THE OAK TIMBER BASE AND MARKET: PAST, PRESENT, AND FUTURE

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Abstract—Since 1992, the oaks (*Quercus* spp.) have accounted for a third of the eastern hardwood growing stock volume, but oak poletimber volume has declined from 27 percent of total hardwood poletimber volume in 1992 to 23 percent in 2012 with most of this change occurring since 2002. This decline is a precursor to a reduction in oak sawtimber volume in the future in the absence of successful timber management efforts to avert it. The decline in oak poletimber volume initially occurred concurrently with a decline in consumption and price of higher grade hardwood lumber and a historic reduction in the margins between lumber and stumpage prices. These declines in price margins appear to be a market aberration since margins recovered to prerecession levels by 2017. The greatest value for oak and most other hardwood species is associated with aesthetic attributes which are influenced by the rate and consistency of tree growth, bole clarity, and wood color. Desirable attributes may take 75 years to develop. The extended period of time it takes oak to mature combined with the price risk due to market variability and changing fashion trends makes the time value of money a barrier to oak management. An understanding of economic factors that influence hardwood markets should be embodied in the development of timber management plans. Successful oak regeneration could be promoted as a part of hardwood sustainability certification, thereby transferring the management costs to the current customers of hardwood products.

INTRODUCTION

In 2012, oak species (*Quercus* spp.) accounted for 34 percent of eastern hardwood growing stock (Oswalt and others 2014). This percentage has remained unchanged since 1992 (Powell and others 1993). What has changed is the proportional volume of oak poletimber [5 to 10.9 inches diameter at breast height (dbh)] which has declined from 27 percent in 1992 to 23 percent in 2012 (Oswalt and others 2014, Smith and others 2004). Nearly all this change has occurred since 2002. The decline in poletimber volume of oak species since 1992 is a precursor to reduced oak sawtimber volume in the coming decades. This decline has been predicted for decades, and management plans have been developed to prevent it but apparently not implemented on the scale necessary to avert it.

A major barrier in the implementation of timber management plans for oak is the length of time it takes for trees to grow to a merchantable size (Barton and Schmelz 1986) and the opportunity cost of the money required to accomplish silvicultural activities if it were invested in endeavors other than timber management. Another factor is that hardwood markets, the ultimate force affecting when trees are harvested and their value, may not be fully understood or integrated into management plans. It is important to recognize that the market factors that influence successful implementation of hardwood management can differ from those prescribed for softwood management.

This paper examines the oak resource, the major markets for this resource, and economic and financial barriers to oak management. Changes in the oak inventory will be examined relative to changes in the eastern hardwood timber base. This is followed by an examination of changes in the most important market for hardwood timber, lumber and related sawn products, and the importance of oak species in this market. Included in this analysis is a discussion of some important aspects of hardwood lumber and stumpage prices. Next, the market and financial aspects of successfully managed timberland is compared and contrasted for southern yellow pine versus the oaks. The last section summarizes important aspects of hardwood markets that may be useful to understand and incorporate into oak management plans.

CHANGES IN THE OAK TIMBER BASE

The eastern hardwood resource can be examined in terms of species groups with the oaks comprising four of these groups (table 1). The select white oak group is primarily composed of white oak (*Q. alba*), bur oak (*Q. macrocarpa*), and chinkapin oak *(Q. muehlenbergii*)

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while the most important select red oaks on a volumetric basis are northern red (*Q. rubra* L.) and cherrybark oak (*Q. falcata* var. *pagodifolia*). The most important species contained in the other white oak group are chestnut oak (*Q. prinus*) and post oak (*Q. stellata*). The other red oak group is the largest of the oak species groups in terms of total volume with the most important species being black oak (*Q. velutina*), water oak (*Q. nigra*), scarlet oak (*Q. coccinea*), southern red oak (*Q. falcata* var. *falcate*), willow oak (Q. *phellos*), and laurel oak (*Q. laurifolia*). In addition to the oak groups, other important hardwood species groups include hard maple [primarily sugar maple (*Acer saccharum*)], soft maple [primarily red maple (*A. rubrum*) and silver maple (*A. saccharinum*)], sweetgum (*Liquidambar styraciflua*), ash [primarily white ash (*Fraxinus americana* L.) and green ash (*F. pennsylvanica* Marsh)], yellow-poplar (*Liriodendron tulipifera* L.), and the hickories (*Carya* spp.)

Changes in the volume of growing stock between 2002 and 2012 for the major eastern species groups are shown in table 1. A common trend exhibited in all species groups is either slow increases or net declines in the volume of poletimber-size trees with the most pronounced declines occurring in the oak species groups. This decline is a result of long-term regeneration issues associated with oak species (Lorimer 1993). An associated trend is the relatively small net volume increase of mid-size (11–16.9 inches dbh) select white oak, select red oak, and other red oak. The combination of negative net growth of poletimber and low net growth of mid-size trees (11–16.9 inches dbh) means that relatively fewer oak trees will be transitioning to the larger size class in the future. This suggests that past forest management efforts have not been successful and proactive management options should be considered to increase the survival of the remaining small-diameter trees to avert even larger decreases in future oak inventory – if only to enable future mast production.

MAJOR MARKETS FOR HARDWOOD LUMBER AND RELATED PRODUCTS

The most important markets for higher quality hardwood timber in terms of value are lumber and related products. The major domestic market for hardwood lumber can be separated into four major sectors (table 2). Hardwood lumber consumption in the furniture sector was traditionally dominated by the wood household industry with lesser volumes consumed by the wood office/commercial and institution furniture manufacturers. These industries are influenced by style and fashion considerations that cause the demand for different species and groups of species to vary over time. The construction and remodeling sector includes kitchen cabinets, millwork (doors, windows, molding, etc.), and wood flooring. Fashion consideration also influences species selection in construction products. Most lumber used in the furniture and construction sectors is higher grade product sawn from higher quality logs. However, lower grade hardwood lumber can be used in the production of strip flooring.

Pallets and crossties are the most important industrial markets (Luppold and Bumgardner 2016). While sawn material used for industrial application must be sound, it can have knots and blemishes and is produced predominantly from the cants (log centers) of higher quality logs or lower quality roundwood. Hardwood lumber and related sawn products are also used in the production of other goods including whiskey barrels, handles, gun stocks, solid guitar bodies and necks, decorative boxes, and toys.

Table 1—Net change in eastern hardwood growing stock volume by major species group and diameter category, 2002 to 2012, in million cubic feet

Species group	Total net change	5 to 10.9 inches	11 to 16.9 inches	17 inches and larger
Total hardwood	59,018	-9,108	24,526	43,596
Select white oak	6,255	-1,334	2,365	5,224
Select red oak	5,186	-1,159	903	5,443
Other white oak	3,721	-1,036	2,072	2,687
Other red oak	5,636	-1,771	1,014	6,392
Hickory	4,517	-183	2,581	2,117
Hard maple	4,647	208	3,031	1,406
Soft maple	8,509	195	5,067	3,247
Sweetgum	1,792	-235	637	1,393
Ash	4,995	543	2,254	2,199
Yellow-poplar	9,194	347	1,786	7,058

Sources: Smith and others (2004), Oswalt and others (2014).

Traditionally the largest domestic consumers of hardwood lumber have been the fashion-influenced furniture and construction sectors (table 2). In the early part of the 21st century, wood household furniture production was displaced by imports (Luppold and Bumgardner 2016). In 2006, home construction started to decline preceding the Great Recession of 2008 and 2009. The industrial sector was not nearly as affected by this series of events. As a result, the proportion of lumber used in the fashion-related sectors declined from 56 percent in 1999 to 39 percent in 2009. This change in relative demand caused prices of higher and mid-grade hardwood lumber to fall to historically low levels (fig. 1).

Another market for hardwood lumber that has been increasingly important is exports (table 3). Lumber exports can range in quality but tend to be skewed to the higher grades (Luppold and Bumgardner 2013). In 1991, exports accounted for about 8 percent of the total hardwood lumber consumption volume and about 16 percent of higher grade lumber sales on a volume basis. While hardwood lumber exports declined during the Great Recession, they surpassed prerecession levels by 2011, and in 2017, 40 percent of the higher grade hardwood lumber manufactured in the United States was exported.

HOW DO OAKS FIT IN THE CURRENT MARKET?

Oak species accounted for 41 percent of the eastern hardwood lumber production in 2010 (U.S. Census Bureau 2011) and is consumed by every domestic sector. However, the most important domestic user of appearance lumber today is the wood flooring industry,

Table 2—Total domestic hardwood consumption and consumption by the furniture, construction and remodeling, industrial, and all other sectors for selected years, in million board feet

Year	Total domestic consumption	Furniture	Construction and remodeling	Industrial	Other
1982	8,136	2,480	1,441	3,342	873
1991	10,001	2,578	2,524	3,952	946
1999	12,011	2,677	4,009	4,578	747
2004	10,728	1,608	4,036	4,408	676
2006	10,696	1,323	4,063	4,614	696
2008	8,901	996	2,929	4,367	609
2009	6,884	619	2,036	3,707	521
2011	6,982	537	2,156	3,703	587
2015	8,061	575	2,587	4,032	866

Sources: Luppold and Bumgardner (2008, 2016).

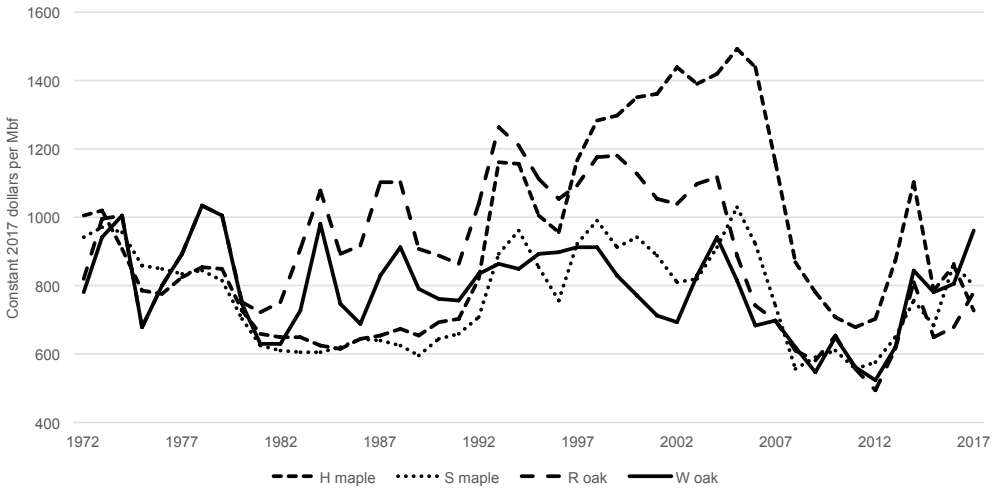

Figure 1—Inflation-adjusted prices of number 1 common Appalachian hard maple, soft maple, red oak, and white oak, 1972 to 2017. (Developed from HMR 1971 to 2017; U.S. Department of Labor 2018).

Table 3—U.S. hardwood lumber exports, the proportion of exports to total consumption plus exports, and the proportion of exports to appearance consumption plus exports for select years from 1991 to 2017

Year	U.S. hardwood lumber exports	Proportion of exports to total estimated consumption plus exports	Proportion of exports to appearance consumption plus exports
	million board feet	*percent*	*percent*
1991	882	8	16
1999	1,183	9	16
2002	1,172	10	17
2006	1,323	11	21
2009	801	10	25
2014	1,653	17	37
2017	1,875	20	40

Source: Luppold and Bumgardner (2016), updated to 2017.

and the dominant species used by this industry are red and white oak. Oak species are preferred by crosstie manufactures because of their durability. White and bur oak are the species used in whiskey barrel production.

In 2017, the oaks accounted for nearly 44 percent of exports with red oak exports being nearly twice as high as white oak exports (U.S. Department of Agriculture 2018). The major export markets for red oak are East Asia (China and Vietnam) and North America (Canada and Mexico) while the white oak export market is more diffuse with Europe being the most important regional market. The oaks also account for nearly 40 percent of log exports on a volume basis with red oak exports being nearly three times higher than white oak.

SOME IMPORTANT ASPECTS OF HARDWOOD LUMBER AND STUMPAGE PRICE

While lumber prices of most hardwood species have fluctuated over the last several decades because of fashion considerations (Luppold and Prestemon 2003) there is no discernable trend (fig. 1). By contrast, hardwood stumpage prices have been trending upward since the early 1970s with the exception of the declines associated with the Great Recession (fig. 2). The declines in stumpage prices during the Great Recession were unusual because stumpage prices since 1970 have been less sensitive to economic downturns than lumber prices yet correlated with lumber prices during periods of economic expansion (Luppold and others 2014). Since 2011, stumpage prices and the margin between stumpage and lumber prices reached or exceeded prerecession levels by 2017. But, will stumpage prices increase more than lumber prices in the future?

In competitive markets, economic gains at higher market levels (such as cost saving technology or better marketing) eventually accrue to the base resource. This is especially true when owners of the resource do not have to sell at any given time due to spoilage. In the case of hardwood timber this causes stumpage prices to be less sensitive downward (Luppold and others 1998). Additionally, hardwood trees normally increase in value if left to grow.

As timber becomes larger, natural defects including knots are overgrown resulting in higher prices per board foot. The exact relationship between increased value and tree size is difficult to quantify because there are numerous factors influencing value (Wiedenbeck and others 2004). These factors can be termed the four Cs of hardwood timber and log value. The most important factor is bole quality and resulting log *clarity* (Rast and others 1973, Wiedenbeck and others 2004). Another factor is ring *count*; tighter ring count (slower growth) is especially important for veneer logs (Wiedenbeck and others 2004) and white oak stave logs. Related to ring count is ring *consistency* which also can be termed texture consistency. The last factor is *color* which varies by subspecies and also can be affected by genetics, soils, and other site-specific factors.

Another aspect to timber value is that logs of different oak species have different lumber grade yields as a result of physiological factors including the propensity to self-prune (table 4). Northern red oak logs have greater yields of high- and mid-grade lumber than black oak or white oak logs of the same grade. Chestnut oak has a relatively poor grade yield because of the volume of wormy material associated with this species (Hanks and others 1980).

The relative yields of the different grades of hardwood logs and the increased sawing cost associated with smaller diameter logs is reflected in the Ohio log price data shown in table 5. Importantly, low-grade logs have a similar value regardless of species while higher quality

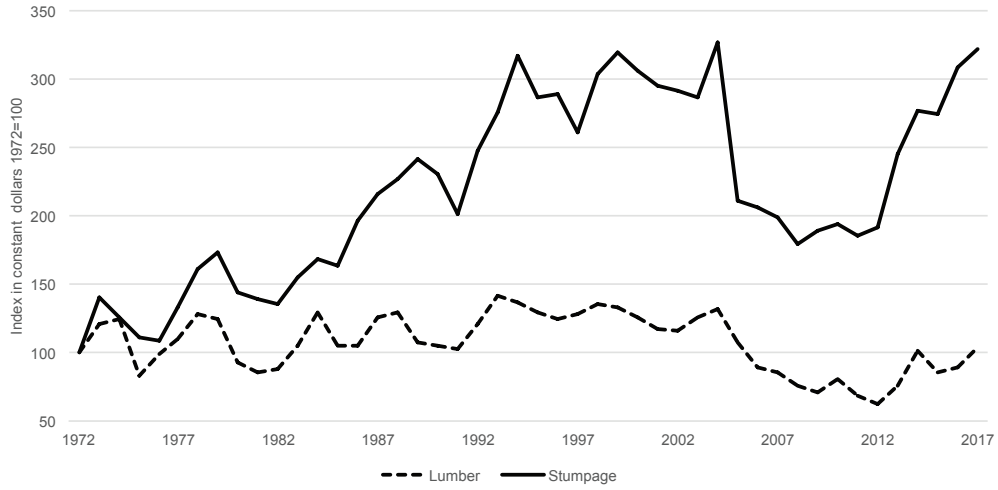

Figure 2—Deflated price indexes for composite oak stumpage and lumber price, 1972 to 2017, with associated weight of 70 percent for red oak and 30 percent for white oak. (Developed from: OWSP and OSUE 2018; HMR 1972 to 2017; USDL 2018).

Table 4—Percentage yield of high-grade (FAS, Sel, and 1F), mid-grade (1C and worm hole no defect FAS, 1C, Sel, and 1F), and low-grade (grades 2A and below and sound wormy) lumber for Forest Service log grade 1, 2, and 3 of black oak, northern red oak, chestnut oak, and white oak

Species	Log grade	High-grade lumber	Mid-grade lumber	Low-grade lumber
Black oak	Grade 1	38.4	31.1	30.5
	Grade 2	12.6	29.5	57.9
	Grade 3	5.3	18.9	75.8
Northern red oak	Grade 1	49.0	28.3	22.7
	Grade 2	22.0	34.5	43.5
	Grade 3	7.0	22.3	70.7
Chestnut oak	Grade 1	15.0	50.3	34.7
	Grade 2	6.5	39.1	54.4
	Grade 3	1.1	21.4	77.5
White oak	Grade 1	33.7	31.1	35.2
	Grade 2	12.2	27.9	59.9
	Grade 3	3.7	17.2	79.1

Source: Developed form Hanks and others (1980).

Table 5—Prices (dollars per thousand board feet) of prime, number 1 common, number 2 common, and blocking grade sawlogs per thousand board feet (Doyle Scale) in Ohio

	White oak	Red oak	Hard maple	Black cherry	Hickory	Yellow-poplar
Prime	1,183	739	1,038	865	575	585
No. 1 com.	675	568	558	493	425	372
No. 2 com.	372	339	317	311	288	289
Blocking	220	198	198	198	215	206

Source: OWSP and OSUE (2018).

sawlogs can be 3 to 5 time more valuable than low-quality logs (table 5). The difference in the interspecies value of higher grade logs are mainly the result of fashion considerations but also are influenced by yield of higher grade lumber.

MARKET AND FINANCIAL FACTORS OF SOUTHERN YELLOW PINE VERSUS OAK MANAGEMENT

Southern yellow pine plantations are predominantly artificially regenerated even-age stands that are normally planted, thinned, and harvested within a finite timeframe of 25 years or less. The end markets (pulpwood/chips, sawlogs, and bark) are understood prior to planting. The trees that are harvested are true commodities, identical to one another in form and value, and normally transported to mills in tree length or chip form. The financial returns of pine plantations are relatively easy to project although these projections are not always met. Pine plantations normally have the same ownership through the entire planting-to-harvest cycle, but even when ownership is transferred, the value of the plantation can be projected over the remaining life of the stand. Additionally, the value of the roundwood harvested during the thinning process has the same per-pound value in the pulpwood and bark markets as the roundwood harvested in the final clearcut.

The oaks are normally found in naturally regenerated uneven-age multi-species stands and, except in the case of a clearcut, there is no finite beginning or end of life of these stands. A high proportion of these stands has been repeatedly disturbed by seemingly random markets and natural processes making each stand somewhat unique but definable in terms of composition, structure, and site index. The length of time it takes most oak species to transition from sapling to merchantability may be as short as 50 years but can exceed 75 years. In higher quality stands, individual trees can have considerably different values and the logs harvested from these stands can be sold individually or as finite groups with specific attributes. There also is a high degree of natural (nonhuman-induced) mortality within hardwood stands which declines as surviving trees become greater in diameter.

Hardwood trees become considerably more valuable once they reach merchantable size. However, there is no unique specification of what is merchantable size because of spatial and temporal market factors. While the end markets for oaks and other long-lived hardwood species are somewhat understood, they have and probably will continue to change over time, introducing another element of temporal risk in the investment equation. Some of this temporal uncertainty is the result of cyclical fashion and style changes. Another factor is change that occurs in domestic and international personal income growth. The greatest factor contributing to the domestic decline in higher grade hardwood lumber consumption between 2008 and 2017 has been low economic growth and associated stagnate if not negative change in real income.

The most important contributor to the value of hardwoods is the human aesthetic and emotional connection with wood (Song and Zhao 2012, Tsunetsugu and others 2007). Traditionally, the best logs for aesthetic applications have the clarity, ring count, ring count consistency and color and associated attributes discussed by Wiedenbeck and others (2004). The fashion aspects can be temporal in any given culture but in a world market of multiple cultures it may be less important because fashion trends in one country may not transition to another.

DISCUSSION AND CONCLUSIONS

The greatest barrier to hardwood management appears to be the opportunity cost of the money required to finance forestry activities if that money were invested in other, higher yielding endeavors which is associated with the time value of money. When expecting an annual return of 4 percent compounded monthly, an investment of $1,000 would have to net $2,700 in 25 years, $7,360 in 50 years, and $20,000 in 75 years. A basic concept in risk theory is the greater the uncertainty, the higher the required rate of return. Doubling the interest rate to 8 percent requires a return of $7,300 in 25 years, $53,900 in 50 years, and $395,000 in 75 years for the same $1,000 investment.

As indicated in figure 2, oak stumpage prices have increased at about 6.1 percent per year in nominal terms and an acceptable 2.5 percent in real (inflation-adjusted rate) terms. Still, pine management seems considerably more attractive than long-term hardwood management because of the shorter duration of these investments (25 years or less) and lower risk. Since the greatest value of higher quality hardwood trees occurs only after they reach merchantable size, there is little or no market for roundwood resulting from prescribed thinning or improvement cuts. Attempts to circumvent the time-value-of-money problem in hardwoods by developing trees with faster growth rates ignores the importance of the apparent linking of hardwood attributes (e.g., color, species) and the human aesthetic and emotional connection with wood associated with ring count and ring consistency attributes. However, while the time-value-of-money argument may be a good explanation for why hardwood management has not taken place, it is less relevant given the aging of the oak timber base (table 1).

Today, nearly all the net growth of oak species is in large-diameter trees. While the life of these trees can be extended through fire and disease prevention, there is little that can be done to improve their quality. The

portions of the timber base that appear to have the greatest investment opportunity in the next 25 years are mid-size trees and poletimber. Still, any active management on these trees including the removal of invasive vegetation and cull material or intermediate cuts of larger trees must be examined on a cost-return basis. The potential consequence of root damage and associated damage-induced heartwood should also be considered in susceptible species groups which include the maples, ashes, and yellow-poplar. Cost and return considerations over a relatively short period are especially important for attracting high-net-worth individuals considering timber investment as part of their retirement portfolio.

Oak regeneration cannot be easily promoted as a standalone product but may be sold as a coproduct in combination with harvesting/timber stand improvement. Early stand intervention may also be economically feasible as demonstrated by Siry and others (2004). Even when the cost of encouraging oak regeneration during the harvesting process cannot be justified using time-value-of-money equations, it may be justified to the investor as "doing the right thing" if the perceived costs are acceptable (e.g., conservation financing). In this cost-revenue analysis all institutional structures such as tax law, inheritance tax, and direct or indirect subsidies should be included. Still, there will not be a one-size-fits-all solution for hardwood or oak management but rather several strategies that can be expanded or contracted so as to adapt to forest structure, composition, site index, and location of individual stands. Other variables that have to be considered are the objectives of the investors, who because of tax laws, have become timber management organizations, real estate investment trusts, or high-net-worth individuals.

Another way of covering the cost of better management is to include it as part of the attributes associated in the price of roundwood sold, which is a central concept behind forest certification. Having oak regeneration as a direct component of the timber certification process would pass the cost of regeneration to the final consumer of lumber and related products. However, while the market for hardwood lumber and related products over the past decade did not provide much opportunity to market the idea of oak management as part of the harvesting cost, the growth in the domestic and world economies since early 2017 may provide a greater opportunity to promote oak regeneration.

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