | 53 | 10 |
| Total | 10 | 28 | 51 | 11 |

More than half of the black walnut sawtimber in the United States was graded as grade 3 in the most recent inventories. This grade is suitable for lumber and other miscellaneous products and can often have more "character" than higher grades. For example, furniture made from low grade black walnut lumber with knots and other sound defects adds to the charm and diversity of each piece (Chenoweth 1995).

From a nut production perspective, tree grade is not of major importance. In fact, the best nut producing trees are often those with lower grades because they have more limbs to produce nuts. Black walnut products come from a wide variety of sources beyond the typical forestlands. Because of the economic value associated with black walnut, the eastern United States are scoured for trees that are of the size and condition for producing nut and for the timber industry. Aside from black walnut, there are not many tree species where cull and nonforest trees are considered of economic value.

## Current Annual Removals

Current annual removals are estimated for wood fiber products only, current annual nut production can be more accurately estimated by others. In the North Central Region, an estimated 7 million cubic feet of black walnut growing-stock and 5.3 million cubic feet of black walnut non-growing stock are currently harvested based on the most recent Timber Product Output surveys (Table 9). Of the harvested black walnut, about 82 percent (10.1 million cubic feet) was removed from the site, generally to a processing facility and 18 percent (2.2 million cubic feet) was left on the ground as logging residue/slash.

Missouri and Indiana were the leading states in the North Central Region in current annual total black walnut harvested volume. These two states had similar levels of growing-stock removals but different levels of non-growing stock removals. Missouri, in 1993, had more black walnut harvested from non-growing stock sources (2.5 million cubic feet) than from growing-stock (1.8 million cubic feet). Indiana's 1990 black walnut harvest from growing stock (1.8 million cubic feet) was five times the harvesting from non-growing stock (343 thousand cubic feet). States besides Missouri in the North Central Region with a large percentage of total black walnut harvest from non-growing stock include Iowa and Wisconsin.

Almost 20 percent of all of the black walnut harvest in the North Central Region was from cull (non-growing stock) trees. Cull trees are on timberlands but they do not meet the requirements for growing stock. Cull trees include short-log trees, trees with excessive sweep and/or crook, trees with excessive taper to where they do not meet the minimum top diameter, and rotten trees. While FIA classifies these as cull trees, they obviously constitute an important part of the supply of black walnut in the region. Missouri and Iowa both had significant volumes of cull black walnut trees that were harvested for sawlogs. In addition to the cull tree harvest, more than 1.3 million cubic feet of black walnut are harvested annually in the North Central Region from trees that are not on timberlands. These trees occur on pasture land, in narrow wooded strips, in windbreaks, and in other locations and generally provide a significant portion of the annual nut harvest.

## CONCLUSIONS

Several state inventory results from the 1940's through the 1970's seemed to confirm the concerns expressed about the perceived dwindling supply of black walnut. Other states, however, were showing significant gains in volume. Ohio, the number one black walnut State in terms of growing-stock volume, posted a 22 percent increase in growing-stock volume from 1968 to 1979. Kentucky dramatically increased its black walnut growing-stock volume from 1963 to 1975. Thus, the changing black walnut picture was different depending where one looked. Overall, national compilations show a significant increase in black walnut volume. Inventories in the 1980's and early 1990's show significant gains in black walnut growing-stock volume in all of the primary walnut states. Illinois and Indiana showed the most impressive gain, rising from 44.9 million cubic feet in 1962 to 119.1 million by 1985 and from 64.5 million cubic feet in 1967 to 127.2 million in 1986, respectively.

Why this sudden increase? During this same period, the volume of all hardwoods increased dramatically as hardwood forests matured. However, the rate of increase of black walnut was significantly greater than for other hardwoods. This perhaps may be explained by two factors. First, because black walnut is pest resistant and alleopathic, growth is seldom impeded. Secondly, many black walnut trees were already well established in pasture land that reverted to forest land in the 1970's and 1980's. These trees, with their significant volumes, would have been new additions to the total growing-stock volume.

More than half of the existing black walnut timberlands are in sawtimber-sized stands. These stands have limited potential for redirecting management toward improved quality and stocking rate. Additionally, many of these older stands have been subjected to practices such as grazing that limit their long-term productivity. Returns on investments are limited in older stands when compared to similar investments on younger stands. However, more than two-thirds of the black walnut trees in the United States are currently less than 5 inches d.b.h., which is an excellent size to actively manage for both nut and timber production. In this size class, pruning, releasing, thinning, and other management activities have the potential to greatly improve the quality as well as the quantity of black walnut in the stand, especially if they are on highly productive sites.

The supply of black walnut nuts and timber would be enhanced if establishment and management were focused on sites with high productivity potential. With the majority of black walnut timberlands owned by non-industrial private landowners, the future supply is dependent on land management goals that include nut and timber production. Private landowners own land for many purposes, if improving the quantity of black walnut is of high priority, public agencies could target these landowners for increased management, technical assistance, and cost-share programs. To date, plantations have not made a significant impact on the supply of black walnut. However, if the current level of planting continues, if they are adequately managed, and if they are planted on productive sites, plantations have the potential to improve the future supply of black walnut.

The overall future for black walnut appears bright, the number of black walnut trees has been consistently increasing, growing-stock volume has consistently been on the rise, and the number of plantations has been constantly increasing. If this growing resource is adequately managed, questions about the long-term supply of high quality of black walnut for both nuts and timber will be answered.

## APPENDIX

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# History of the Eastern Black Walnut Nut Industry

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Most writings, papers and books on the subject of the Eastern Black Walnut have been almost one hundred percent directed to the growing of Eastern Black Walnut trees and treating the nut merely as a seed which may, with proper care, ultimately become a tree. Few papers and certainly no book has been published on the subject of shelling and processing Black Walnut nuts for human consumption. To my knowledge, no paper has ever been written which would give proper credit to those persons and companies that have been "the industry" in the 20th century. Therefore, I am pleased to accept the challenge for hopefully presenting at least some of the facts about how the industry developed and by whom.

Most of my knowledge comes from my own experiences in running the business which was started by my father, B. Ralph Hammons, in the year 1946. In 1946, I understood that his was sort of the beginning of the industry and I guess that really was the beginning , but I later learned that even prior to 1946 in many parts of the United States where Black Walnut trees are native and where the nuts grow wild, various individuals, had tried to find a way to crack and process the nuts commercially. One of the first in the business and possibly where it all started was Mr. E. A. Smalley, who, while living in Kansas City, Missouri, invented a way to separate small particles of soft nut meats from the hard shells by machine. Mr. Smalley first patented the process, moved to Knoxville, Tennessee and then founded Smalley Manufacturing Company to build its machines. His machine was mostly sold and used in the pecan industry at first, but he adapted his machine for sorting Black Walnut nutmeats as well. Mr. Smalley also built and installed the first machines used to crack the hard-shelled Black Walnuts and most all efficient high volume cracking machines built since that time have at least some of the same principles as discovered by Mr. Smalley.

Several small companies were started in the mid 1940's and one of the first was in Sulphur Springs, Arkansas. It was started with a group of employees using hammers to crack the nuts and others picking out the goodies and sorting and separating the good nutmeats from the shell - - all by hand. That company moved to Gravette, Arkansas in 1955 and was re-organized as Gravette Shelling Company, owned and managed by Mr. Mandel Raffee. When Mr. Raffee died in 1965, the company was purchased by the Hammons Products Company and managed by Mr. Lloyd P. Harris of Gravette. Another company was the Akar Walnut Company. Mr. Akar cracked Black Walnuts in a plant in Morristown, Tennessee and then transported the nutmeat goodies to his plant in Broadway, Virginia for final processing, inspection and boxing. Mr. Akar developed health problems and closed his operations around 1960. Another plant in Virginia was located in the town of Staunton in the Shenandoah Valley, but that plant closed in 1946.

Two other plants were started in Nashville, Tennessee, sometime in the mid 1940's. One was called Block Brothers which was owned and operated by Mr. George Block and his brother, Sam Block. George's son-in-law, Jimmy Cox, ran the company from about 1950 until his death around 1980 and the business was closed at the time. The Block company was mainly in the business of buying and selling furs, hides, roots and herbs. The other plant in Nashville was located directly across the street from Block Brothers near downtown Nashville. It was owned and operated by Mr. Frank

Fleishman and Mr. Fleishman sold his business to the Block company around 1970. The Mick Walnut Company was started along about that time also with a small plant in Kentucky. Mr. Mick operated the plant in the late 50's and early 60's but then closed after a few years. Some other start-up plants were in existence in Kentucky in the mid 40's and 50's but none lasted more than a few short years. The R.E. Funsten Nut Company, located in St. Louis, Missouri owned a shelling plant in Kentucky in the 50's. They shelled and processed black walnuts but they closed their plant around 1960. Barnes Walnut Company was started in Bolivar, Missouri in the early 1950's by Mr. Bufford Barnes. Mr. Barnes sold his business to the Funstein Company around 1975 but then the Funstein Company closed in 1980. Indiana Walnut Company was started in 1987 by Mr. Norman O. O'Bryan in Lafayette, Indiana but the business lacked financing and only lasted about three years.

While the efforts of these many companies greatly added to the demand and marketability for Eastern Black Walnut nutmeats while companies were in business, the Hammons Products Company located in Stockton, Missouri has played a major role in developing the industry as we know it today. My father, B. Ralph Hammons owned a retail grocery, feed and produce business in the small rural town of Stockton. In 1945, there was a large crop of Black Walnuts in Missouri, there was no market for the crop, and the crop of nuts was just going to waste. Dad learned that the plant in Staunton, Virginia was needing more nuts and he contracted with them to buy and sell the nuts he could get here in Missouri. So he organized a buying program with produce dealers and companies in many of the small towns in southwest Missouri and he brought some three million pounds of nuts that were hand-hulled, sun-dried and packed in burlap bags. He hauled the nuts by truck to a rail siding in the town of Diggins, Missouri, east of Springfield, and shipped them to the plant in Virginia. The plant in Virginia closed down the next year so Dad decided to take a chance and put in his own plant in Stockton. That first year, 1946, he bought only one hundred thousand pounds of nuts but at least that was a beginning. Of course, the business grew through the dedication and determination of my father and others working with him. The company now averages buying and processing approximately 26 million pounds of nuts in shell each year that are purchased from buying stations located across sixteen states.

The main reason that Hammons Products Company has survived and grown where others did not was keen dedication and determination of the people themselves. Mr. Myrl Roberts was in charge of our plant operations and productions of nutmeats from the very beginning. Myrl was with my father in 1946 in Knoxville, Tennessee to look at machinery built by Smalley Manufacturing Company. After Dad agreed to buy the machinery, he and Myrl started driving home and Dad asked Myrl, "Do you really think we can make it work?" So Myrl looked Dad straight in the eye, paused and in great seriousness stated, "Well, Ralph, you've bought it so now we've GOT TO MAKE IT WORK!" That's the way it's always been in the Hammons Company - - if we start it, we've got to make it work. Kenneth H. Howard, a highly skilled machinist, was a son-in-law of the inventor, Mr. Smalley. Ken Howard became a close friend to my father and Ken joined the company in 1948. He brought new ideas for cracking and processing the hard nuts and from 1948 to 1953 Ken Howard, Myrl Roberts, and my father together designed and built three new cracking machines. These machines have been over-hauled and modified many times but we're still using the basic cracking machines today - - because we've never found a better way to do it. When Dad and the industry recognized the need for a machine to remove the outer soft hull in order to buy enough nuts in the shell, again Ken Howard, Myrl Roberts and father found a way to do it, and they patented the new discovery and invention.

In 1954, Dad suffered a severe heart attack, which was thought to have been brought about by the stress from working twenty hours most days trying to make the business work. On several occasions, Dad had discussed the Black Walnut business with his brother-in-law and my uncle, Mr. Clarence C. Cavender. In fact, Clarence told me that Dad had tried to get him to join him in the business at the start, in 1946. Anyway, Dad asked Clarence to come to Stockton and keep business going until he recovered and could return. Clarence accepted the challenge and liked it so well he stayed until officially retiring from the business in 1977. A lot of credit for growing the business and the total industry must be given to Clarence. Clarence and I worked together in running the plant. I took care of nut meat sales and marketing. Clarence was in complete charge of all nutshell operations. He did the job! At 86 years of age, Clarence is still interested in seeing the company and the industry continue to grow.

As the second generation manager of business, I owe a lot to all the dedicated, hard-working people who have helped make it work. I sort of grew up in the business doing what I could to help in the summer months when school was out. My first paycheck was in June, 1948, at age 15. My job was to wash and dry the nut shell that had been discarded and bulldozed down the hill behind the plant. Dad wanted to recover that shell to grind in a hammer mill and sell to powder companies for making dynamite. That was the beginning of our nut shell division. For the first several years the shell was strictly considered to be a by-product from cracking and processing nuts. But now the shell business is really a separate industry of its own. It has become a very major part of our business.

In 1969, I invited Mr. Gus S. Rutledge, to my office to discuss planting new Black Walnut trees to increase our supply of nuts for processing in the future. Gus soon joined the company and was in charge of our public relations in agriculture, which included growing new trees. Gus possessed many talents and later was in charge of buying all nuts to be processed as well as heading up our nut shell division. Gus retired in1996, but he continues his keen interest in the business.

Dad's brother, Ferrell O. Hammons, retired from the company in 1973. He had been in charge of buying nuts in the shell. At his retirement party, I announced that Ferrell had bought enough Black Walnuts in the shell that if all the nuts that he bought were loaded in one-hundred-thousand-pound rail cars, it would take a train 60 miles long to haul them all. That was in 1973, and we bought and processed nearly one-half billion pounds of nuts since that time. Certainly Ferrell Q. Hammons did a lot to help in the success of the company.

Certainly there are many other persons, each in his own way, that have all played a part in making the history of the Eastern Black Walnut industry as it is today.

# Status Report On The Eastern Black Walnut Nut Industry, Nut Markets, By-Products, And Future Challenges

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## OVERVIEW

Eastern Black Walnuts are unique among the world's tree nuts. The native American nut, known among customers only in the United States, produces annual harvests that are only a fraction of all tree nuts including almonds, walnuts (English), pecans, hazelnuts, cashews, pistachios, brazil nuts, macadamias, and even pine nuts.[1] With the black walnut's much lower yield of nutmeats, the total annual consumption is about 2-3 million pounds, or less than .1% of the other tree nutmeats.[2]

While the production volume is relatively small, the rich, distinctive flavor of the Eastern Black Walnut makes it a true delicacy. That robust flavor enhances many foods as an ingredient (not snack) nut. Annual consumption is growing steadily, markets for nut shells and uses for other by-products are growing, interest is growing outside the United States, and the future looks bright.

The following paragraphs discuss these areas of the black walnut nut industry:

- Markets for Black Walnuts nutmeats;
- Uses for nut shells and other by-products; and
- Challenges and opportunities for future growth.

## BLACK WALNUT NUTMEAT MARKETS

Eastern Black Walnuts are used all over the United States in baked goods, ice cream, and candies. While the strongest consumption is in the natural growing regions, the midwest and east-central states, consumption is also strong in places like Florida and Arizona with large numbers of people who come from the natural growing regions.

Presently about 2 million pounds of black walnut nutmeats are used each year. The greatest volume still is used in **home baking.** Traditional recipes such as cakes, cookies, pies, and nut breads, along with new recipe ideas that use the unique flavor in items such as salads, side dishes, and entrees, provide a stable base for usage of black walnuts. This is greatest during the fall months as holiday baking consumes almost half the annual usage. The trend for fall consumption provides opportunities for exposure and promotion, but it also makes the nut business very seasonal. Most

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[1] 1997 Worldwide harvests for Tree Nuts were as follows:
Almonds - 969 million pounds (shelled); Walnuts (English) - 1,375 million pounds (in shell); Pecans - 375 million pounds (in shell); Hazelnuts - 1.406 million pounds (in shell); Cashews - 2,156on pounds (kernels); Pistachios - 425 million pounds (in shell); Macadamias – 36 million pounds (shelled); Black Walnuts (Eastern) – 29 million pounds (in shell)
Source: "World Consumption and Production Trends", published by International Nut Council, July, 1998; Hammons Products Company.

[2] Black Walnuts average about 8% yield for wild nuts (based upon purchased wet weight). Other tree nuts average 40% to 60%. Applying these estimates, other tree nuts produce over 4.5 billion pounds of nutmeats.

of the baking nuts are sold in food stores under a variety of name-brand labels in package sizes from 2 ounces to 20 ounces. In the future, as people bake less and eat out more, the industry must promote increased usage of black walnuts in restaurants and other food service outlets.

**Ice cream** is one food in which people enjoy black walnuts year-round, especially during the spring and summer months. Black walnut ice cream is very popular in many regions of the United States. Some companies report it ranking as high as 3rd on the flavor list. About 40%, or 800,000 pounds, of black walnuts are used every year in black walnut ice cream. Familiar brands include Baskin-Robbins, Blue Bell, Braum's, Edy's, Hiland, Mayfield, Belfonte, Yarnell, Barber, and many others. The ice cream market is growing, as each year more companies make black walnut ice cream. New flavors such as black walnut fudge and black walnut oatmeal cookie ice cream will help further growth.

**Candies** including fudge, brittle, and high quality chocolates create a special blend of sweetness with the robust black walnut. Many small candy makers in the midwest and eastern U.S. have loyal customers who love their black walnut items, but the high cost of the nutmeat has kept most large confectioners away.

Black Walnuts are not just tasty, but they also can be very nutritious. While most of the calories are from the oils and fat, there is no cholesterol.[3] Almost all the fat is unsaturated, both mono- and poly- unsaturated, which are associated with a healthy diet. Black Walnuts are nutritionally similar to other tree nuts, for which research is demonstrating some very positive health benefits including reduced risk of heart disease[4] and reduced levels of blood cholesterol, particularly LDL ("bad") cholesterol.[5] Much research remains to be done to support the positive health benefits of nut consumption. As that research is undertaken and the results are publicized, the market potential for all tree nuts, including black walnuts, will increase significantly.

## NUT SHELLS AND BY-PRODUCTS

**Black Walnut Shell** is among the hardest of all nut shells or seeds.[6] About 60% (wet weight) of the purchased raw black walnuts is shell, which results in about 12-18 million pounds of shell each year. Obviously, an economical use for the shell is critical to the success of the black walnut nut industry.

After the nut is cracked and the nutmeats removed, the raw shell is ground into six basic sizes for industrial uses. The primary use where hardness is important is **abrasive blast cleaning and polishing.** Jet engines, electronic circuit boards, jewelry, gun casings, musical instruments, engine parts, ships, and submarines all are cleaned with black walnut shell as a "soft grit abrasive." Cosmetics and soaps often contain nut shell for its abrasive action. The shell also is used extensively in **oil well drilling** as lost circulation material seals in fracture zones, which prevents loss of

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[3] A ¼ cup serving of Black Walnuts contains 190 calories, 150 of which are from fat, and no cholesterol. Of the 16 fat grams, 10are polyunsaturated, 5 are monounsaturated and only 1 is saturated.
Source: Dr. Milton Bailey, University if Missouri, Department of Food Science & Nutrition.

[4] *See* Fraser, G.E., Sabate, J. , Beeson, W.L., Straham, T. M. : "A Possible Protective Effect of Nut Consumption on Risk of Coronary Heart Disease". Arch. Internal Med., 1992; 152: 1416-24.

[5] Sabate, J., Fraser, G. E., Burke, K., Knutsen, S. et al. "Effects of Walnuts on Serum Lipid Levels and Blood Pressure in Normal Men"'N. Engl. J. Med., 1993: 3 28:603-07.

[6] Black Walnut shell has a hardness (Moh's) rating of three and a Modulus Elasticity of 170,000 p.s.i. Other shells and seeds have a much lower elasticity of 10,000 + p.s.i., so they are not as durable.

pressure and drilling fluid when cracks develop in rock around the well. Finely ground black walnut **shell flour** is used as a filler in many products such as glue for plywood, dynamite, plastic and rubber products, and in castings to make figurines.

The market for black walnut shell is good. It is known by many users as the best media for abrasives and lost circulation material. English walnut, pecan, or other shells can supplement the supply when black walnut shell is not available, which keeps the prices competitive. Still, the hard shell is a very important product of the black walnut nut industry. As Gus Rutledge used to say, because of the shell "the black walnut affects every man, woman, and child in the United States every day."[7]

**Oil Stock** is a by-product of the nut cracking and processing that is used in animal feeds. The meal and dark nutmeats from the black walnut provide a feed that is high in energy because of its fat content, and also is a good source of protein. About 2 million pounds is produced each year and used by farmers and feed producers located near the black walnut shelling plants.

**Hull,** or the green/black outside husk of the black walnut, is not presently marketed extensively. The hull is typically removed at the nut buying stations and is spread on pastures or other land areas where it oxidizes quickly. It can be used as a natural stain, but the water-weight and handling make transportation unfeasible. There are some interesting potential uses for black walnut hulls that could create markets for some of the hull, including medicinal applications or nutrition supplements. More research is needed, however, before the benefits can be proven and any markets developed.

**Black Walnut Oil** has potential but is not being produced or marketed at this time. Research has been done on extracting edible oil, and preliminary surveys show some interest in the flavorful nut oil for use on salads and other foods, much like olive or other nut oils. The nutrition profile is positive and the flavor seems to have some appeal. More extensive market research will determine whether black walnut oil has real potential as a profitable by-product of the black walnut nut industry.

## FUTURE CHALLENGES AND OPPORTUNITIES

The future of the eastern black walnut nut industry is exciting. The industry is small but is seeking to improve in all areas from tree cultivation and nut production, to nut hulling, handling, drying, and processing, to promotion and marketing of black walnut nut products. Due to the small size and lack of large economic rewards, progress is slower than for other tree nut industries with much larger crops and yields.

One major challenge is **nutmeat yield.** The average wild-crop yield is only about eight percent (8%). This means that 100 pounds of nuts that cost $16-$18 ($.16 - $.18 per pound including hulling and freight) will produce about 8 pounds of nutmeats. By the time shelling plant costs and selling expenses are added, the market price of the black walnut is much higher than other nuts, which inhibits both market growth and ability to pay more to the grower or harvester. The yield is even worse in some years, as low as 6.5% on purchase weight, which makes the economics even more challenging. The major opportunity from this is to increase the nutmeat yield, which can be done

[7] Gus Rutledge is a former Vice President of Hammons Products Company, promoting Black Walnuts since 1972.

with careful nut procurement practices, better hulling/handling systems, improved shelling plant efficiency, and harvesting nuts from managed trees that produce superior-yielding nuts.

Another major challenge is **nut supply instability.** From 1994 through 1998 the supply of wild eastern black walnuts was adequate to meet the increasing market demand. The industry was blessed with an average of 27 million pounds in-shell during those five years, a dramatic increase from the previous three years. The 1998 wild crop, however, was only about 11 million pounds, putting pressure on supply until the fall 1999 harvest. The ability to procure consistent and ever-increasing supplies of nuts from wild trees is a very real long-term challenge to continued growth of the industry. The challenge is met partially by procuring wild nuts from a wide area. Although Missouri produces the most nuts, up to 18 states produce enough wild black walnuts to support buying stations. The long-term opportunity is to develop managed orchards that can consistently produce significant harvests of superior-yielding nuts. For those higher-yielding nuts a higher price could be paid which would produce a better incentive and return on the investment for the orchard growers. For example, if a grower produced black walnuts that averaged 20% hand-test yield, all fancy grade, and if all nuts were cleaned with moisture less than 4.5%, then that grower could be paid perhaps $.20 to $.25 per pound, a much more attractive price than the current $.10.

A third major challenge is the **lack of familiarity with the flavor of the nutmeat.** This is partially due to the regionality of the wild nut and partially to the small size of the industry with few marketing/promotion funds. Also, traditional consumers who loved the distinctive flavor lived in the black walnut growing regions, and perhaps picked up nuts themselves, but have succumbed to mortality (many have grown old and died). However, efforts to educate new generations of consumers through package design, recipe promotion, new product formulation, and public relations are meeting success as shown by the increased consumption over the past 8 years. Food trends moving toward rich, robust flavors and interest in "new" flavors with some tradition, also present opportunities for eastern black walnuts. Finally, oversees markets present fascinating new possibilities, as people in Germany, Japan, and other countries have shown interest in the flavor - - but this will take some time and market development.

## SUMMARY

The eastern black walnut nut industry is relatively small and obscure among tree nut industries of the world. It only exists in the United States. Its source of supply is wild nuts harvested by hand. Its product often is confused with the more common "walnut" even by people in the natural growing regions. These are not problems; rather, they are opportunities for the industry to grow and develop further.

Those who work with black walnuts are entrusted with stewardship of an amazing resource. The industry traces back to the first native Americans who ate the wild nuts. It has grown with foresight, ingenuity, and leadership. And it will continue to thrive and grow into the next century, facing challenges and opportunities with the same spirit and optimism that fueled its early years.

The status of the eastern black walnut nut industry is good. The greatest is yet to come!

For more information, check the black walnut website on the internet at:
www. hammonsproducts.com

# Social Aspects of the Eastern Black Walnut

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Burdened with fluctuating economies and expanding urban development of our rural landscapes, we need to focus on places and efforts that support rather than fragment our lives; places and efforts that balance the hard, standardized, and cost-efficient with the natural, personal, and healthful. (Gallagher, 1993) The unique dual path of the wild and commercial eastern black walnut industry is already providing opportunities for balance in our increasingly complex lives.

This chapter is provided to encourage the reader to sit back and examine the beneficial aspects of the eastern black walnut in terms of long-term economic stability for communities and/or regions, infrastructure to support the industry, and the inherent desire for people to have a balanced relationship with the environment.

## LONG-TERM ECONOMIC STABILITY FOR COMMUNITIES

With national trends moving in the direction of less agricultural farmland and more urban growth, the potential impact upon major eastern black walnut producing areas such as southwestern Missouri could be significant. The types of people moving into these rural areas are in many cases not familiar with the rich culture of the region, nor are they aware of the potential of crops such as eastern black walnuts. "Putting land into eastern black walnuts is a good way to invest in future generations, as well as a natural and good thing to do with newly acquired property." (Dilsaver, 1998)

According to a 1995 Gallup Poll study (Wolfe & Chambers, 1995) commissioned by Southwest Missouri Resource Conservation and Development (RC&D), over 4 out of 5 (82%) landowners viewed "beauty or nature appreciation" as being a somewhat or very important reason to own their wooded land. Also, "keeping the land in your family" was an important consideration. People inherently like to have trees on their property. More than 1/3 (37%) of landowners surveyed intended to plant trees on their land, and almost 2/3 (65%) of landowners stated that if provided with trees, they would plant them.

Planting eastern black walnuts on suitable property would provide aesthetic beauty, as well as a valuable long-term investment in the future. Approximately one out of ten (11%) surveyed landowners said they would be willing to pay for forest management services. New, higher yielding strains of eastern black walnut are being patented and planted throughout the eastern black walnut growing region of the U.S. as well as other continents. As the interest in eastern black walnut grows, so will the industry as a whole.

## INFRASTRUCTURE TO SUPPORT THE INDUSTRY

The eastern black walnut industry will follow two paths. One will be the continued usage of the wild crop, so we will need to continue to focus attention and appreciation for the multiple inherent values provided by a "free" natural renewable resource.

The second will be a commercial extraction, but people must be reminded to value and appreciate the importance of balance, harmony, economy, renewability, and sustainability of this unique tree crop. Although not "wild" or "natural" in the traditional sense, a planted field of medium size eastern black walnut trees spaced 20 feet by 40 feet apart can be a peaceful and beautiful place to visit. Psychologists have shown that even short visits to city parks contribute to improved moods (Hull, 1992). Relaxation and stress reduction occur when people are viewing natural landscapes (Ulrich, 1981).

Companies like Hammons Products in Stockton, Missouri invest a portion of their yearly revenue into research and development to come up with new and better ways of growing and processing eastern black walnut. Ways that also take into account the social aspects of this unique tree crop. Hammons currently has three plant materials patents on three different trees selected for their very high nut yielding capacity. It is these types of efforts that will enable the eastern black walnut industry to grow and thrive in the future.

## INHERENT DESIRE FOR PEOPLE TO HAVE A BALANCED RELATIONSHIP WITH THE ENVIRONMENT

Each unique type of landscape is often also the location of a unique cultural meaning for humans that share that landscape. "A sense of place is part and parcel of the effort to find meaning in the land and to create personal and cultural identities. Places in the landscape are infused with meaning and are more than the sum of their biophysical attributes or their associated plants, animals and landforms. The meanings associated with certain places obviously are derived from experiences in them, and these experiences are quite variable. They can come from growing up in a particular region, such as the flat openness of the Midwest, from listening to grandparents and relatives describe their lives on the family farm, or from adventure experiences traveling the wild rivers of the West. These personal experiences are tied to other people and their lives, to ways of life and play, and to a culture that has been greatly shaped by the natural environment." (List & Brown in Driver et al, 1996, p. 461-462)

The influence of black walnuts in southwestern Missouri is a classic example of culture shaping around nature. A culture all its own has grown up around a basically wild crop. Generations of families each Fall have put tiny and adult sized hands to work gathering the pungent, fleshy nuts on their farms. Nuts from trees are sometimes considered a nuisance, but more often a field full of fallen wild black walnuts is considered a great source of charity funds or spare holiday gift money. Gathered nuts are processed at hulling stations provided by black walnut processing plants such as Hammons Products Company in Stockton, Missouri. The hulling machines pry and rub the thick fleshy husk off the nuts, and then they are bagged and weighed. A typical pick-up load of 600 pounds of nuts can yield a nice sum of money. Three generations together at a hulling station realizing the benefits of their efforts from collecting black walnuts on the family farm is a common sight.

To ignore this sense of place and culture is to ignore the people, ideas, and the meanings that are attached to these places. These meanings and ideas are as important as the biophysical attributes of specific landscapes and ecosystems. It is important that landowners consider the psychological and spiritual consequences of their land management decisions in addition to the economic, scientific, and environmental consequences. The eastern black walnut provides the opportunity for

landowners to establish a balanced relationship with the environment as well as a solid long-term investment in future generations, both economically and spiritually.

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# Economics of Eastern Black Walnut Agroforestry Systems

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Fifteen cents doesn't go far these days, unless it has lots of time. For instance, if you invested 15 cents at 8% interest compounded annually over 60 years you, or your grandchildren, would eventually collect more than $50. That's the power of money over time. At the same time, if you spent 15 cents today and had to wait 60 years to get a return on it, you must receive at least $50 to get your money's worth at 8%. So, who is going to spend 15 cents today and wait 60 years for a payoff? If you have planted a tree seedling with the intention of growing a fully mature timber tree, you already have made such a commitment. That seedling probably cost you 15 cents and perhaps more. If it was more, you must receive more than $50 in 60 years to cover your minimum expected return of 8%.

An easy way to visualize the power of money over time is to recall the old story of the blacksmith and the chintzy horse owner. The owner had the blacksmith shoe his horse. When he went to pay the bill, the smithy said he wanted $100 for the job. The owner thought that was totally outrageous and told the smithy so. The smithy, being a reasonable and clever man, offered an alternative.

"I'll tell you what I'll do. I put 32 nails in those horseshoes. You pay me a penny for the first one, two cents for the second, three cents for the third and so on until you have paid for the 32 nails and we'll call it even." The horseman didn't hesitate and jumped at the opportunity to pay only pennies per nail. Of course, when he learned that the constant doubling of the price would eventually add up to millions of dollars, he reneged and gladly paid the $100.

To offset the effects of time we can take two approaches to our tree plantation systems that will offer a higher return on our investment. We can reduce as far as possible the amount of money we invest in the early years. However, we must be careful not to cut costs to the point of reducing income from the trees later on. Some added costs in the beginning such as regular herbiciding and investment in quality seedlings definitely will pay off in later years.

The second alternative to offsetting long-term costs is to design a system that also has income as soon as possible. This early income offsets the early costs. Many agroforestry practices such as alleycropping and silvopastoral systems where livestock graze the alleys offer this early income opportunity.

What has become known as the "Missouri Basic System of Agroforestry" is typical of these multifaceted systems.

## THE MISSOURI BASIC SYSTEM

Because every practitioner's system will be different in some way, it is necessary to create a baseline or model black walnut agroforestry system to compare with.

The "Missouri Basic System of Black Walnut Agroforestry" essentially is that system that was demonstrated by Gene Garrett, director of the University of Missouri Agroforestry Center, at the Sho-Neff Plantation at Stockton, Mo. and was adopted by HarperHill Farms and others around Missouri and Midwestern states. In its simplest form it is a forage/nut/timber system where the forage is harvested for hay. This basic system is used as a model because it is the one (with many slight modifications) that has been most widely accepted by landowners.

(See Black Walnut Agroforestry--Missouri Basic System for outline of practices and costs and returns.)

Profitability under the Missouri Basic System of agroforestry begins and ends with the walnut trees. In most cases, the sustained profitability of the enterprise will almost totally depend on nut production. Accepting that premise dictates that management priorities for the system be directed toward the tree crop, not to the supporting or alley crops.

It simply means that when a decision must be made that will favor one or the other, the walnut trees and the resultant nut crop will receive first consideration.

However, income from secondary enterprises such as hay, livestock, row crop or between-the-row or between-the-trees crops play a most important role of providing cash flow, especially during the first 10 to 15 years. From the standpoint of return on investment, these interplanted crops with their annual up-front incomes have a major effect on reducing the costs of accumulated interest on the first-year investment in seedlings, planting, grafting and other maintenance costs.

When an agroforestry system is analyzed for profits and return on investment over a 60-year period, it becomes obvious that high initial establishment costs severely reduce average annual percentage return on investment. The 60-year analysis is used because it is at that point that the 8 to 9-foot butt log is mature and can be cashed in for nearly full value. It is at this point in the life of the plantation that the landowner will be faced with a critical economic decision--Is the log market such that cutting and selling the logs and investing the income at current rates more financially attractive than the expected annual net income from continued nut harvest. The landowner also will have to take into consideration the increased risk of loss of the log value to natural disasters such as disease, fire and lightning.

But we have the luxury of postponing that decision for 60 years. Most likely our children or grandchildren will bear that burden. Our concern is more immediate. Will a black walnut agroforestry system make money now or within a reasonable time? The answer: An unequivocal "Yes."

## DETERMINING COSTS AND YIELDS

In practice, black walnut agroforestry will have different profitability potential for every practitioner depending on their individual financial circumstances and how the agroforestry system fits into the overall farming operation.

Black walnut agroforestry farming systems are a relatively new concept. The oldest established systems now are only a quarter century old. Therefore, the economic information available for making profitability analysis is limited. In many cases it is necessary to project yields of nuts and log

values based on wild, native tree production in non-plantation settings. However, there is enough accumulated data from individual nut yields on trees of various ages, both wild and grafted, that conservative yield projections can be made with some confidence.

Costs associated with production practices are fairly well established. Records from the plantations established at Hammons Products Company's Sho-Neff Plantation at Stockton, Mo. for the last 25 years and from HarperHill Farms at Butler, Mo. for the past 13 years offer reliable and current information (see attached cost references). Future costs such as those for mechanical nut harvesting (see separate chapter) are taken from similar costs for pecan harvest and from experimental walnut harvesting trials.

To determine profitability of a farming system it is necessary to analyze the costs and income over the lifetime of the crop. For an annual crop such as corn or soybeans it is a rather simple process because there are only single-year costs and incomes to calculate. For a perennial crop such as black walnut and supporting crops such as forages in the alleys, the calculation is more complex because of the cumulative effects of costs and income, especially in the establishment years.

The 60-year analysis also is useful for making comparisons of profitability between agroforestry systems. A simple change such as switching from planting bareroot seedlings and field grafting in the third year to planting nursery-grafted seedlings can have a major effect on the landowner's rate of return on investment over the long term.

## IS IT PROFITABLE?

Black walnut agroforestry is a commitment--a long-term commitment. Most likely, as in the example of the Missouri Basic System, from 10 to 15 years will be required before a net profit is realized when interest on the investment to establish the plantation is figured in. However, when the return on investment over a long period (60 years) is considered, the investment can be highly profitable. When compared to a similar investment in a mutual fund over many years the rate of return on the agroforestry system of 10 to 20% or more is very competitive.

When the Missouri Basic System was analyzed for long-term profitability, it was determined that it had an Internal Rate of Return, or an annual return on investment in the case of a mutual fund, of 17%. That's projected over 60 years. The analysis also indicated that if you expected an 8% return on your investment you could pay $620 an acre for the land used in the system. Remember, the Missouri Basic System is based on rather conservative yield and income estimates. And, it includes a $7 an hour labor charge for all production practices.

As a comparison, the profitability of the Missouri Basic System without a nut crop was made. While the Internal Rate of Return was still a respectable 12%, the amount a landowner could invest in land at an expected return on investment of 8% was only $75 an acre. In short, this system would not pay for itself. However, some landowners would find this quite acceptable since they already own the land and might find an agroforestry practice suited their needs and fit their overall farming plans.

A third comparison was made where the trees were grown for timber only and neither nuts nor hay was harvested. In this case the Internal Rate of Return dropped to less than 3% and the land investment at an expected 8% return dropped to a negative $245 per acre.

To illustrate that every agroforestry operation will express unique profit potential because of varying input costs and selection of differing production practices, an analysis of the Missouri Basic System was made with the assumption that the operator owned the harvesting machinery and was using it to harvest 300,000 pounds or more of nuts each year. This level of nut harvesting reduces the harvest equipment ownership costs to a minimum. In this case the Internal Rate of Return was increased to 20% a year and the landowner could have invested $943 an acre in his land at an expected 8% return.

| RATE OF 32% NITROGEN PER ACRE IN OUNCES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Radius (ft.)** | **Area (sq.ft.)** | **30 lbs.** | **40 lbs.** | **50 lbs.** | **60 lbs.** | **70 lbs.** | **80 lbs.** | **90 lbs.** | **100 lbs.** | **150 lbs.** |
| 2 | 13 | 0.48 | 0.64 | 0.8 | 0.8 | 0.96 | 1.12 | 1.28 | 1.44 | 2.08 |
| 3 | 28 | 0.96 | 1.28 | 1.6 | 1.92 | 2.24 | 2.4 | 2.72 | 3.04 | 4.64 |
| 4 | 50 | 1.6 | 2.24 | 2.72 | 3.36 | 3.84 | 4.48 | 4.96 | 5.44 | 8.32 |
| 5 | 79 | 2.56 | 3.52 | 4.32 | 5.28 | 6.08 | 7.04 | 7.84 | 8.64 | 13.12 |
| 6 | 113 | 3.68 | 4.96 | 6.24 | 7.52 | 8.8 | 9.92 | 11.2 | 12.48 | 19.2 |
| 7 | 154 | 5.12 | 6.72 | 8.48 | 10.24 | 11.84 | 13.6 | 15.36 | 17.6 | 25.6 |
| 8 | 201 | 6.72 | 8.8 | 11.04 | 13.28 | 15.52 | 17.6 | 20.8 | 22.4 | 33.6 |
| 9 | 255 | 8.48 | 11.2 | 14.08 | 17.6 | 19.2 | 22.4 | 25.6 | 28.8 | 41.4 |
| 10 | 314 | 10.4 | 10.4 | 17.6 | 20.8 | 24 | 27.2 | 32 | 35.2 | 51.2 |
| 11 | 380 | 12.64 | 17.6 | 20.8 | 25.6 | 28.8 | 33.6 | 38.4 | 41.6 | 62.4 |
| 12 | 452 | 14.88 | 20.8 | 25.6 | 30.4 | 35.2 | 40 | 44.8 | 49.6 | 75.2 |
| 13 | 531 | 17.6 | 24 | 28.8 | 35.2 | 41.6 | 46.4 | 49.6 | 59.2 | 88 |
| 14 | 616 | 20.8 | 27.2 | 33.6 | 41.6 | 48 | 54.4 | 60.8 | 67.2 | 102.4 |
| 15 | 707 | 24 | 32 | 38.4 | 46.4 | 54.4 | 62.4 | 70.4 | 78.4 | 116.8 |
| 16 | 804 | 27.2 | 35.2 | 44.8 | 52.8 | 62.4 | 70.4 | 80 | 88 | 132.8 |
| 17 | 908 | 30.4 | 40 | 49.6 | 60.8 | 70.4 | 80 | 89.6 | 100.8 | 150.4 |
| 18 | 1018 | 33.6 | 44.8 | 56 | 67.2 | 78.4 | 89.6 | 100.8 | 112 | 168 |
| 19 | 1134 | 36.8 | 49.6 | 62.4 | 75.2 | 88 | 100.8 | 112 | 124.8 | 187.2 |
| 20 | 1257 | 41.6 | 56 | 68.8 | 83.2 | 97.6 | 110.4 | 124.8 | 139.2 | 208 |

## MEASURING HERBICIDE SPRAYED AREA
## (Acres/100 feet sprayed on both sides of tree row)

***(Formula: 2 times spray width times 100 divided by 43,560 equals acre per 100 feet of row)***

**(Spray width)**
**1-foot width = .0046 acre/100 feet of tree row**
**2-foot width = .0092 acre/100 feet of tree row**
**3-foot width = .0138 acre/100 feet of tree row**
**4-foot width = .0184 acre/100 feet of tree row**
**5-foot width = .0230 acre/100 feet of tree row**
**6-foot width = .0276 acre/100 feet of tree row**

Calculating actual sprayed area per acre based on 40-acre field with rows 40 by 20 feet: 1 quarter-mile row=1,320 feet minus turn rows (area at ends of field to turn equipment from 20 to 40 feet without trees planted) times 2 (two ends)=40 to 80 feet=1,240 feet (80 feet of turn row area) times 3-foot spray strip=.0138 (from table above) times 1,240 feet of sprayed length of row divided by 100 feet=1.24 times .0138=.017 acres (almost 1/5 acre sprayed per quarter mile of row). There are 33 rows in a 40-acre field a quarter mile long laid out on 40 by 20 spacing. So, 33 rows=.017 (acre/row)=5.6 actual acres sprayed or only 14% of the total field.