Trends in Production of Hardwood Tree Seedlings Across the Northeast United States From 2008 to 2016

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Abstract

Bareroot hardwood seedlings are grown at both State and private nurseries across the 20-State U.S. Department of Agriculture (USDA), Forest Service, Northeastern Area. When propagated as bareroot seedlings, hardwood species such as oak, walnut, and black cherry are better suited for large-scale plantings due to size and cost factors. Here, we report on trends in the production of hardwoods and conifers at State and private nurseries in 2016 and on trends for four fine hardwood species from 2008 through 2016 at State nurseries: red oak (*Quercus rubra* L.), white oak (*Quercus alba* L.), black walnut (*Juglans nigra* L.), and black cherry (*Prunus serotina* Ehrh.). Black walnut exhibited the steepest drop in production relative to the other three hardwood species in spite of having the highest stumpage values of the fine hardwoods. State nurseries are increasingly dependent on private landowners for their market share but may be imperiled by budgetary shortfalls in the future. A decline in seedling demand may be a function of several factors, including declines in Conservation Reserve Program funds or downsizing of markets for timber. We discuss the implications of declining tree seedling sales on State nursery operations and the consumers who depend on them.

Introduction

Forests in the 20 States served by the Northeastern Area State and Private Forestry program of the USDA Forest Service (figure 1), hereafter referred to as the Northeast, provide many services including watershed protection, wildlife habitat production, mineland restoration (Ashby 1996), timber production, and recreational use. Even though the percentage of forest cover in the Northeast has increased since the early 20th century, forests are increasingly in close proximity to, and encroached on by, urban development (Oswalt and Smith 2014). Forests are also increasingly parceled as land ownership patterns change (Butler and Ma 2011). Northeastern forests are also threatened by invasive pests such as chestnut blight (*Cryphonectria parasitica*), Dutch elm disease (*Ophiostoma ulmi*), and emerald ash borer (*Agrilus planipennis*). Invasive plants such as bush honeysuckle (*Lonicera japonica* Thunb.), autumn olive (*Elaegnus umbellata* Thunb.), multiflora rose (*Rosa multiflora* Thunb.), and raspberry (*Rubus* spp.), along with aggressive native pioneers such as tulip tree (*Liriodendron tulipifera* L.) and sugar maple (*Acer saccharum* Marshall), can choke out both natural and artificial tree regeneration (Morrissey et al. 2010). This effect may be further compounded by herbivory from high populations of white-tailed deer (*Odocoileus virginianus*; Kern et al. 2012). The combination of invasive pests and herbivory has created unprecedented gaps in urban and rural woodlands across the Northeast, requiring an increase in management of tree species whose regeneration would otherwise be suppressed.

Disturbance regimes in northeast forests have changed dramatically during the past century, which affects regeneration of plants and trees. Wildfires occasionally still occur in remote forests of the Appalachian Mountains and in the northern Great Lakes regions but not at the high frequency that historical records indicate (Heinselman 1973). Instead, fires are infrequent and may be large in scale, such as the Pagami Creek (2011) and Ham Lake (2007) Fires in Minnesota or the Gatlinburg (2016) Fire in Tennessee. The Northeast is largely devoid of large-scale clearcuts from logging operations, which provide sunlight for regeneration of shade-intolerant species such as oaks *(Quercus* spp.).

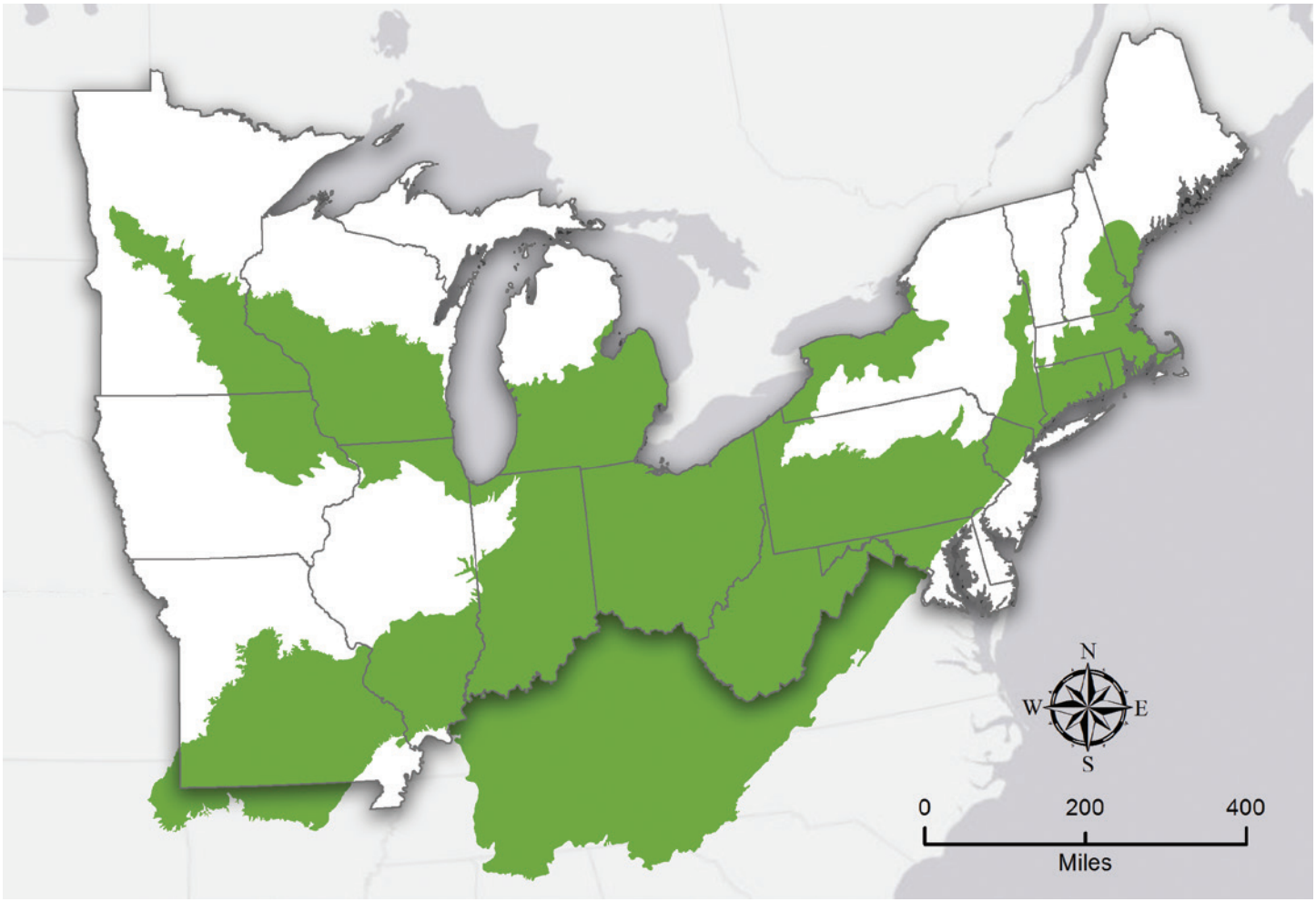

Figure 1. Map of the Northeastern Area of the United States, with the range of central hardwood forest species shown in green.

When naturally occurring seed sources are not available, or regeneration of a particular species is desired, tree planting is necessary to maintain or restore forest cover, especially for oaks, walnuts (*Juglans* spp.), and to a lesser extent black cherry (*Prunus serotina* Ehrh.). The central hardwood region does not have distinct boundaries (Fralish 2003; figure 1), and species associated with these forests span a large portion of the Eastern United States. We focus on hardwood species that are relatively common in this region, have intrinsic wood values, have developed forest products markets, and face a myriad of challenges from invasive plants, insects, and pathogens.

Northern red oak (*Quercus rubra* L.; Sander 1990) and white oak (*Q. alba* L.) are commonly found in forests across the Northeast (figure 1) and are highly prized for their wood quality for furniture and other products. White oak is uniquely suited for barrels used in the crafting of bourbon, an important local industry in Kentucky and, to a lesser degree, Tennessee (Thornberry 2014), as well as for wine barrels. The dense, dark heartwood of black walnut (*Juglans nigra* L.) is used as a high-valued veneer in furniture markets and in the production of other specialty products such as gun stocks. Black cherry is commercially valuable in New York, Pennsylvania, and West Virginia for use in cabinetry and furniture (Burns and Honkala 1990). All four of these species are commonly used for reforestation or afforestation in the central hardwood region (Fralish 2003) and are thus classified as fine-hardwood species based on their timber quality. They are also favored for restoring wildlife habitat, because they represent both soft (black cherry) and hard (oaks, walnut) mast sources for a variety of birds and other wildlife.

The American forest nursery industry began, and rapidly evolved, during the 20th century (Haase 2010). In the early 20th century, State and Federal nurseries were constructed to reforest large swaths of land denuded by timber barons. These nurseries were funded,

in large measure, from Federal job programs initiated during the depression in the 1930s (Dumroese et al. 2005). The first State nurseries, located in New York and Pennsylvania, were established in 1902 (Alban and Dix 2013, Verschoor 2007). Subsequently, every State in the Northeast established a nursery, and in most cases multiple nurseries, to meet their reforestation needs. As land was reforested and timber harvesting shifted westward, demand for seedlings declined, resulting in the closure of many States' nurseries. Currently, 13 State and 44 private nurseries in the Northeast produce approximately 95 million seedlings annually (Hernández et al. 2016). These seedlings, sometimes called "conservation grade," are generally small statured, low cost, and lightweight for carrying in a planter's side bag. Conservation-grade seedlings are commonly planted into sites that are commercial or landscape scale for restoration or reforestation.

The private forest nursery industry in the Northeast has steadily gained market share during the past 50 years, as new technologies and efficiencies have streamlined production, so that fewer laborers are needed to run large operations. Advancements in the container nursery sector have also contributed toward increased efficiency of tree planting operations. For example, stout seedlings that contain a soil plug are nimble for tree planters and can be stored for longer periods before planting compared with their bareroot counterparts. Prices between small containerized and bareroot seedlings are often comparable for the same size trees. Hardwood seedlings, however, are usually much larger than conifer seedlings of the same age, as they tend to allocate a larger proportion of resources to root growth. The large, fibrous root systems of hardwoods are critical for the tree's survival after planting. As such, conservation-grade bareroot hardwood seedlings are generally more successful than container stock types (Zaczek et al. 1995), because the container sizes required to contain the immense hardwood roots are necessarily large and bulky. Nonetheless, fewer private nurseries supply bareroot seedlings, as opposed to container seedlings, largely because of the low profitability of selling small, conservation-grade seedlings.

Tree planting has waxed and waned with the U.S. economy and with incentives that drive land conversions to or from agriculture. Conservation Reserve Programs (CRP), offered to private landowners through the USDA Farm Service Agency, are critical resources to supplement costs of tree planting on private, agricultural (i.e., nonforested) land. Tree planting has historically increased sharply with Federal or State incentives such as the Boundary Waters Canoe Area wilderness designation in Minnesota (Reed 1997), the 1929 State Reforestation Act in New York State (Verschoor and Van Dyune 2012), and the Civilian Conservation Corps in the 1930s. Many factors, such as the global economy and changes in the forest products industry that affect stumpage values for harvested trees, influence declines in tree planting. For nonindustrial private landowners, changes in cost-share programs are often a primary determinant of tree planting and management (Hoss 2012). Large-scale shifts in demand for tree seedlings affect public and private nurseries alike.

During lean years, when demand for seedlings is low, private and State nurseries find creative solutions to maintain operations. Larger private nurseries that have a wider market share and an agile operation may focus on new markets that allow them to survive. Production at State nurseries, in contrast, is usually legislatively limited to certain species or stock types for specific uses (i.e., conservation, restoration, or reforestation). Their consumer base is also limited, often to citizens of their State, which limits their ability to expand market share. State nurseries survive because they serve functions other than growing trees for reforestation. For example, they also grow shrubs for restoration and provide free tree seedlings for students and other outreach programs. State nursery facilities are often shared with other State offices, so costs can be shared among other government functions. In addition, some State nurseries host training centers or educational facilities for students and the community on the premises. Other State nurseries have become centers for seed processing and storage for native plants and trees. Despite their intrinsic value to citizens, State nurseries across the country suffered steep fallout from the most recent recession (2008 to 2010); six State nurseries closed permanently in the past decade citing budgetary woes (California, Louisiana, Ohio, Oregon, Texas, and Utah). In the Northeast, State nursery closures have historically been permanent, and land is usually repurposed for other uses. In some States, declining seedling demands have led to consolidation of nurseries. Minnesota consolidated two nurseries into one in 2009, and Wisconsin consolidated three nurseries into one in 2016. Small, private nurseries enter and exit the marketplace with fluctuations in supply and demand and are deeply affected by downturns.

This article reports on trends in tree seedling production from 2008 to 2016 at State nurseries based on annual surveys and discusses the future supply of hardwood tree seedlings across the Northeast based on these trends.

Description of the Annual Survey

The production of tree seedlings at State nurseries across the United States has been reported annually since 2008 (private nurseries were included from 2013 onward) by the Reforestation, Nurseries, and Genetic Resources team, a program of the USDA Forest Service, State and Private Forestry. A survey, conducted by a third party, requests the number of tree seedlings shipped from all forest and conservation nurseries in the country and is collected separately for three main regions: the Northeastern Area, Southern Region, and Western Region. These data are reported annually in *Tree Planters' Notes* (TPN); details regarding the methodology and assumptions used are reported in Harper et al. (2014). For this report, we summarized data from the past 9 years (2008 to 2016) at State nurseries across the Northeast to evaluate temporal trends in seedling production. We also summarized 2016 data for both State and private nurseries. We focused on seedling production at State nurseries because, unlike private nurseries, State nurseries in the Northeast are asked to provide information on species produced in addition to the information provided for the annual report for TPN. Furthermore, we have incomplete datasets for the private sector prior to 2013. Northeastern States that lack a public nursery (Connecticut, Maine, Massachusetts, Rhode Island, and Vermont) are excluded from this summary. The Ohio State nursery closed in 2009 (Zippay 2008), but production was reported for 2008.

Main Findings: Hardwoods Versus Conifers

In general, conifers are more widely grown and planted relative to hardwood seedlings across the Northeastern nursery sector. In 2016, the number of conifer seedlings reportedly shipped by State and private nurseries in the Northeast was almost three times that of hardwoods (figure 2). Hardwood tree seedlings accounted for 22 percent of total production for private nurseries in 2016 and 31 percent of total production for State nurseries

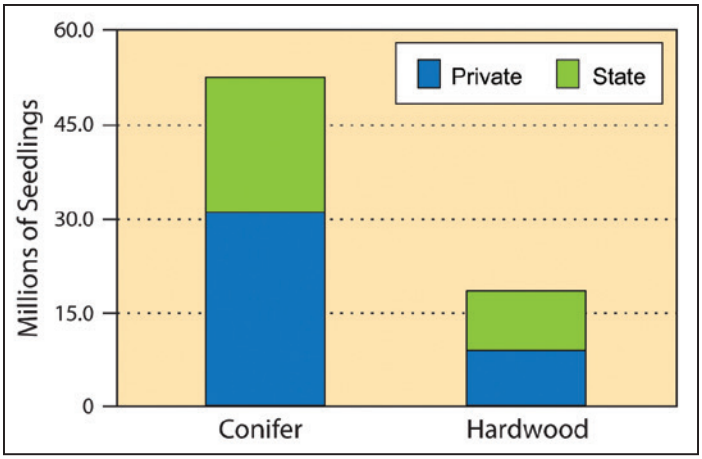

Figure 2. The total number of hardwood and conifer seedlings (bareroot + container) produced by private and State nurseries (Hernández et al. 2016).

for the same year. At State nurseries, hardwood trees are primarily sold as bareroot stock, as opposed to containerized stock of any size (table 1). In contrast, roughly one-third of all hardwood seedlings at private nurseries were sold in some type of container, but the container sizes are not reported.

Hardwood production also varies within the Northeast which we loosely define as three areas: Mid-Atlantic (Maryland, New Hampshire, New Jersey, New York, and Pennsylvania), Midwest (Illinois, Indiana, Iowa, Missouri, and West Virginia), and Great Lakes (Michigan, Minnesota, Ohio, and Wisconsin) Six other States in the Northeast Area are not included because they do not have State nurseries. The highest production from 2008 to 2016 occurred in the Midwest, followed by the Great Lakes and the Mid-Atlantic (figure 3). Indiana produced the most hardwood seedlings among all States (25 million), followed by Missouri (16 million) and Wisconsin (15 million; figures 3 and 4). Seedlings produced at all State nurseries, except Missouri and West Virginia, are sold only to residents of the State as mandated by State statute. From 2008 to 2016, production of hardwoods and conifers at State nurseries dropped 61 and 47 percent, respectively (figure 5).

Table 1. Survey results for hardwood tree species (bareroot and containerized seedlings) sold at private and public nurseries in the Northeastern Area during fiscal year 2016.

Nursery	Bareroot	Container
Private	6,774,026	2,109,700
Public	9,530,108	1,610
Total	16,304,134	2,111,3310

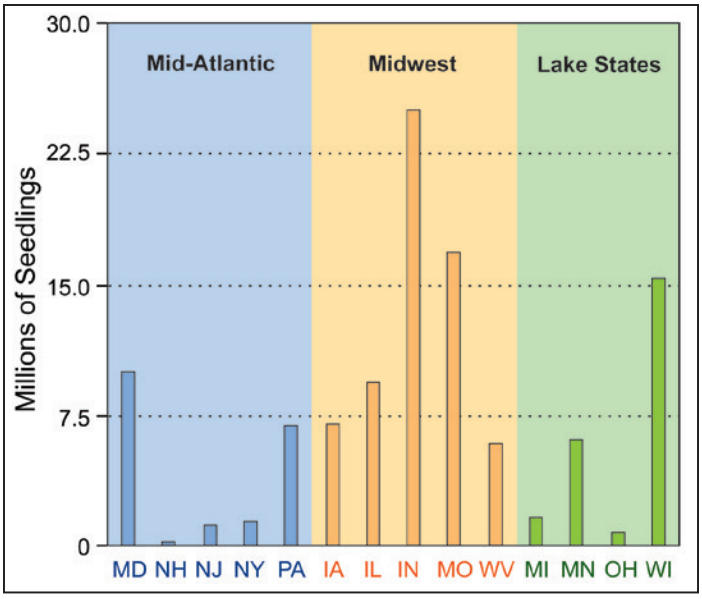

Figure 3. Total production of hardwood seedlings at State nurseries in the Northeast from 2008 to 2016.

Figure 4. Red oaks growing in a bareroot nursery bed in Wisconsin. (Photo by C. Pike, 2016)

Main Findings: Fine Hardwoods

Northern red oak had the highest total production among hardwood species during the 9-year period reported here (figures 4 and 6). The number of red oak seedlings grown at State nurseries dropped 57 percent from a peak of 3.5 million in 2008 to 1.6 million in 2016. White oak seedling production ranked second to red oak in recent years and declined 48 percent during the period. Black walnut production experienced the steepest drop (65 percent) among these four species for this period. Black cherry production is relatively small compared to oak and walnut but also dropped 46 percent, from a peak of 776,000 in 2008 to 418,000 seedlings in 2016 (figure 6).

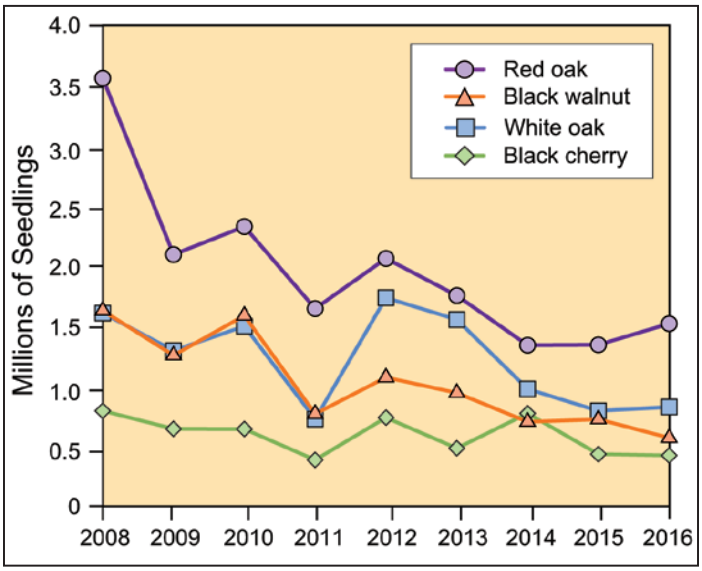

Figure 6. Annual production of four major hardwood species at State nurseries in the Northeast from 2008 to 2016.

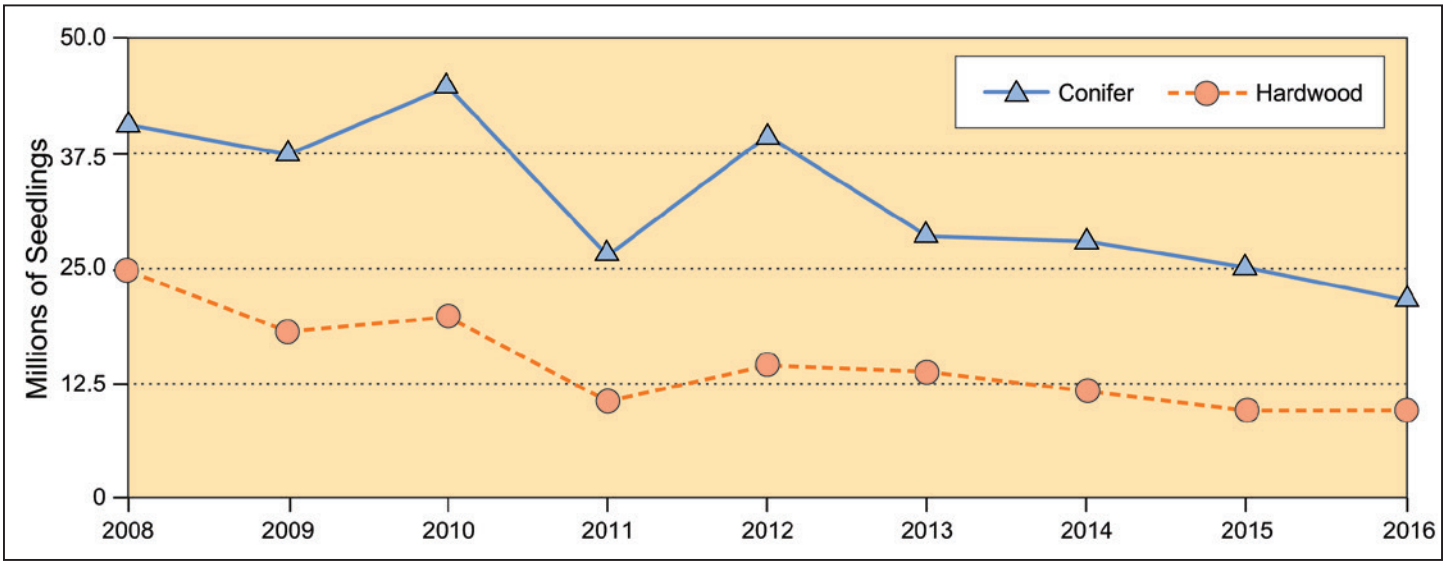

Figure 5. Total number of conifer versus hardwood seedlings shipped annually from 2008 to 2016 at State nurseries in the Northeast.

Discussion

Based on survey results, the number of seedlings produced at public nurseries in the Northeast declined during the 2008-to-2016 period, mirroring the global recession in the United States during that time. The CRP, which reimburses private, nonindustrial landowners for tree planting and management, experienced steep declines in the years prior to 2008 (McDonald 2013), which likely contributed to the substantial downfall in seedling demand in the period following the 2008 market crash.

State and private bareroot nurseries are important suppliers of hardwood seedlings for reforestation and restoration in the Northeast. State nurseries supplied more than one-half (58 percent) of all bareroot hardwood seedlings in 2016, while private nurseries produced 42 percent. Prices per bareroot hardwood seedling are relatively low, ranging from $0.30 per seedling to more than $3, whether purchased from State nurseries or from wholesale private nurseries. Bareroot hardwoods are usually sold as 1-year-old seedlings (1-0) and occasionally as 2-0, because they are comparatively large in stature relative to conifers of the same age. Containerized operations, most of which are run by private nurseries, offer a greater variety of stock ages but at a cost. As the container size increases, the price for consumers increases exponentially. The price increase is high enough that large containerized seedlings, whether hardwoods or conifers, are generally more profitable for private growers than small bareroot seedlings, but they serve different markets. Large, containerized trees (often balled and burlapped) are suitable for small-scale plantings in urban parks and residential areas but are too large (and expensive) for landscape-level reforestation or restoration projects. Both stock types, container and bareroot, are needed to supply markets in the Northeast that benefit future timber markets, create habitat for wildlife, protect waterways, and benefit urban communities.

Several nurseries in the Northeast continue to struggle to find markets for tree seedlings, suggesting that the downturn in tree planting has yet to rebound. Declines in the forest products industry have reduced seedling sales (Oswalt and Smith 2014), but past Federal cost-sharing funds (e.g., CRP) are widely cited for boosting tree planting (Alban and Dix 2013, Auer 2011, Hoss 2012). With decreasing sales (and revenue), budgets for many State nurseries were reduced to critically low thresholds, the effects of which can exacerbate a downturn over a number of years. Collectively, some State nurseries have managed to diversify their output during budgetary lean years. For example, bundles of trees and shrubs are designed for specific purposes such as wildlife habitat, fruit production, nut production, quail habitat (Hoss 2012), or riparian buffers (Alban and Dix 2013). Until demand for tree seedlings rebounds, budgets of many State nurseries will remain at critically low levels.

Nonindustrial private landowners, or family woodland owners, are the largest consumer of tree seedlings grown at State nurseries, according to a 2016 survey conducted by the National Association of State Foresters (NASF 2016). Michigan is the only State nursery in the Northeast where legislative mandates prohibit sales to private landowners. Outside of Michigan, in States with State-run nurseries, landowners are accustomed to purchasing speculatively from available inventory instead of ordering in advance. Landowners are also accustomed to placing small orders (i.e., bundles of 10, 25, 100, or as many as 500 conservation-grade seedlings). This option is available in spite of the added administrative costs of selling small quantities of trees; such small-scale orders are often too expensive to administer for private nurseries. State Soil and Water Conservation District programs do purchase large quantities of seedlings from State or private nurseries for resale to family woodland owners, providing additional outlets for tree seedlings in some States. In general, if a State nursery closes, family woodland owners may have difficulty finding private nurseries that are willing to sell small quantities of speculatively grown, conservation-grade seedlings that are local enough to be reasonably well adapted to their climate.

The fine hardwood species on which we report in this article all experienced a reduction in seedling demand from 2008 to 2016, but the decline in black walnut is particularly noteworthy. Walnut is typically planted for timber because its stumpage value can be twice as high as that of white oak or red oak (Settle et al. 2015), and to a lesser degree, for its edible nuts. It is less desirable for urban plantings because the nuts are messy, and landowners may be concerned about the effects of Juglone, an allelopathic chemical it emits that can inhibit

growth of nearby plants (Jose and Gillespie 1998). Black walnut, however, is notoriously site specific and requires high inputs to produce valuable timber. Landowners who aim to improve habitat for wildlife species may favor oak and cherry, because their mast are consumed by a multitude of wildlife and require fewer inputs than walnut. As such, oak and cherry are commonly used for restoration projects with a range of management objectives. In spite of having the highest stumpage value of the fine hardwoods, the extensive inputs for management after planting, and other factors that make it less desirable for woodlands, may have disproportionately affected demand for black walnut seedlings.

Future Direction

Tree planting remains a critical strategy to enhance forest regeneration across rural and urban forests. State and private nurseries alike are key suppliers of tree seedlings to public land managers and family farms but have experienced revenue losses due to declining seedling demand. Consumers' access to conservation-grade seedlings may be compromised if nursery industries fail or State nurseries close. Wildfires, invasive species, and climate change all contribute to shifts in forest age classes across rural and urban environments and should eventually increase demand for tree seedlings. The future for seedling demand for reforestation and restoration projects on private land will also depend largely on the extent that landowner assistance programs, such as the CRP and the Environmental Quality Incentive Program, are authorized in the upcoming Farm Bill.

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