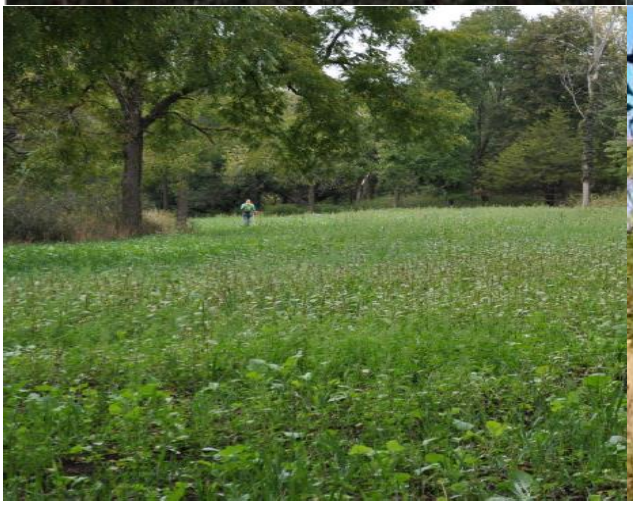
Grunow Property Management Plan



By the Fall 2013 Senior Capstone Students

THE UNIVERSITY of WISCONSIN FORESTRY

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Executive Summary

The purpose of this project was to collect data and prepare a management plan to achieve Dr. Gary Grunow's objectives to promote large trees, maintain or improve natural resources, establish Quality Deer Management-Legacy Lands status, and achieve economic sustainability. The management of the property by the previous landowner was governed by expectations of the Managed Forest Law program; therefore, some of the proposed options that are outlined in this plan may conflict with some of the past guidelines. Data were collected in September and October of 2013 by seventeen forestry students from the Department of Forest and Wildlife Ecology University of Wisconsin-Madison. They used their knowledge in forest science and natural resource management to design and implement a comprehensive natural resource inventory. This is outlined in the data collection methods section (Appendix I), and the resulting information served as the foundation for the team's management recommendations.

The Grunow family property is located several miles west of Dodgeville, WI, in Iowa County. The property inventoried is 815 acres and comprises 696 acres of forest, 91 acres of agricultural land, and 64 acres of restored prairie and savanna. The land is part of the Driftless Area of Wisconsin, which is characterized by the lack of glaciers during the most recent glacial advance. Much of this landscape is covered by medium-textured soils that are moderately susceptible to erosion because they occur on moderate and steep slopes. Harker Creek flows through the middle of the tract, forming a corresponding riparian zone. Dominant tree species include sugar maple, black walnut, basswood, oaks, and ashes. The diameter distribution for many of the forest stands is indicative of an uneven-aged stand. Forest cover types were delineated from the relative abundance of overstory tree species and were used to develop silvicultural practices. Sugar maple is the most abundant advanced regeneration, followed by ash species, but, in both cases, most individuals are less than 12 inches in height. Understory vegetation is mainly composed of grasses and forbs. Notable invasive species found on the property include garlic mustard, multiflora rose, and honeysuckle. The volume of coarse woody debris ranged from 0 to 435 cubic feet per acre. Hinge cutting, a common technique used in timber stand improvement, has been practiced in various locations of the property and has contributed to increased volumes of coarse woody debris.

In order to achieve landowner goals while generating income from tree harvests and agricultural crops, a selection harvest regime combined with invasive control treatments is recommended. Restoration techniques, such as the expansion of oak savanna, prescribed burning, mowing, herbicide use, and conversion of agricultural fields to indiangrass for forage, are recommended to conserve natural resources. A scenario of no management, where natural succession allows the forest to move toward old-growth characteristics, is presented for comparison.

Four harvesting units are proposed in five-year intervals based upon projected tree stocking levels that are determined from the current basal area and tree density. Since the abundance of black walnut is generally uniform across the property, an 18-inch

diameter-limit harvest, labeled black walnut management, would begin in 2013 and be conducted across the entire forested area of the property to coincide with other harvest units. The first adequate stocking level for a designated selection harvest occurs in 2018, encompassing 157 acres of several cover types. The 2023 harvest unit is a 282-acre portion that is projected to be the source of greatest economic return. A final 2028 harvest unit follows the same guidelines for the remaining 47 acres of well-stocked forest. On either side of Harker Creek, a 100-foot riparian buffer zone is recommended to avoid adversely affecting stream water quality and trout habitat.

The degree to which each unit is harvested determines the economic return and resulting forest structure. Considering Dr. Grunow's goals, two harvest magnitudes are suggested: big-tree and intensive management. Through retention of large-diameter trees, big-tree management is more conducive to development of a mature-appearing forest with greater structural diversity. The intensive management scenario, which harvests those large-diameter trees, results in a more uniform and younger-appearing forest with less structural diversity and larger projected economic returns. Income from sawtimber yields for the 2018 harvest unit will be $66,100 under big-tree management compared to $235,900 under intensive. The 2023 harvest unit contains the most timber value, generating $263,700 under big-tree management and $438,800 under the intensive scenario. The 2028 harvest unit contains the least acreage, providing $74,900 under big-tree management and $123,600 under intensive management. These harvest intensities do not apply to black walnut management on the property. Every black walnut that reaches 18 inches in diameter is recommended to be cut on a five-year rotation. Black walnut management will generate $176,000 in 2013, $64,000 in 2018, $104,000 in 2023, $121,000 in 2028, and $28,800 in 2033. All scenarios are designed to continue sustainably after the first three selection harvests and can be repeated.

Under the management guidelines provided, forest health and suitable habitat for deer populations can be sustained while producing a source of income for Dr. Grunow. There are many opportunities available to meet landowner goals for the property and we advocate the following plan that combines the best combination of recommended opportunities. Implementing a big-tree harvest on the 2023 harvest unit, which covers the greatest acreage, will help to achieve the objective of retaining large-diameter trees. Intensive harvests in 2018 and 2023 will increase economic return. Natural resources can be maintained by reducing erosion through the conversion of agricultural crop fields to indiangrass forage. Restoration of native oak savanna through expansion and extensive invasive species control will help restore portions of the property to pre-settlement conditions. Implementing black walnut management, along with the recommended harvest regimes in 2018, 2023 and 2028 (that take place in addition to forage plantings), will generate an estimated revenue, during the 15-year period, of $1,668,500 (net present value).

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Introduction

The following report provides Dr. Gary Grunow with ecologically sound and economically feasible management opportunities that address his objectives.

The Grunow property is located within the townships of Dodgeville and Linden, Wisconsin, just west of Dodgeville (Figure 1). The inventoried compartment consists of 815 acres composed of 660 acres of forest, 91 acres of agricultural land, and 64 acres of restored prairie and savanna.

Dr. Grunow expressed his visions and goals for the property at an initial meet and greet session. The goals included aesthetic components such as the presence of large trees and protecting natural resources, as well as qualifying the property as a Quality Deer Management Legacy Land. These goals are to be accomplished while maintaining or enhancing the property's economic productivity.

Data were collected in September and October of 2013 by 17 students from The University of Wisconsin-Madison Department of Forest and Wildlife Ecology. Their education in forest science provides knowledge that is essential to creating and implementing a professional sampling design and developing an economically and ecologically viable management plan.

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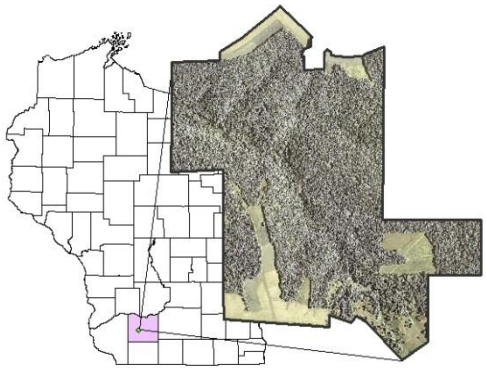


Figure 1. Map of Wisconsin with Iowa County highlighted and study area displayed.

Portions of the Grunow property are currently enrolled in state and federal landowner incentive programs, such as the Wisconsin Managed Forest Law (MFL). Many of the management options recommended in this plan, such as prescribed burning in woodlands, do not take into consideration requirements of current MFL contracts. We believe, however, that recommendations can be implemented without issue and that a forester would accept our harvest recommendations based on the data collected and presented in this plan.

Property Background

History of Vegetation and Land Use

Vegetation and land use on the Grunow property have undergone many changes since pre-settlement times. Climate, disturbance regimes, and land use patterns have changed the vegetation on the property. Before Euro-American settlement, Native Americans maintained prairie and savanna conditions in southwestern Wisconsin. During the nineteenth century, as settlers moved west and forced Native Americans from their lands, much of the prairie and savanna landscape was converted to farmland. This conversion of land to agriculture continued into the middle twentieth century. However, from the 1930s to the present, forest cover in southern Wisconsin has increased as farmland area has declined (Rhemtulla et al 2007).

Vegetation Prior to Euro-American Settlement

Between 1833 and 1866, the United States General Land Office surveyed an area of land that later became the state of Wisconsin. The U.S. Public Land Survey System divided the state into townships of 36 square miles. Townships were further divided into 36 one square mile sections. The Grunow property is spread across three sections that were surveyed between 1832 and 1833. The southeastern portion of the property is located in section 19 of township T6N R3E, and the southwestern and northern portions of the property are found within sections 13 and 24 of township T6N R2E. Though some small Euro-American settlements and farms had been developed in Iowa County by this time, the vast majority of land surveyed was native. In their notes, the surveyors frequently described sections in and around the Grunow property as “thinly timbered” by a variety of oak species (Lyon 1832).

Maps of pre-settlement vegetation for the entire state have been compiled from these survey notes (Cottam and Loucks 1965; Finley 1976; Mladenoff 2009). The maps show that the property was a mixture of oak savanna and prairie. The dominant tree species were bur oak, white oak, and black oak. Shagbark hickory may have also had a presence (Cottam 1949). Understory shrub species likely included American hazelnut and red root. Prairie grasses were believed to be predominantly big bluestem and little bluestem (Cottam 1949; Cottam and Loucks 1965). Native Americans maintained prairies and savannas in the area by burning them each year (Curtis 1959; Anderson and Brown 1986). Without frequent fires, these widespread prairies and oak savannas could not have been maintained, as only the driest sites sustained these cover types in the absence of fire (Peet and Loucks 1977). The rich mineral deposits in the region held by Native Americans attracted settlers who displaced them (WHC 1881). These settlers soon implemented a new regime of agriculture and fire suppression that began to reshape the land. Today, the property serves as evidence of the tendency for these vegetation types to succeed to sugar maple and basswood forest when left undisturbed

Agriculture and Euro-American Settlement

Dodgeville was the first Euro-American settlement in Iowa County and was founded by General Henry Dodge in 1827. Iowa County proved to have ample lead deposits, so Dodge and his fellow settlers started mining that same year. In 1829, the first farm in the county was established by Captain J.B. Estes in the town of Linden (WHC 1881). Iowa County's population quickly grew to 1,500 by the year 1830 due to the success of lead mining and the establishment of farming. Population growth was further accelerated by construction of the Military Road that passed just south of the Grunow property and connected Prairie du Chien to Green Bay. Built between 1832 and 1837, the Military Road was the first major road of the Wisconsin Territory (Durbin and Durbin 1984). The road was initially proposed to improve the military's ability to protect settlers from Native Americans by increasing mobility between forts Crawford, Winnebago, and Howard. Ultimately, the road was of little benefit to the military due to the lack of confrontation between settlers and Native Americans. However, it did promote western expansion and growth of the mining industry.

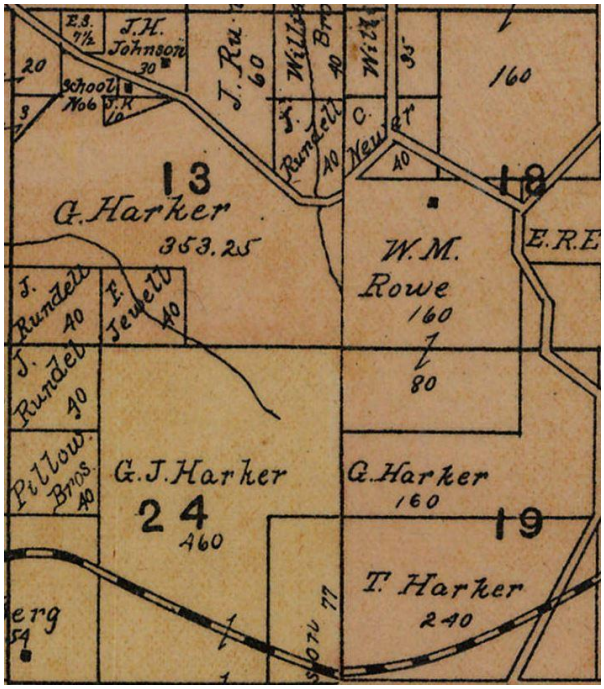


Figure 2. Portion of a 1901 map of Iowa County showing acreage and ownership across sections 13, 19, and 24 that contain the Grunow property (WWH 1901).

As the population of the county grew, so did the farming industry. An 1870 map of the county shows the Grunow property divided amongst several landowners (Wrigglesworth 1870). The sizes and shapes of the properties imply that they were used for agriculture, and the *History of Iowa County, Wisconsin*, published in 1881, confirms that more than 1,500 acres of the three sections that contain the Grunow property were being farmed at that time (WHC 1881). Of the late nineteenth century farmers who had a share of the property, the Harker family left the greatest mark on the land. Besides being the namesake of the creek that runs through the property, the Harkers owned 1,080 acres of the farmland just mentioned, and included most (Figure 2) of the Grunow property (WWH 1901). To some extent, the prairies and savannas that once dominated the property were likely cleared to allow for agriculture. This conversion contributed to the loss of 79 percent of deciduous savanna and 90 percent of prairie from southern Wisconsin due to farming between 1850 and 1935 (Rhemtulla et al. 2007).

Forest Growth and the Planting of Walnut

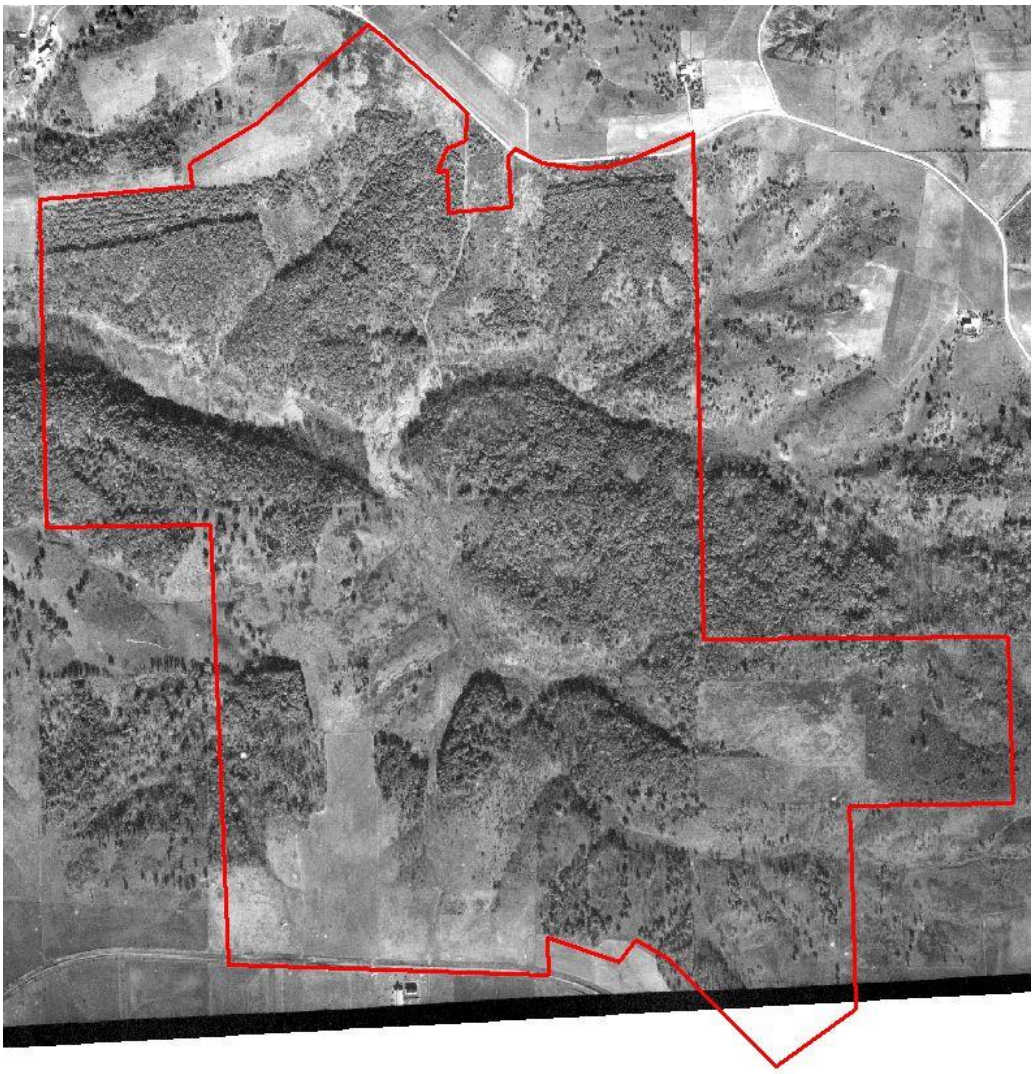


Figure 3. 1937 aerial photo of the Grunow property (USDA 1937).

After farming by the Harker family ceased, reforestation on the Grunow property occured. It is also possible that portions of the property remained undisturbed throughout the expansion of settlements and agriculture during the nineteenth and early twentieth century. According to Cottam (1949), large trees measured during the 1940s in the dense oak forests of southwest Wisconsin were greater than 79 years old, and the forests studied were mostly even-aged. Cottam concluded that many southwest Wisconsin oak forests must have been growing since the 1850s. The earliest available aerial photo of the property is from 1937 (Figure 3) and shows a mix of forest, farmland, and pasture (USDA 1937). Shortly after this photo was taken an economic land survey

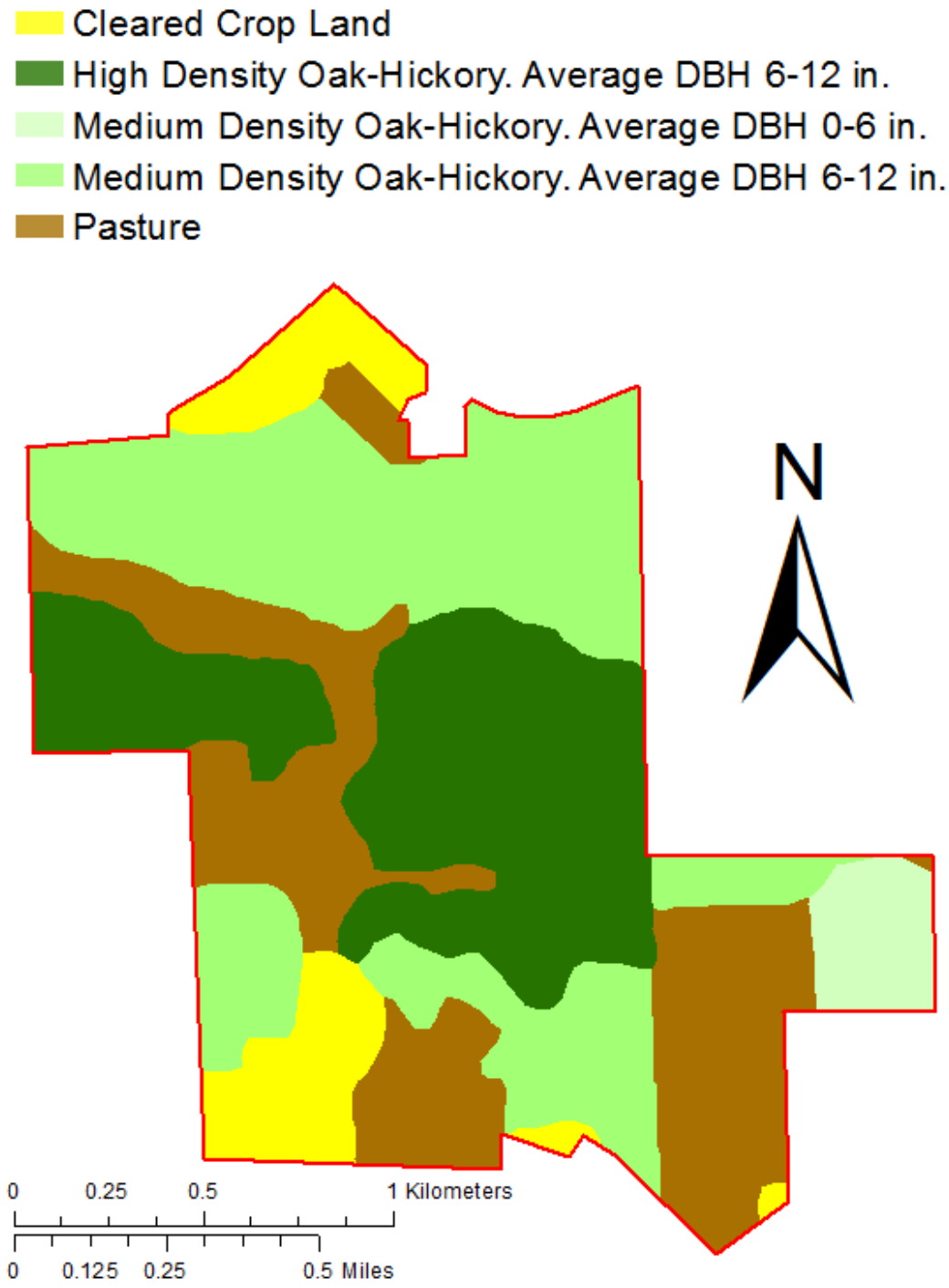


Figure 4. Map of 1939 vegetation cover compiled from hand drawn survey maps (WDA 1939). DBH is diameter at breast height (4.5 feet above ground).

of the state was conducted, including Iowa County in 1939. Maps produced from the survey (Figure 4), show that the Grunow property had some farmland along its edges, pasture along the creek, and areas predominately forested with oak and hickory covering most of the remaining acreage (WDA 1939). The survey further detailed the relative density of forest across the property and the average diameter of trees for different cover types. Few records or specific details regarding management and land use are available after the 1939 survey besides the planting of the black walnut seding during the 1960s and 1970s that form the present day black walnut forest today. When comparing the most recent aerial photo of the property (Figure 1) to the photo from 1937 (Figure 3), the pasture and many thinly forested areas are now continuous forest. The area and density of forest on the Grunow property has increased since the middle of the twentieth century. Fire suppression favored fire intolerant tree species such as black walnut, basswood, and maples at the expense of oak and hickory.

Geology and Topography

Iowa County is located within the Driftless Area of Wisconsin, a region that was not covered by the Wisconsin glaciation that ended nearly 22,000 years ago. The Driftless Area is underlain by karst topography, which is characterized by caves, bluffs, rivers, springs, cold streams, prominent ridges, and deep valleys overlying limestone bedrock (Driftless Area, 2013). The property elevation is approximately 1,000 feet above sea level and its considerable relief can be seen in the map below (Figure 5). The upper boundary of the property along Highway Q lies on a hill, with runoff from the hill and agricultural fields contributing to downslope erosion. This runoff feeds Harker Creek and has resulted in deep trenches along the slope

Soils

Approximately 60 percent of the soils on the property are silt loams (Appendix II and Figure 6). Loam soils are composed of relatively even proportions of sand, silt, and clay (40-40-20), and silt loams in particular have a slightly higher silt content. These soils fall toward the middle of the spectrum between sand and clay, and exhibit beneficial properties of both. They contain more organic material and can hold more moisture than sandy soils, while having better infiltration and drainage than clay soils. These soils are well-suited for agriculture crops and trees, as they hold nutrients and water while allowing excess water to drain away. Most of these silt loams are in various classes of the Dubuque silt loams series based on the slope and level of erosion. These soils are moderately deep where not eroded, well-drained, and high in loess, an accumulation of wind-blown sediment (USDA, 2004). They are underlain by limestone bedrock and have a thin layer of either limestone residuum or a paleosol, which is high in clay content. According to the United States Geological Survey (USGS), these soils are classified as moderately eroded, yet these soils are deemed “prime farmland” and “farmland of statewide importance” when located on shallow slopes.” This soil series covers about 30 percent of the property, and are quality farm soils. They pose a low risk for tree seedling mortality due to favorable soil and environmental characteristics such as “a lack of flooding and ponding (unwanted pooling of water),

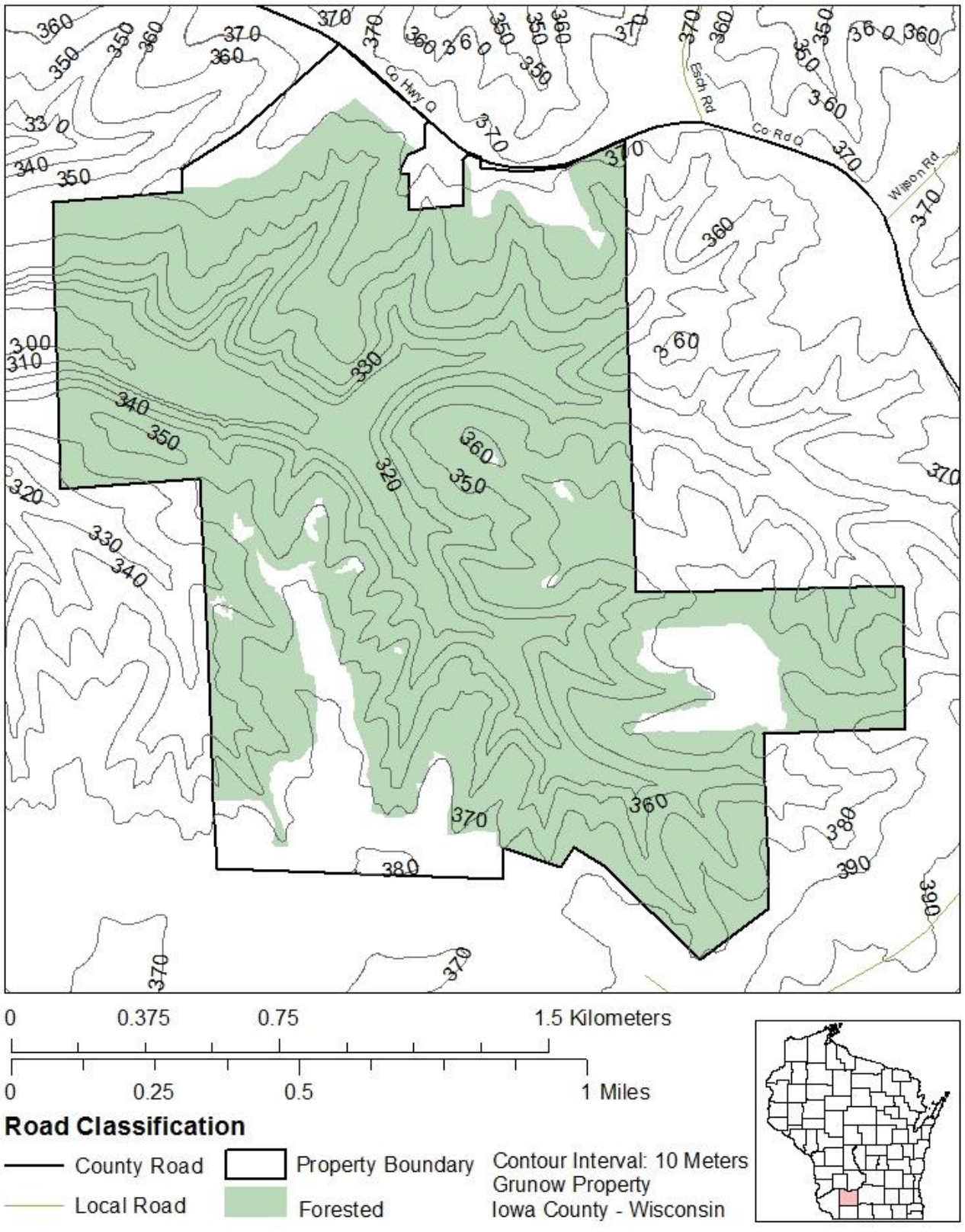


Figure 5. Topographic map showing forested land and elevation. Elevation is meters above sea level.

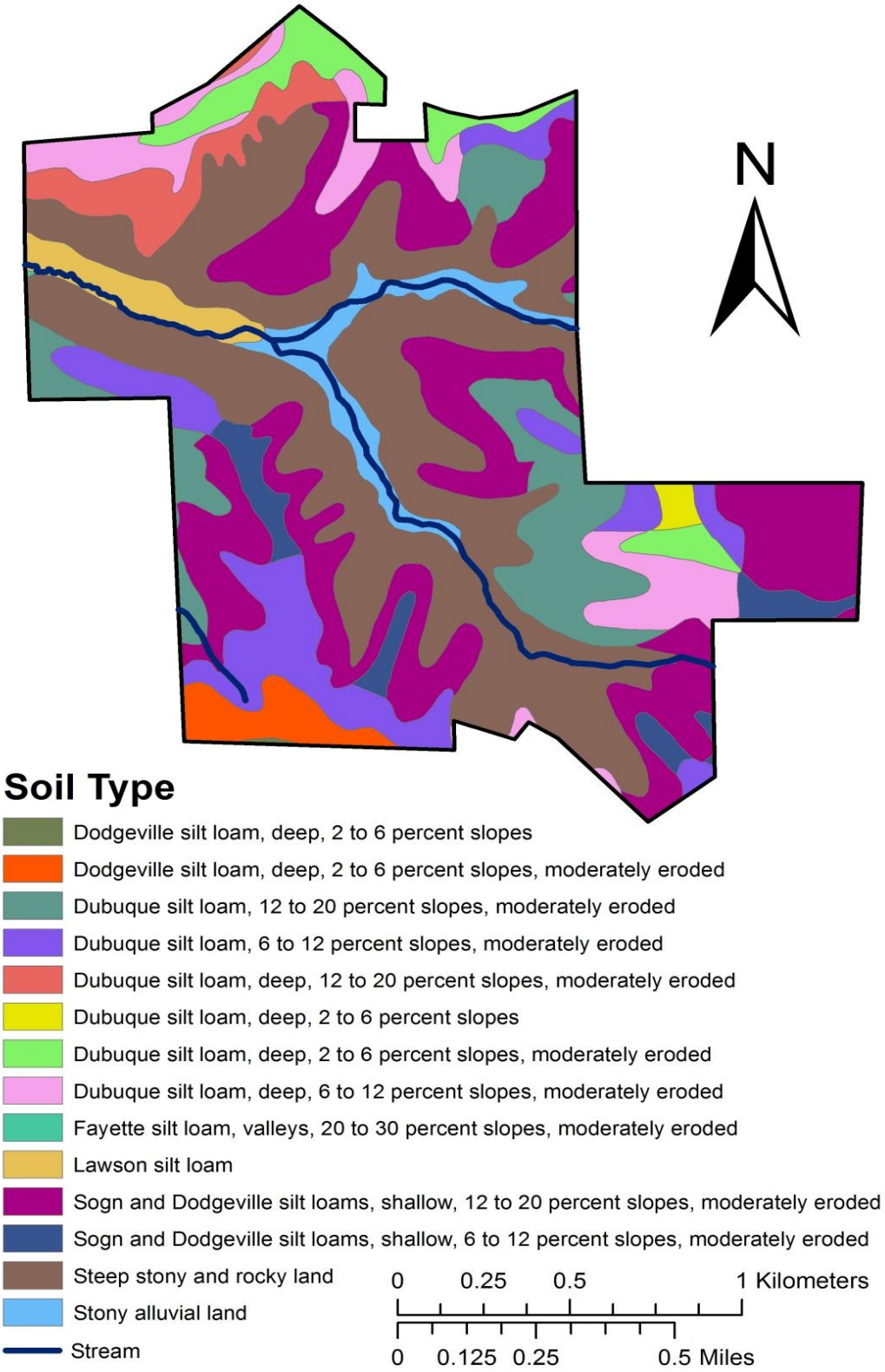


Figure 6. Distribution and description of soil types throughout the property based on NRCS soil survey data.

characteristics such as “a lack of flooding and ponding (unwanted pooling of water), depth to a water table, content of lime, reaction (pH), available water capacity, soil moisture regime, soil temperature regime, aspect, and slope” (USDA NRCS, 2013). Complete soil type descriptions can be found in Appendix II.

Other major soil types include the Sogn and Dodgeville silt loams, which together cover about 25 percent of the property. The Dodgeville series is well drained and was formed by loess and clay residuum from weathered dolomite and limestone. Those soils have moderately slow permeability and overlay limestone or dolomite bedrock (USDA NRCS, 2004). The Sogn series is shallow and excessively drained and also formed in residuum weathered from limestone (USDA NRCS, 2006). These soils have a slight off-road erosion risk.

All the silt loam soils have a low potential for damage by prescribed fire. Based on the limited potential for damage to soil nutrient, physical, and biotic characteristics, prescribed burning may be used as a successful management tool.

About 40 percent of the property is either steep, stony and rocky land or stony alluvial land. Both have a slight off-road erosion risk. All soils on the property are considered moderately suitable for accommodating heavy harvesting equipment, though due to their low strength, the formation of ruts is possible.

Hydrology

The Driftless Region and its steep slopes have a major influence on hydrology. Steep slopes and deep soils create the perfect environment for erosion, which moves down slope and into nearby streams. Early Euro-American settlers exploited the deep soils on the hilltops, resulting in high amounts of erosion that filled in many stream beds and disrupted watersheds. The Driftless Area of Wisconsin is home to many of the state’s trout streams, such as Harker Creek, which is a class one stream located on the Grunow property. A class one trout stream is defined as having high quality trout waters that have sufficient natural reproduction to sustain populations of wild brook trout, at or near carrying capacity (WI DNR, 2013). Actively managing streams and riparian areas can have a beneficial impact on wildlife and local water quality.

Data Collection

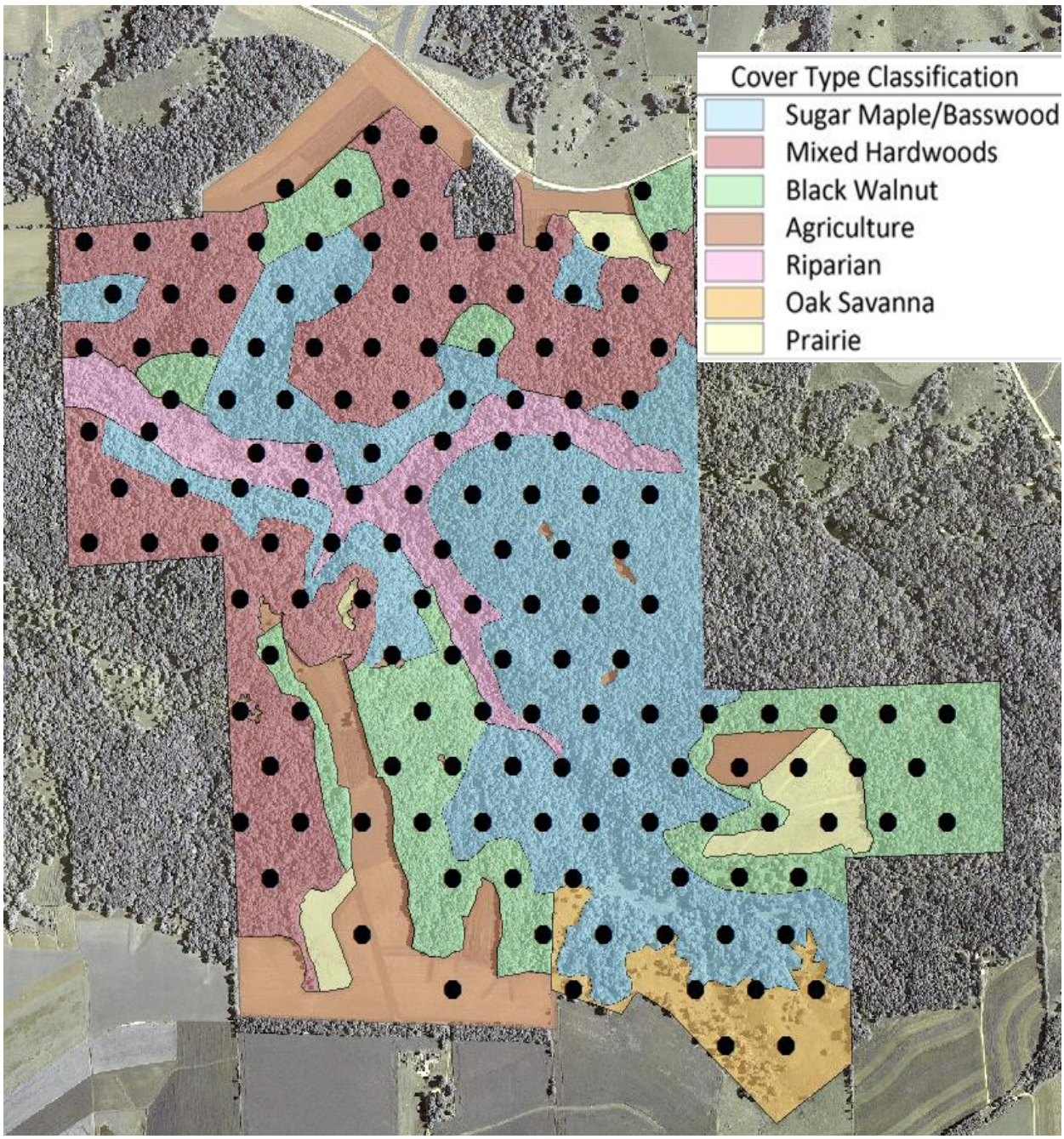


Figure 7. Distribution of plots across Grunow property under a grid-based sampling design. Black dots denote plots sampled.

Plot Sampling Design

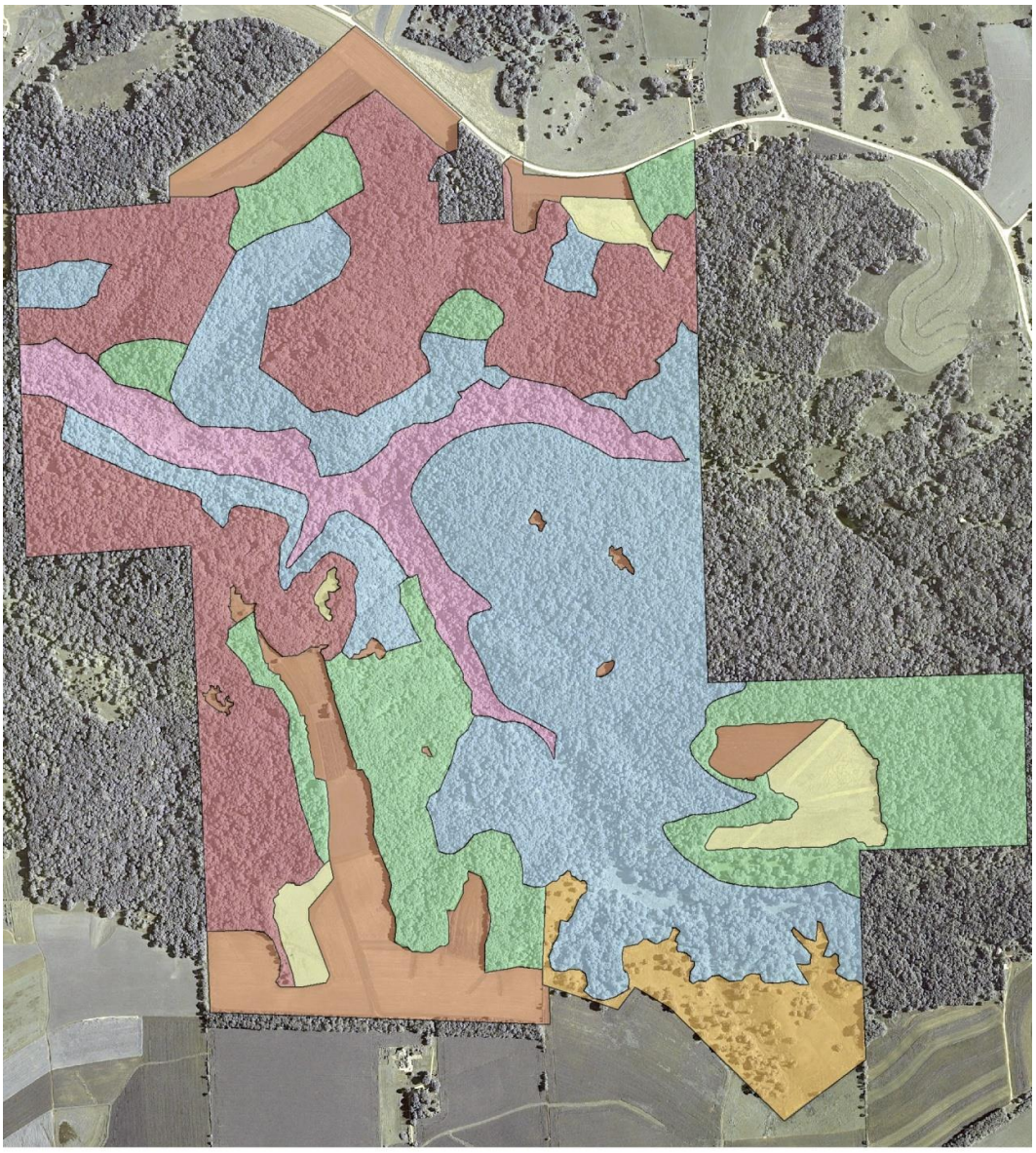
Students were divided into three teams to collect data in assigned compartments across the Grunow property. Under a grid-based sampling design, teams evenly distributed plots across their compartments at approximately one plot per five acres (Figure 7). The data for each plot were composited by major forest or vegetation cover type.

Data Collection Methods

Timber volume and tree density were estimated using variable-radius plot sampling with a basal area factor (BAF) ten prism. DBH was measured 4.5 feet above soil surface. Each tree that was counted “in” a plot was assigned ten square feet of basal area per acre. Basal area was calculated as the sum of the cross-sectional area at breast height of all trees. Basal area of a stand is an average of the total area of a stand covered by timber. Tree density was estimated using the number of trees in each two-inch diameter class recorded at a sample plot.

Sawtimber and pulpwood were measured as board feet and cords, respectively. A board foot is the volume measurement for larger-diameter trees with at least an 11-inch DBH. These trees can be sold as sawtimber for lumber production or veneer for the most valuable and highest quality timber. One board foot is equivalent to one foot by one foot by 1 inch of volume. Saw logs were graded in the field as half saw log sections, eight feet in length. (Appendix V). A cord is the volume measurement of timber sold as firewood or pulpwood. This volume measurement can have a minimum DBH of four inches. Larger trees with poor form and defects were also included in this category. One cord is equal to 128 cubic feet, which is measured in a nicely stacked woodpile, including air between stacked wood, that is eight feet wide, four feet high, and four feet deep. Cords were measured in eight-foot bolts in the field. Pulpwood volume above sawtimber was measured using an empirical growth projection model. The model uses a standard tree diameter taper based on the DBH down to a four-inch top diameter to obtain a cubic foot volume (Dr. Eric Kruger). Additionally, at each plot, coarse woody debris, tree regeneration, native and invasive species cover, soil, productivity, slope, aspect and elevation were measured. A detailed data collection method section is included in Appendix I, which outlines how each variable was measured.

Results



Cover Type Classification	Acres
Sugar Maple/Basswood	261
Mixed Hardwoods	203
Black Walnut	140
Agriculture	91
Riparian	56
Oak Savanna	36
Prairie	28
Total	815

Figure 8. Dominant cover types for the Grunow property with acreage for each.

Timber and Regeneration

Table 1. Timber cover types with respective averages for basal area, tree density, and volume (sawtimber and pulpwood).

Cover Type	Basal Area (square feet per acre)	Density (trees per acre)	Sawtimber (board feet per acre)	Pulpwood (cords per acre)
Sugar Maple/Basswood	79.1	284	3990	15
Mixed Hardwood	91.6	257	5093	16
Riparian	95.0	427	4479	18
Black Walnut	66.9	220	2418	13
Total Forest Area	81.6	274	4008	15

Timber data were collected on 660 acres of the property and divided into four timber cover types based on the dominant tree species recorded per plot. The cover type boundaries and acreage for each cover type are shown in Figure 8. The average total basal area for the forested portion of the property is 81.6 square feet per acre (Table 1). Sugar maple, basswood, ash (green and white), walnut, and hickory are the most abundant species and averaged 274 trees per acre (Figure 9). Sugar maple, basswood, ash, and hickory are the most abundant in the smaller DBH size classes (Figure 9).

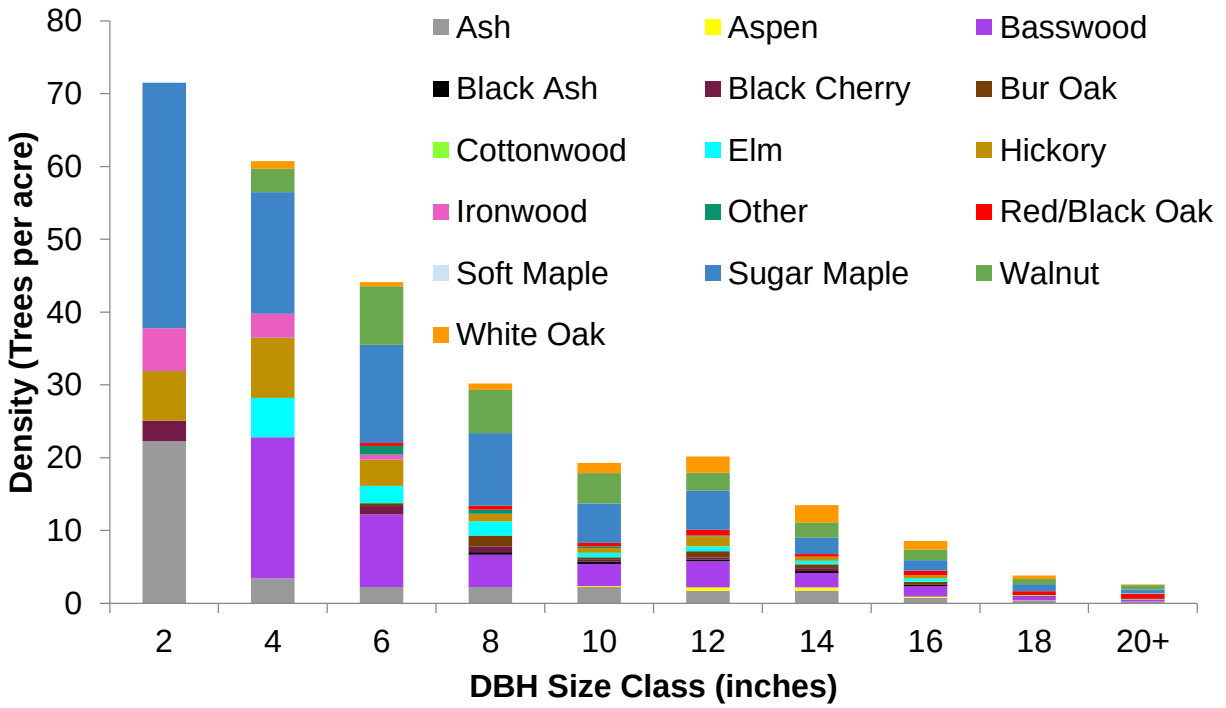


Figure 9. Tree density (trees per acre) grouped into two-inch DBH size classes, which are the DBH rounded up to the nearest even number. The "other" species include apple, cedar, hackberry, and musclewood.

Trees with a DBH larger than 20 inches are grouped together due to the small number of trees in these size classes. Of the 20-inch DBH and larger trees, sugar maple, red/black oak, and walnut represent the majority on the Grunow property (Figure 10).

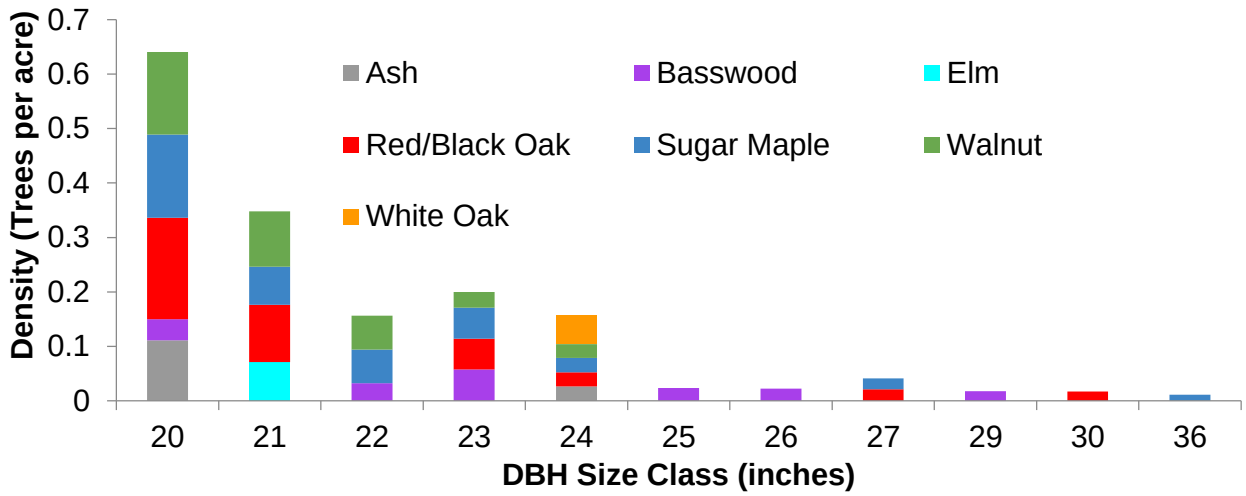


Figure 10. Density (trees per acre) of trees 20 inches and greater shown in increasing one-inch DBH size classes for the forested area of 660 acres.

Merchantable Volume

The major sawtimber species for the Grunow property are sugar maple, walnut, basswood, white oak, and red/black oak (Figure 11). The most valuable species for the property are walnut and red/black oak with 240 and 200 board feet per acre in the Grade 1 category, respectively (Figure 11). Grade is based on diameter and presence of defects in the lower 16 feet of the stem. Grading rules can be found in Appendix V.

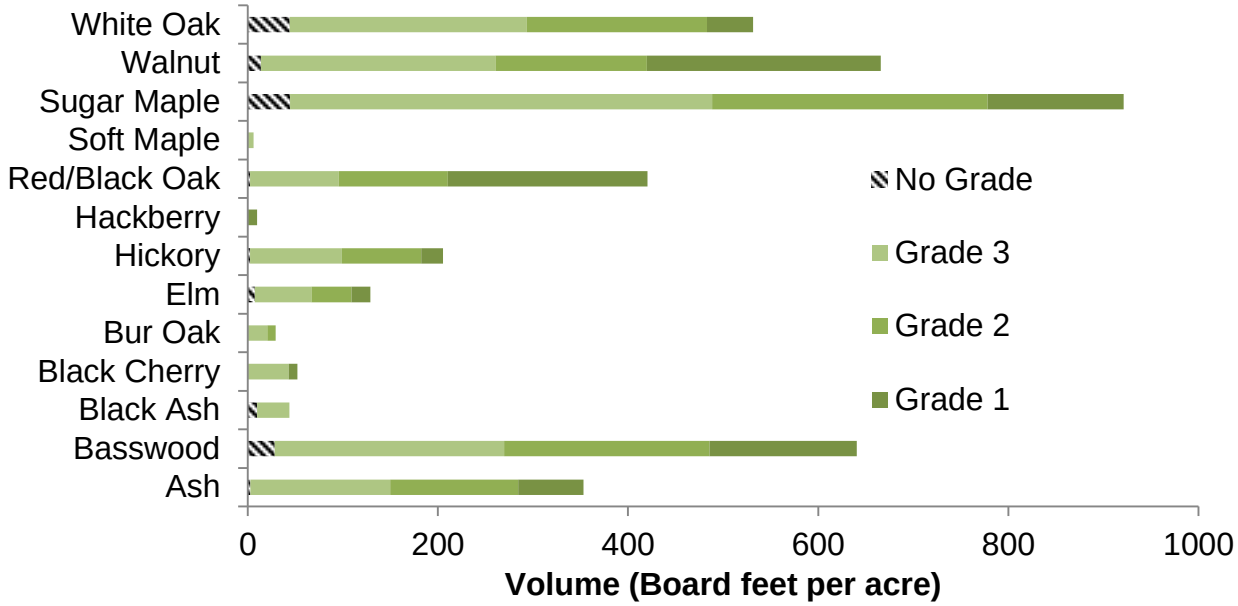


Figure 11. Average sawtimber volume (board feet per acre) by grade for the forested area of 660 acres.

For the forested area measured, there are 15 cords per acre on average. This is largely dominated by sugar maple, walnut, and basswood, representing 4, 3, and 3 cords per acre, respectively. With our data collection system, species will always have a cord volume if the tree has a DBH greater than four inches. A few students visited Scott Sawle, president of Rockbridge Sawmill Inc., in Richland Center, Wisconsin to better understand local timber demand. Rockbridge Sawmill focuses on larger sawtimber to keep their mill running year-round. Therefore, our management options will focus on sustainable harvesting of sawtimber with minimal emphasis on cordwood.

Tree Regeneration

Tree regeneration data were collected at every plot using methods outlined in Appendix I. The most abundant tree regeneration species are sugar maple, ash and ironwood (Figure 12). Sugar maple is the most abundant species in each height class, indicating that without active management sugar maple will dominate the property in the future. Although oak is present as a dominant tree species, there is little oak regeneration. Given the well-documented issues with oak regeneration in Wisconsin, it is not surprising that there is a shortage of oak seedlings throughout the Grunow property understory.

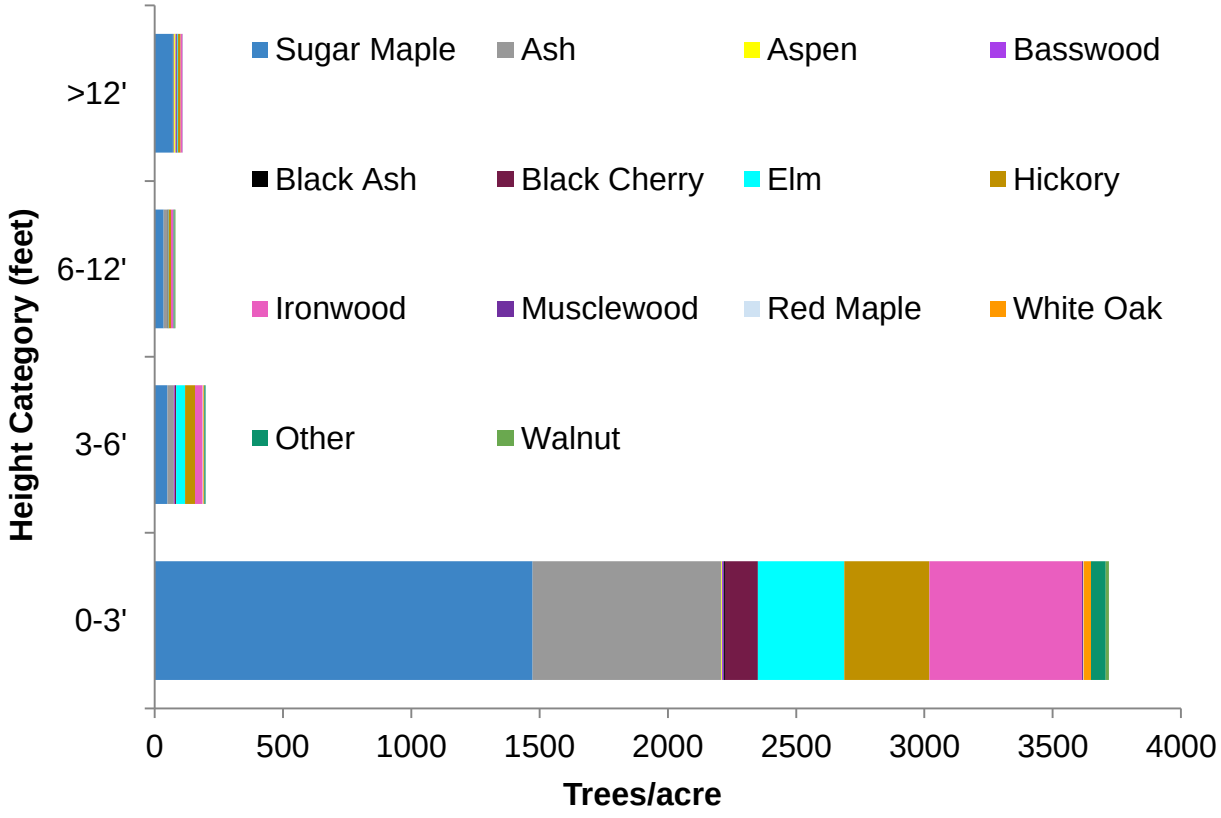


Figure 12. Grunow property tree regeneration (trees per acre) by height (feet).

Cover Type Descriptions

Sugar Maple/Basswood

The sugar maple/basswood cover type is the largest cover type encompassing 261 acres. It has a mean basal area that is slightly larger than the average for the property at 79.9 square feet per acre. We defined this forest cover type as follows: sugar maple and basswood trees must comprise a minimum of 60 percent of the live total stand basal area. The total tree density for this cover type is 284 trees per acre with sugar maple and basswood representing 70 percent of the trees per acre (Figure 13). There is a large amount of sugar maple and basswood in the two-inch and four-inch diameter classes, explaining the large number of trees per acre (Figure 13). Other significant overstory tree species are ash and hickory (Figure 13).

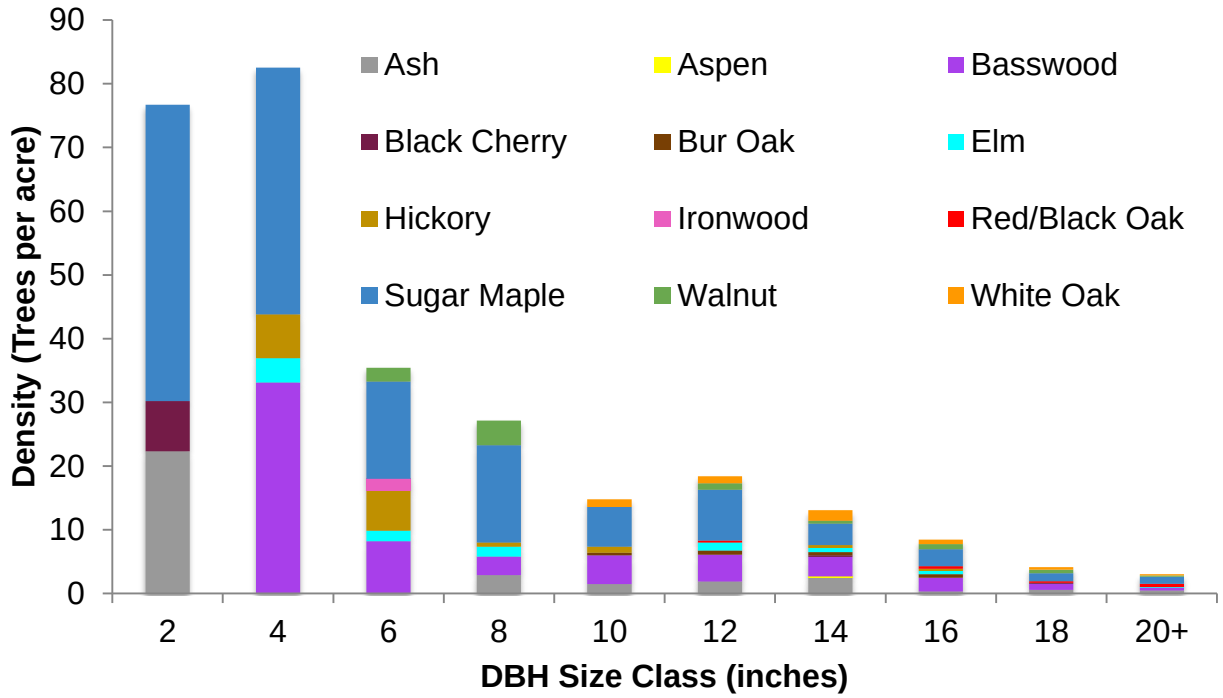


Figure 13. Tree density (trees per acre) for the sugar maple/basswood cover with an area of 261 acres.

Merchantable Volume

The average total volume is 3,990 board feet per acre in the sugar maple/basswood cover type. Sugar maple and basswood account for the majority of the board-foot volume (Figure 14). The total sugar maple board-foot volume is 1,447 board feet per acre (Figure 14). Grade 3 sugar maple board-foot volume accounts for 55 percent of this total volume, while Grade 1 only accounts for 15 percent (Figure 14). The majority of Grade 3 sawtimber is less than 13 inches in DBH for this cover type. Some of the Grade 3 sugar maple should increase to Grade 2 over time. The volume of cords in the sugar maple/basswood cover type is 15 cords per acre. Sugar maple and basswood represent 61 percent of the total cords per acre with very few other species contributing to cord volume.

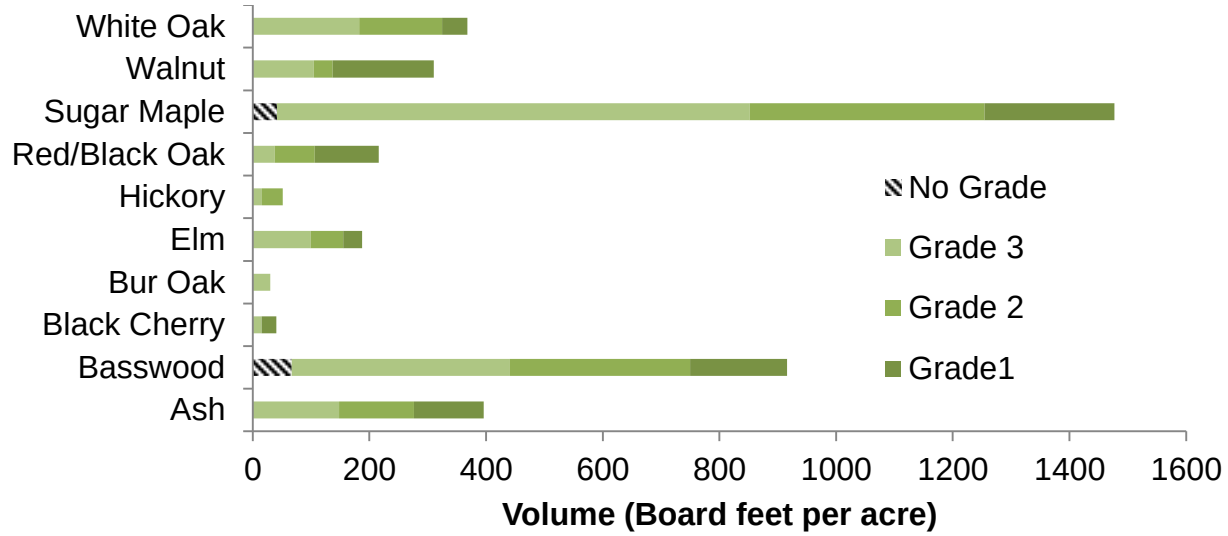


Figure 14. Average sawtimber volume (board feet per acre) of the sugar maple/basswood cover type.

Tree Regeneration

Sugar maple, ash, and ironwood are the most abundant tree seedlings and saplings for the sugar maple/basswood cover type (Figure 15).

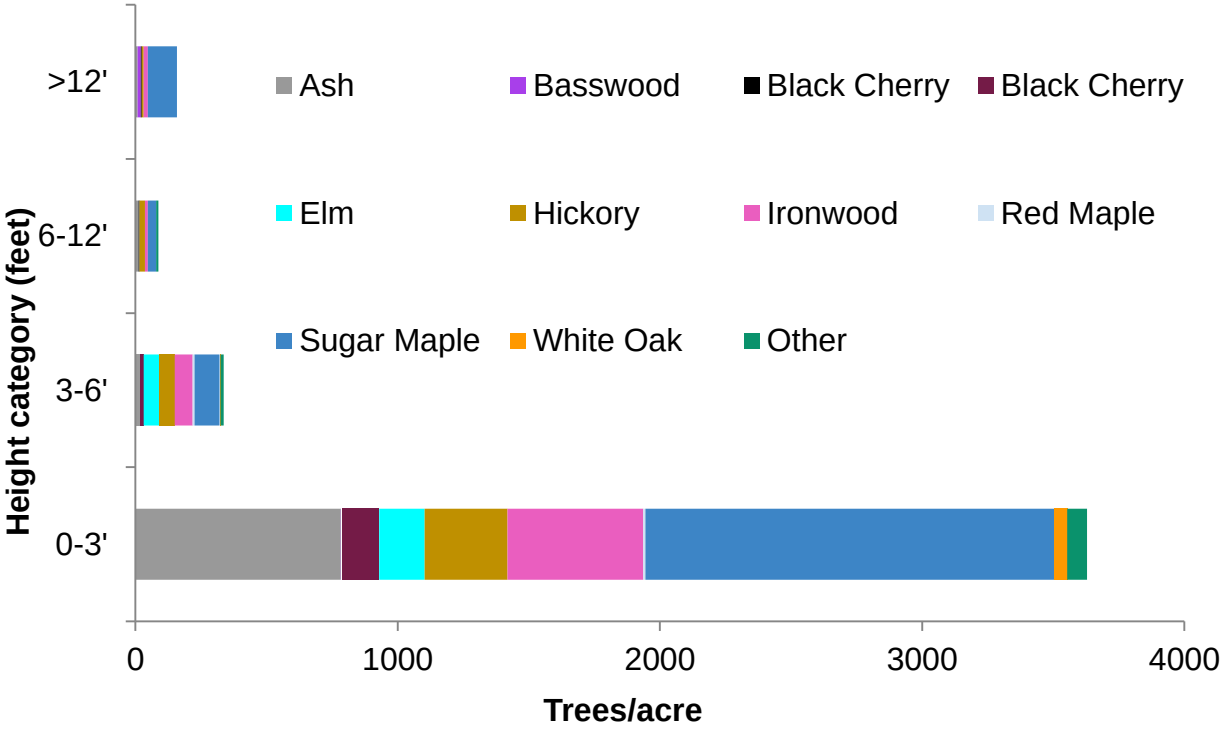


Figure 15. Sugar maple/basswood cover type tree regeneration (trees per acre) by height (feet).

Mixed Hardwood

The mixed hardwood cover type is 203 acres and the average basal area is 91.6 square feet per acre. This cover type contains a mix of hardwood trees, such as ash, sugar maple, hickory, ironwood, and basswood. Average tree density is 257 trees per acre for the cover type (Figure 16).

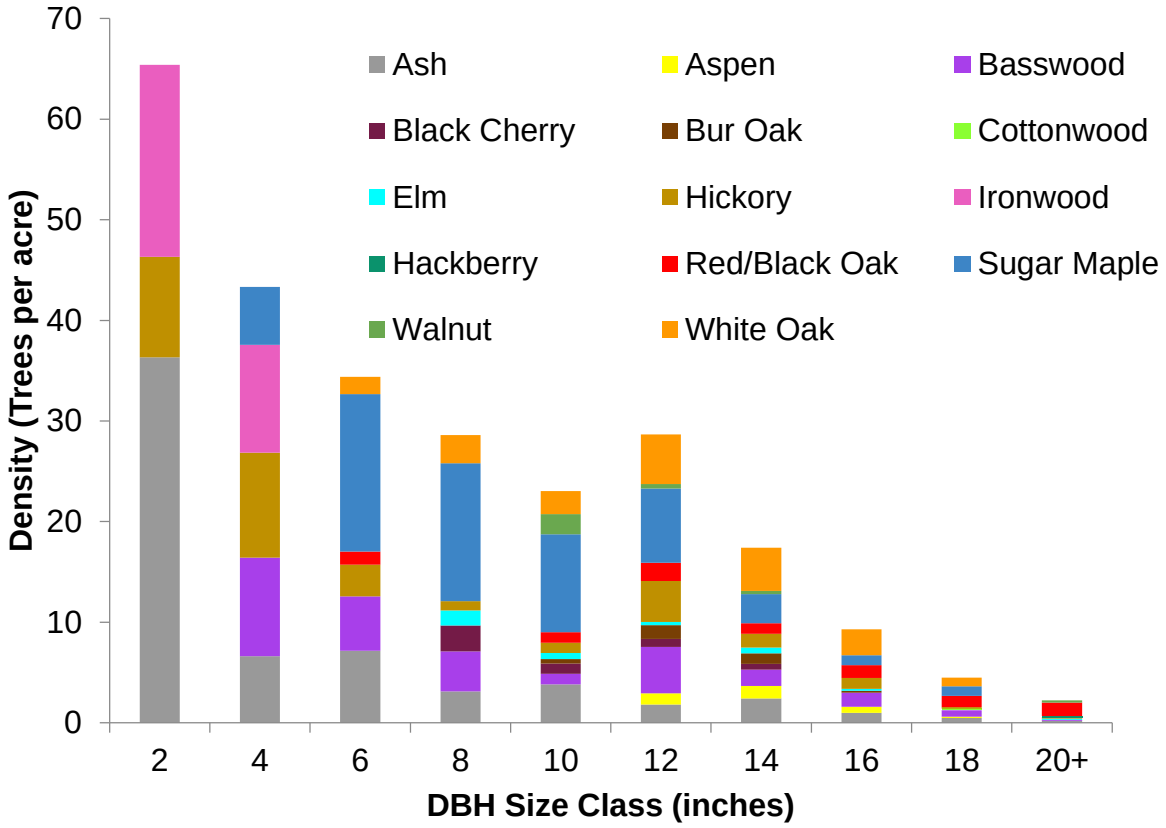


Figure 16. Tree density (trees per acre) for the mixed hardwood cover type with an area of 203 acres.

Merchantable Volume

White oak, red/black oak, and sugar maple are the dominant sawtimber species in the mixed hardwood cover type. The total board-foot volume for this cover type is 5,093 board feet per acre (Figure 17). Red/black oak comprises the greatest Grade 1 volume with 464 board feet per acre, which is 50 percent of the red/black oak total of 933 board feet per acre (Figure 17). The average total cords per acre is 16. The major species are sugar maple, white oak, ash, basswood, and red/black oak.

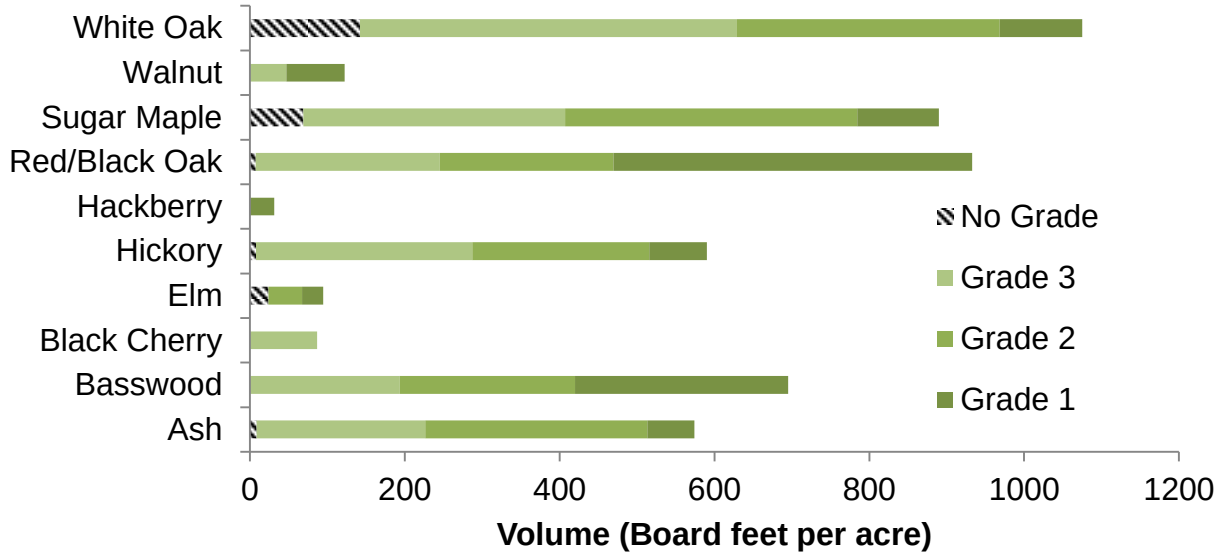


Figure 17. Average sawtimber volume (board feet per acre) for the mixed hardwood cover type.

Tree Regeneration

Regeneration in the mixed hardwood cover type is predominantly sugar maple (Figure 18). These data suggest sugar maple will dominate these forests in the future, unless active timber stand improvement management practices are implemented.

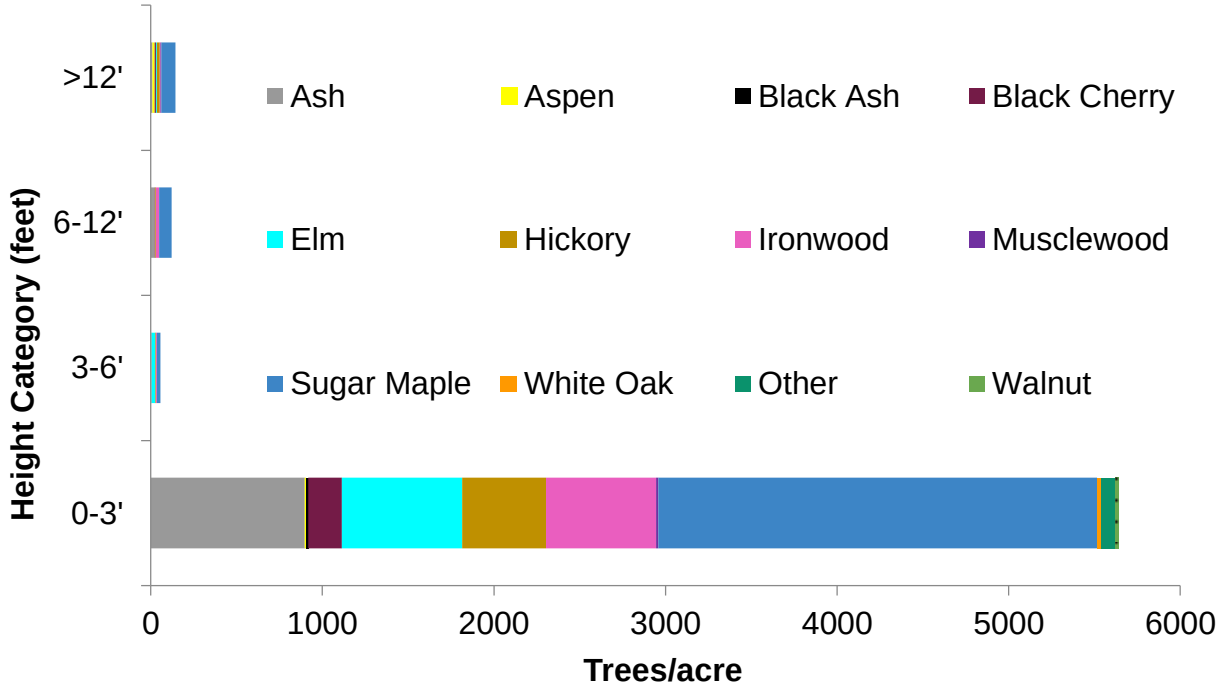


Figure 18. Mixed hardwood cover type tree regeneration (trees per acre) by height (feet).

Riparian

The riparian cover type is defined based on proximity to Harker Creek, soil depth and the presence of black ash. The riparian designation superseded any potential sugar maple/basswood and walnut designations. The riparian cover type totals 56 acres and has the highest basal area of all cover types at 95.0 square feet per acre. The average for total trees per acre for this cover type is 427, which is largely dominated by the 2-inch sugar maple size class, with 122 trees per acre for that category alone (Figure 19). The other major tree species are elm, ash, and basswood, with black ash representing only 14 trees per acre (Figure 19).

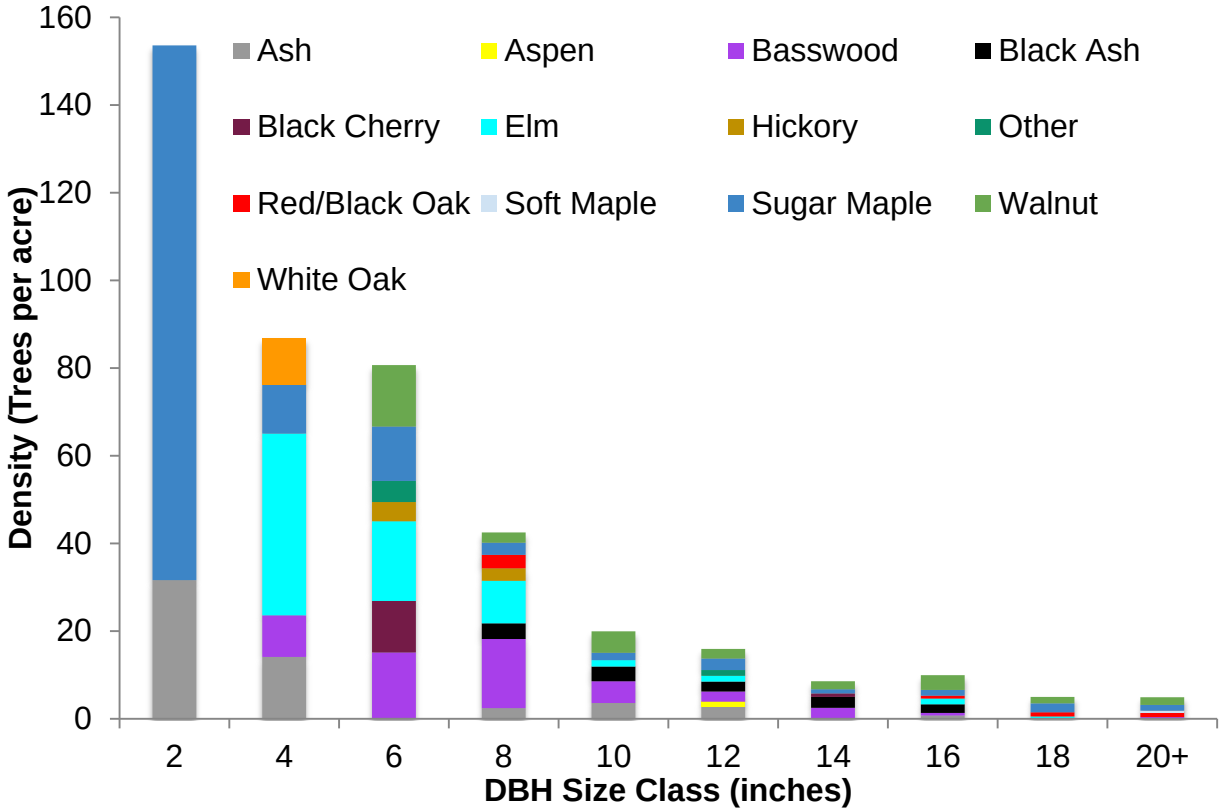


Figure 19. Tree density (trees per acre) for the riparian cover type with an area of 56 acres. The "other" species are apple and musclewood.

Merchantable Volume

In the riparian cover type the total board-foot volume is 4,479 board feet per acre, with walnut and sugar maple contributing over half of the board-foot volume (Figure 20). Walnut located in the riparian cover type is of very high quality with 835 board feet per acre in the Grade 1 designation, which represents 57 percent of the walnut total volume per acre (Figure 20). Average cord volume in this forest type is the highest of all cover types and averages 18 cords per acre. Basswood, walnut, sugar maple, and elm comprise the majority of the cord volume in this cover type.

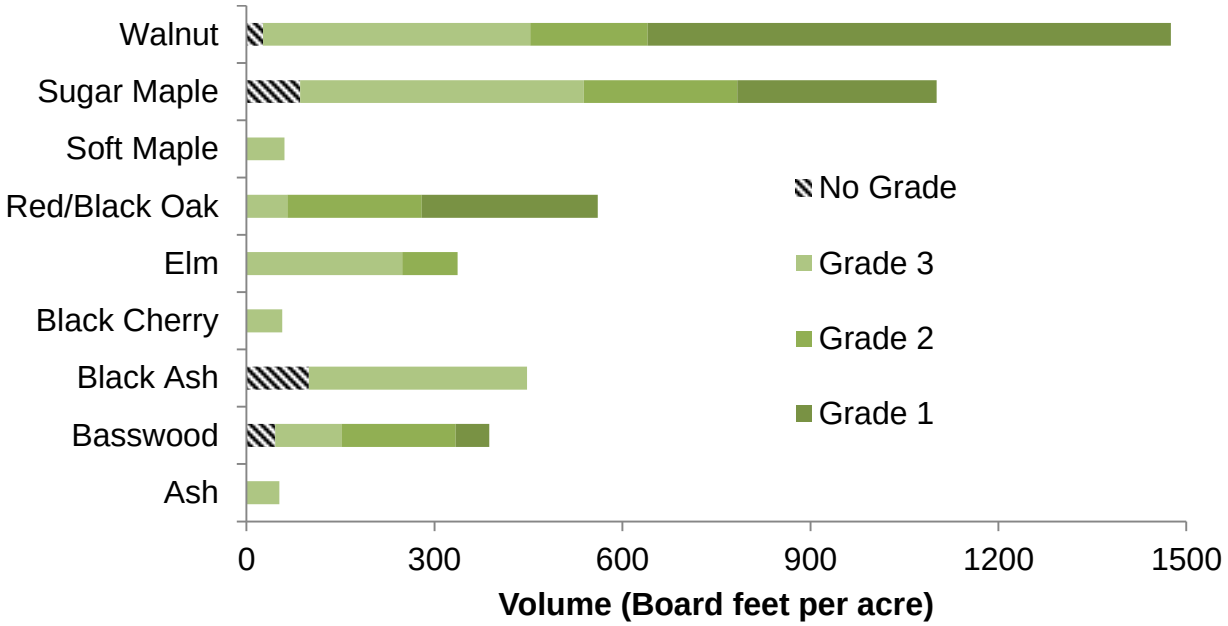


Figure 20. Average sawtimber volume by grade (board feet per acre) for the riparian cover type.

Tree Regeneration

The most abundant tree regeneration species in the riparian cover type are sugar maple, ash, and ironwood (Figure 21). Ironwood is the only species that is moderately browsed in the riparian cover type. There is also an absence of species in the three-foot to six-foot height class, making the future composition of this forest somewhat unpredictable.

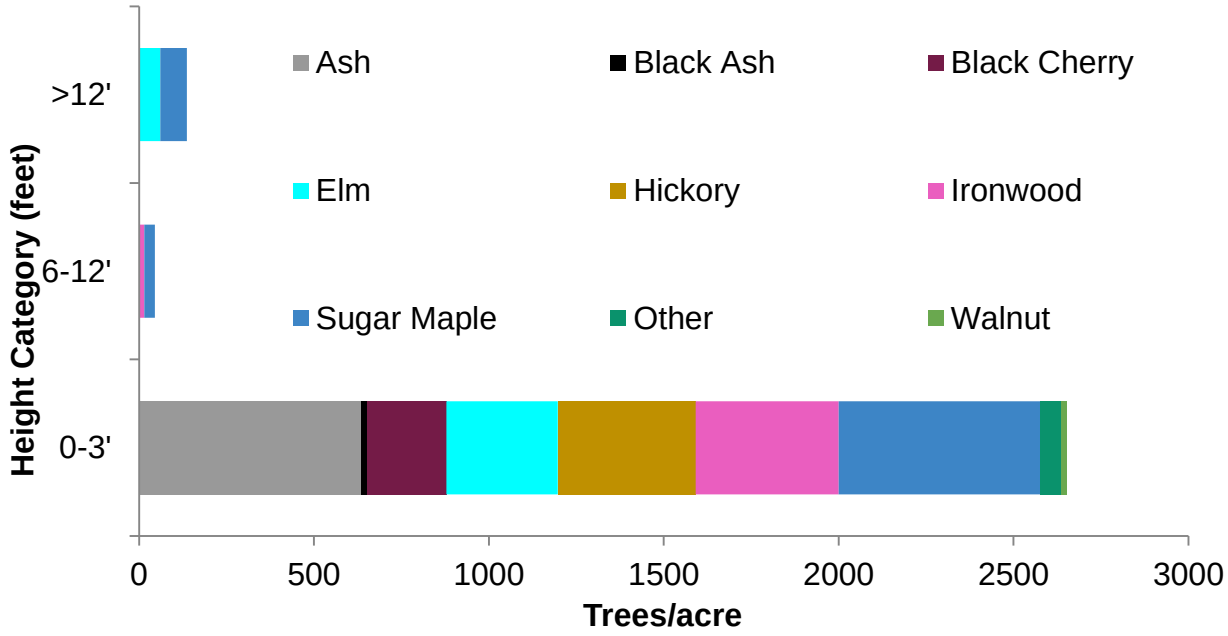


Figure 21. Riparian cover type tree regeneration (trees per acre) by height (feet).

Black Walnut

The black walnut cover type is 140 acres and walnut represents at least 40 percent of the trees. The majority of the walnut trees were planted in this area, causing a fairly even-aged stand. The average tree density for this cover type is 220 trees per acre, with walnut representing 91 trees per acre (Figure 22). The average basal area of the black walnut cover type is 66.9 square feet per acre.

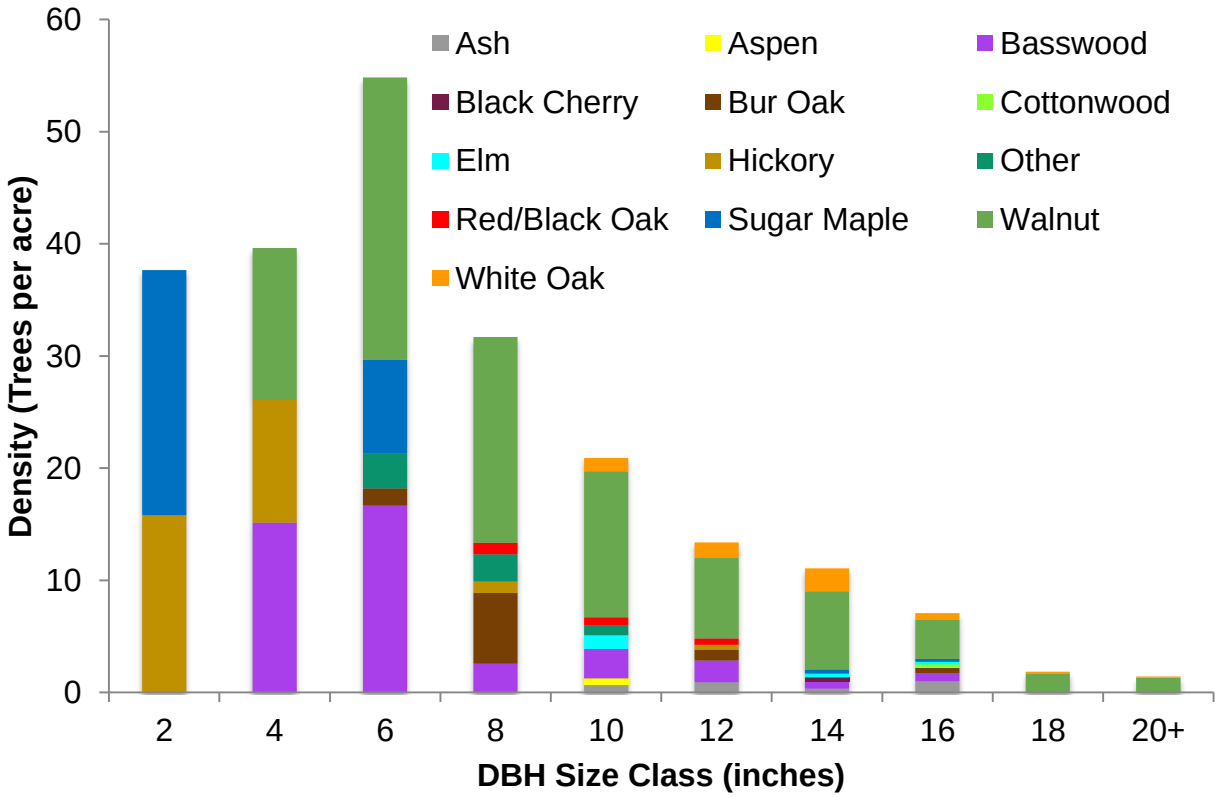


Figure 22. Tree density (trees per acre) for the black walnut cover type with an area of 140 acres. The "other" species are cedar and hackberry.

Merchantable Volume

Board-foot volume for the black walnut cover type is estimated to average 2,418 board feet per acre. Walnut comprises 65.4 percent of the board-foot volume at 1,582 board feet per acre (Figure 23). When broken down by grade, Grade 1 has 336 board feet per acre, Grade 2 has 549 board feet per acre, and Grade 3 has 650 board feet per acre (Figure 23). Walnut produces quality sawtimber once the DBH reaches at least eighteen inches, but value can decrease once the tree is older due to decay (Beyer 2013). Most of the walnut trees in this cover type are smaller in diameter, but will become a higher grade and increase in value as the DBH increases. Cordwood volume is also dominated by walnut at 59 percent of the volume.

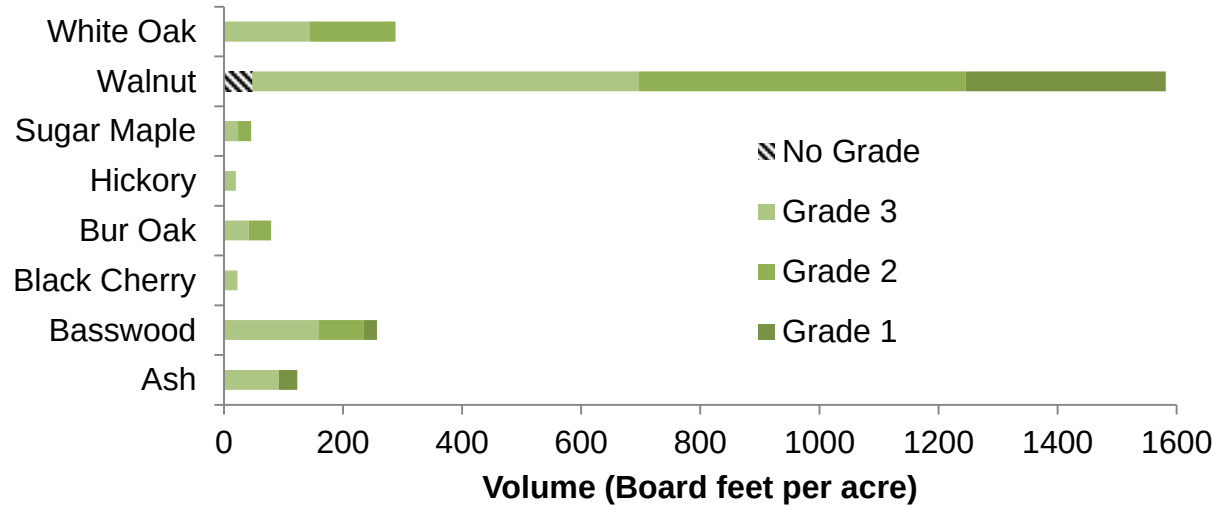


Figure 23. Average sawtimber volume by grade (board feet per acre) for the black walnut cover type.

Tree Regeneration

The most abundant tree regeneration species in the black walnut cover type are ironwood, ash, and sugar maple (Figure 24). There is very little black walnut regeneration, which is heavily browsed. The lack of regeneration under the canopy is indicative of black walnut because it is a shade-intolerant species. Therefore, black walnut cannot be sustainably harvested without planting.

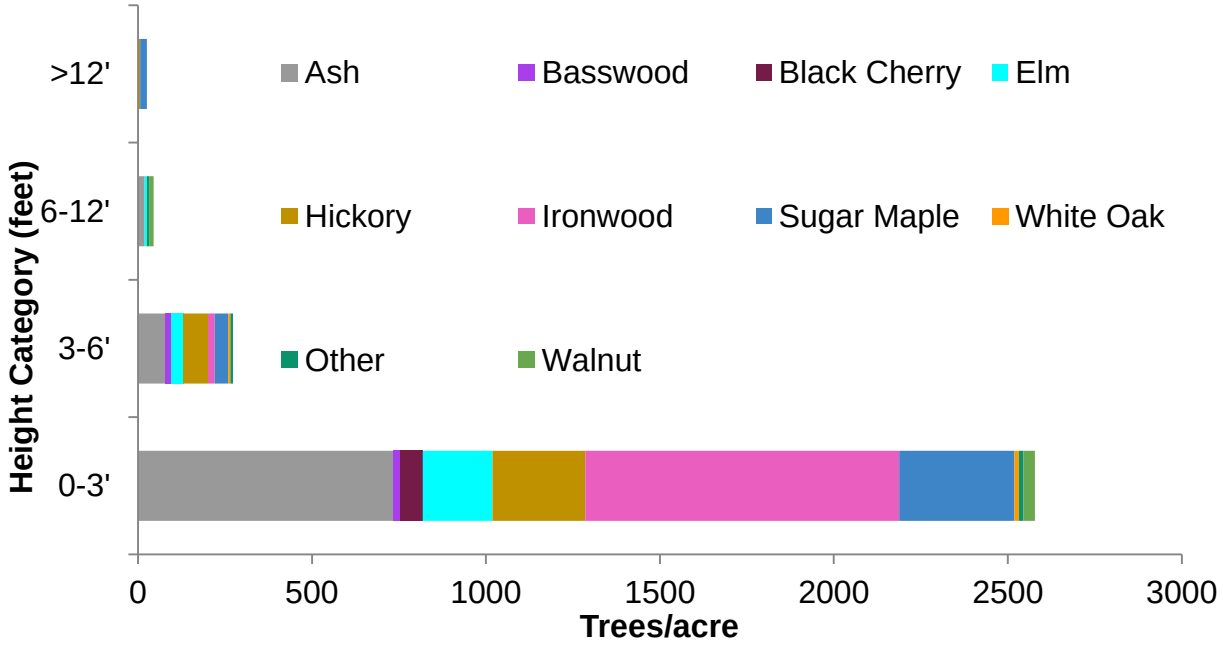


Figure 24. Black walnut cover type tree regeneration (trees per acre) by height (feet).

Oak Savanna and Prairie

The 36-acre oak savanna in the southeast corner of the property includes many species of native grasses and forbs, such as big bluestem, indiangrass, little bluestem, sideoats grama, and switchgrass. The native grasses seem to have populated much of the area on the south-facing slopes.

The basal area of the oak savanna averages 15 square feet per acre. There are five trees per acre within this cover type, with white oak representing two trees per acre.

Other Flora

Understory Vegetation

Understory cover was recorded using methods as outlined in Appendix I. Understory vegetation can play an important role in wildlife forage, as well as influence regeneration of tree species. The abundance and height of vegetation can influence regeneration by creating competition for light. Advanced tree regeneration dominates most plots across the compartment. Grasses, shrubs, and forbs cover a higher percentage of ground in areas where the sun penetrates to the forest floor and along field edges.

Native Cover

Overall, forbs and grasses are the dominant (24 percent) understory vegetation (Figure 25). Prickly ash cover comprises 1.6 percent in the six-foot to twelve-foot height. In some areas, prickly ash cover is extremely dense (Figure 25). Other forbs on the property include pointed-leaf tick-trefoil, Virginia creeper, wild geranium, and sweet cicely, while shrubs and small trees observed include musclewood, alder, sumac, and gray dogwood.

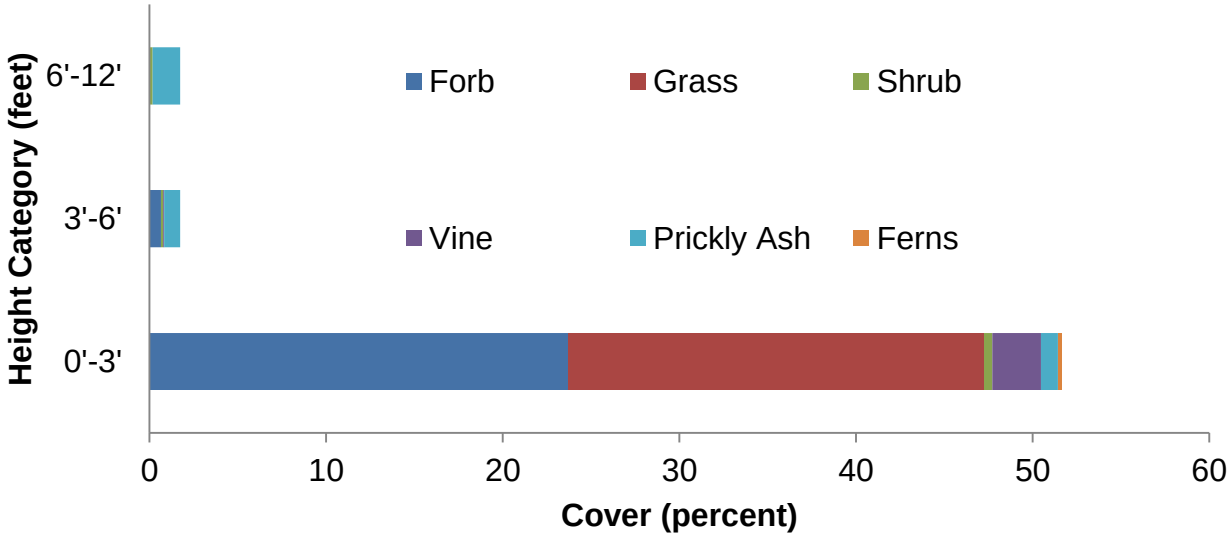


Figure 25. Percent cover by height category (feet) of native vegetation for the forested area of 660 acres.

Invasive Cover

Invasive species pose a threat to the oak savanna and prairie ecosystems on the Grunow property. The most prevalent invasive grasses and forbs include: smooth brome, wild parsnip, Canada thistle, burdock, Queen Anne's lace, spotted knapweed, mullein, nettle, and garlic mustard. Invasive shrubs include European honeysuckle, multiflora rose, Japanese barberry, and Russian olive.

Eradicating invasive species is essential because these plants produce many seeds, seed longevity can be up to several decades, and few wildlife species consume the vegetation. This can affect natural vegetation if unmanaged, creating a monoculture and seed bank for surrounding areas.

The invasive cover for the property is roughly five percent on average (Figure 26). The majority of the invasive cover is garlic mustard (Figure 26).

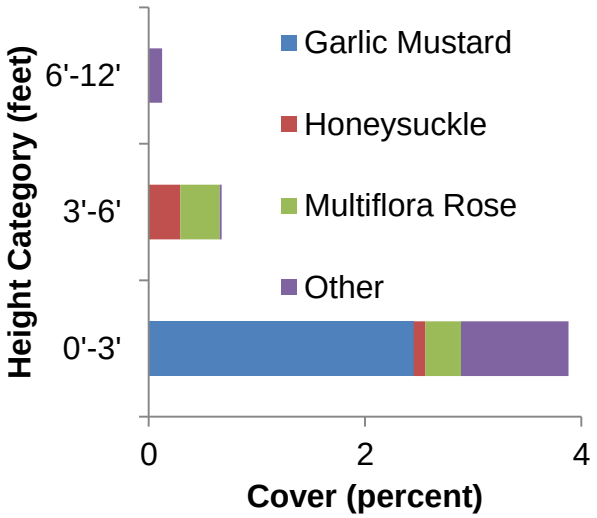


Figure 26. Percent cover of invasive species for the Grunow property shown in three height classes. The "other" species found are burdock and Queen Anne's lace.

Garlic Mustard

Garlic mustard is a biennial herbaceous plant that was observed in all forest cover types. It is a shade-tolerant species that thrives in recently disturbed sites. Seeds are released in early summer and are easily disseminated passively, as well as by humans and animals. Garlic mustard releases chemicals that negatively affect symbiotic relationships between mycorrhizae fungi and native flora, such as grasses, forbs and tree seedlings (Vaughn and Berhow 1999). Seeds can survive in the soil for four to seven years (Baskin and Baskin 1992).

Garlic mustard is concentrated in two or three large pockets in the mixed hardwood cover type. This has the potential to make control tactics more efficient (Figure 27). In many cases, garlic mustard is the dominant ground cover on thinned and hinge-cut sites (Figure 27), arguing for continued monitoring and control during gap creation. White-taileded deer exacerbate the problem by browsing on native vegetation, while leaving garlic mustard to proliferate.

Photo 1. Garlic mustard in bloom. Chris Evans, Illinois Wildlife Action Plan, Bugwood.org

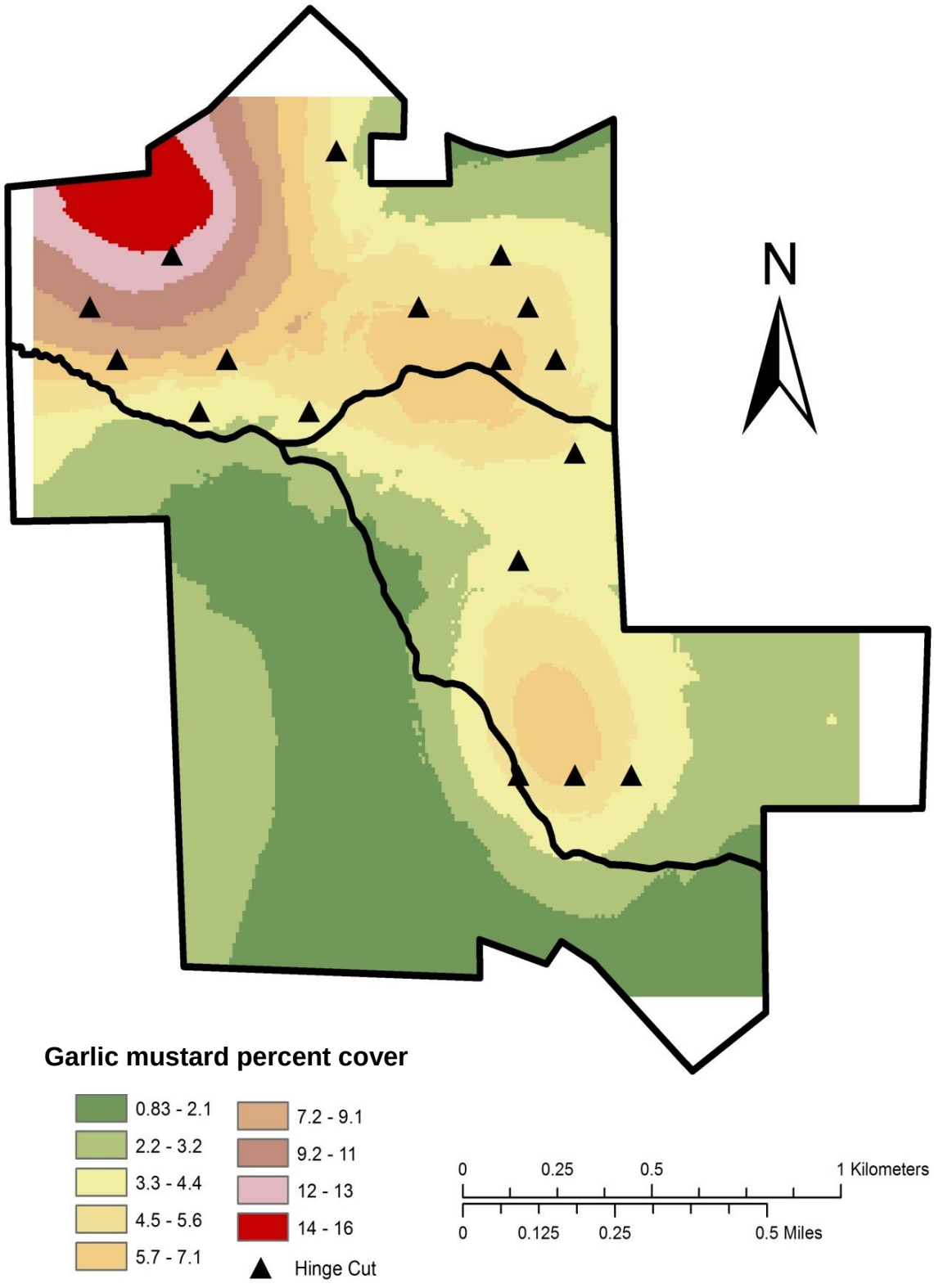


Figure 27. Garlic mustard percent cover on the Grunow property (815 acres). Garlic mustard appears to be more abundant where considerable hinge-cutting has taken place.

Honeysuckle

Honeysuckle is a deciduous shrub that has adapted to a variety of landscapes, allowing it to be a very successful competitor. Honeysuckle produces fruits that are easily dispersed by birds and other animals. It is most abundant in the black walnut cover type.

Photo 2. Honeysuckle. Leslie J. Mehrhoff, University of Connecticut, Bugwood.org

Multiflora Rose

Photo 3. Multiflora Rose. James H. Miller, USDA Forest Service, Bugwood.org

Multiflora rose is a perennial shrub that can be found in prairies, savannas, open woods, and forest edges (Carroll and White, 1997). Birds and other animals often disperse the seeds, which makes control measures difficult. Multiflora rose is the second-most abundant invasive species observed and is most prevalent in the sugar maple/basswood cover type.

Queen Anne's Lace

Queen Anne's lace is a biennial herbaceous plant that is a known invader of dry prairies, abandoned fields, and roadsides (Minnesota Department of Natural Resources 2013).

Photo 4. Queen Anne's lace. Chris Evans, Illinois Wildlife Action Plan, Bugwood.org

Wildlife and Wildlife Resources

The following section describes wildlife species that are or potentially could be present on the property. The resources available to these wildlife species are also discussed.

White-taileded Deer

One of the most important mammal species in southern Wisconsin is the white-tailed deer. Over the last few decades, whitetail deer populations in southern Wisconsin have increased above the goals set by the Wisconsin Department of Natural Resources (WNDR) goal. The 2011 WDNR goal for Unit 75C, which includes the Grunow Property, is 25 deer per square mile (WDNR 2012). Based on trail camera data, deer population estimates are approximately 53 deer per square mile on the property, over 200 percent above the WDNR goal. High populations of white-tailed deer have profound impacts on the forest flora. Heavy browsing by deer in all seasons leads to regeneration failure of desired trees and extirpation of ground flora.

Long-term effects of high deer densities include reduced timber productivity and altered plant and animal communities due to reduced stratification of vegetation. High populations of deer may also increase the chance of spreading chronic wasting disease (CWD). Iowa County has the highest occurrence of CWD in the state of Wisconsin. Confirmed cases have been documented near the Grunow Property. Spread of the disease can be aided by standing water, which was noted on the property. See Appendix IV for a map of CWD in Wisconsin. Another disease important to recognize is the bluetongue virus, which causes high mortality rates in deer. This virus is present in Iowa County and has potential to severely diminish local populations of deer.

Photo 5. White-tail deer. USDA FS, Southern Research Station, Bugwood.org

Wild Turkey

Photo 6. Wild turkey, Gary M. Stolz, USFWS Bugwood.org

Wild turkey populations in Wisconsin have risen significantly over the last few decades. The WDNR considers the restoration of viable populations to be one of the state's greatest wildlife management success stories. As recently as 1970, wild turkey populations were nearly absent from the state. Ideal habitat for this species includes established mixed hardwood or conifer-hardwood stands with scattered openings such as prairie, agriculture, and pasture. Tree species favorable to turkey habitat include cherry, red oak, and hickory for the shelter and food resources each provides (VA Department of Game and Inland Fisheries).

Ruffed Grouse

Ruffed Grouse are associated with deciduous hardwood forests, especially in stands dominated by aspen (Svoboda and Gullion 1972). In colder climates, winter diets consist of buds and catkins of hardwood shrubs and trees. The staminate flower buds of aspens, especially quaking aspen, are the critical winter food resource, with one mature aspen providing as much as eight to nine days of food for one grouse (Cade and Sousa 1985). Nesting females feed extensively on emerging aspen leaves and prefer to locate their nests close to mature aspens (Cade and Sousa 1985).

Photo 7. Male ruffed grouse. USDA FS Southern Research Station Archive, USDA Forest Service, SRS, Bugwood.org

Woodcock

Photo 8. Adult Woodcock. Ricky Layson, Ricky Layson Photography, Bugwood.org

Woodcock prefer intermediate hardwood forests, especially those with aspen or alder, or mixed hardwood and conifer forests (Cade 1985). Diurnal cover preferred by woodcock on breeding and winter range includes a wide array of structural types, with very open or very dense habitats least preferred or unused. Dense stands inhibit woodcock flight and increase predation potential. Very open habitats may not provide adequate concealment for woodcock (Cade 1985). Shrub and tree density affect soil characteristics that determine the abundance of earthworms, which are the main food source for woodcock.

Bobolink

Photo 9. Bobolink. Gerrit Vyn, Gerritvynphoto.com

The bobolink is a grassland bird typically found in native grasslands, hay fields, lightly grazed pastures, and wet meadows (Derchant et al. 2003). Bobolinks prefer hay fields with a high grass-to-forb ratio, which are beneficial for nesting cover. Bobolink abundance is negatively affected by bare ground and plant communities, dominated solely by native grass. Higher amounts of litter and vegetation density are beneficial to species success (Derchant et al. 2003). Bobolink abundance in Wisconsin is highest in cool-season grasses, followed by wet pastures, bluegrass communities, alfalfa/grass hayfield vegetation, and high litter cover (Derchant et al. 2003).

Pileated Woodpecker

Photo 10. Adult pileated woodpeckers. Johnny N. Dell, Bugwood.org

The pileated woodpecker inhabits both coniferous and deciduous forests, but is restricted to areas containing mature, dense, and productive stands. The pileated woodpecker is a key indicator species for the retention of a complete community of cavity nesting birds (McClelland 1979), and if the habitat needs of the pileated woodpecker are met, other woodpeckers also benefit (Schroeder 1983). The critical components of pileated woodpecker habitat are large snags, large trees, diseased trees, dense forest stands, and high snag densities. Snags are defined as standing dead trees that provide wildlife habitat. Pileated woodpecker diet consists mainly of carpenter ants and wood boring insects. A variety of other animals such as birds, snakes, and bats use abandoned woodpecker cavities for various purposes.

Red-headed Woodpecker

Red-headed woodpecker populations have historically fluctuated from abundant to the verge of extinction, but are showing overall trends of decline throughout their range (Smith et al. 2000, Sauer et al. 2011). Red-headed woodpecker conservation in Wisconsin requires protecting oak savanna, other oak-dominated woodlands, and floodplain forest. Suitable breeding habitat has large snags (ten-inch DBH) and/or a high density of dead limbs on the nest tree and within its surroundings, especially low limbs that are within 32 feet of the ground. Nesting suitability increases when these habitat resources occur in clusters rather than in a scattered distribution. In Wisconsin, the red-headed woodpecker is listed as rare or uncommon for its breeding range.

Photo 11. Male red-headed woodpecker. Photo by Dave Menke, U.S. Fish and Wildlife Service.

Snags

Overall, the forested area has 22 snags per acre greater than four inches in DBH (Figure 28). Snag abundance is uniform across each cover type average 23 snags per acre (Figure 28). There are currently five snags per acre with a DBH of ten inches and greater over the entire property (Figure 28). These larger snag trees create great habitat for birds and other wildlife. Different wildlife species take advantage of different parts of the snag, increasing overall biodiversity. Woodpeckers, ducks, owls, chickadees, wrens, bats, chipmunks, squirrels, and frogs are just some of the types of animals that utilize snags in Wisconsin.

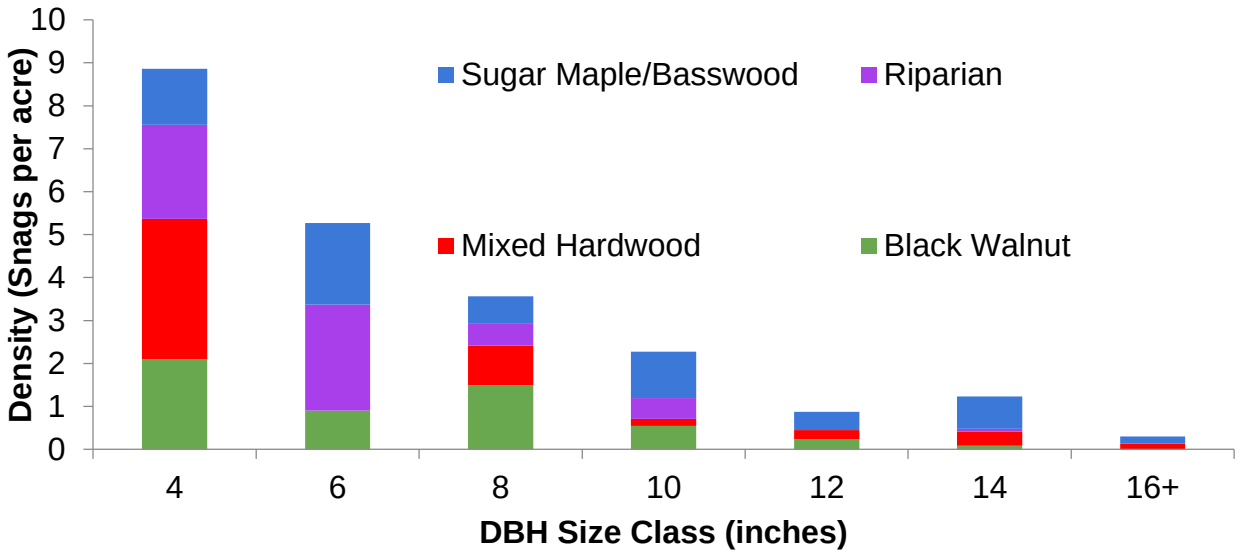


Figure 28. Snag density (snags per acre) by cover type in two-inch DBH size classes for the forested area.

Coarse Woody Debris

Coarse woody debris is a measure of dead woody material on the ground. The accumulation of coarse woody debris can be caused by diseases, insects, fires, storms, wind, natural tree mortality, or anthropogenic causes. For each cover type, coarse woody debris was measured and totals were calculated as cubic feet per acre and total cubic feet. Table 2 shows total volume for each decay class and average volume for each cover type. Most dead woody material on the property is highly decayed. The oak savanna and mixed hard-wood cover types show the largest coarse woody debris volume per acre, while black walnut shows the least. Oak savanna coarse woody material may be overestimated because of a possible outlier within the plot sampling areas.

Photo 12. Coarse woody debris on Grunow Property. Photo by Aaron Streicher.

Table 2. Total coarse woody debris volume for each decay class (1 being recently dead and 5 being very decayed); Average coarse woody debris volume for each cover type within the Grunow Property.

Coarse Woody Debris					
Decay Class	1	2	3	4	5
CWD Volume (Total CuFt)	1,952	5,174	12,812	9,777	6,382
Cover Type	Black Walnut	Sugar Maple/Basswood	Mixed Hardwood	Oak Savanna	Riparian
Average CWD Volume (CuFt/acre)	159.0	271.0	369.6	435.5	298.1

Management Opportunities

This section outlines opportunities for management of the property. These opportunities range from no activity to intensive activity. In this study we considered no management, timber stand improvement, harvesting options, and restoration opportunities.

No Management

Although results from our data point to many opportunities for economically sustainable natural resource management, we considered no active management as a baseline that all other management scenarios can be compared against to assess trade-offs. The absence of forest management and restoration is not necessarily the cheapest alternative, but may minimize stream sedimentation while continuing to provide habitat for wildlife species currently inhabiting the property. However, no management might not resolve current soil erosion, and also misses the opportunity to enhance habitat for more early successional wildlife species. Even though no management avoids the impacts of multiple harvest entries on soil erosion, it does not address forest soil erosion that is currently taking place in dry washes. This erosion is compounded by steep topography and a sparse litter layer throughout much of the property. Without management, we might expect this current erosion to worsen. Under this scenario, we also estimated the continued growth of timber volume for the Grunow property.

No management may be a viable option for maintaining stream quality. Since Harker Creek has self-sustaining populations of native brook trout, the current management regime is likely to continue to favor the brook trout. In contrast, eroded soil from harvesting operations has the potential to adversely affect these populations as the result of increased stream turbidity. This is because higher stream turbidity makes foraging much more difficult for species like brook trout, which rely heavily on vision for seeking out prey (Sweka & Hartman, 2001). Keeping the stream clear should help maintain healthy brook trout populations.

According to our empirical growth model used to estimate future timber volume, trees on the Grunow property will increase in volume even without periodic harvesting. Figure 29 summarizes the projected merchantable volume increase across the entire property if no active management takes place. Sawtimber volume is projected to increase by 3,700 board feet per acre during the next 20 years. Sugar maple is projected to add 1,600 board feet per acre, and black walnut is estimated to add 1,000 board feet per acre. The model we used to project growth used a constant mortality coefficient and does not take into account canopy competition among neighboring trees. Therefore, it is possible stand volume growth may be slightly over-estimated. Allowing trees to reach biological maturity and succumbing to natural forms of mortality may allow natural succession to occur and move the property towards an old-growth forest structure. This may be an aesthetically pleasing option, and serve as a scenario to attain larger trees. However, there are inherent risks involved with growing larger trees such as mortality from diseases, insect outbreaks, and windthrow. Moreover, the diverse array of stand types on the property would likely decrease in acreage as they become outcompeted by more shade-tolerant tree species. This may inevitably increase the proportion of the

sugar maple/basswood cover type, as these are some of the dominant shade-tolerant trees on the property. This will cause most other shade-intolerant and mid-tolerant tree species such as oak, ash, aspen, walnut, hickory and black cherry to diminish over time. Oak and hickories will continue to persist on drier ridge tops and nutrient-poor areas where sugar maple and basswood cannot survive. However, an overall decrease in tree biodiversity in the long-run could be expected without active forest management.

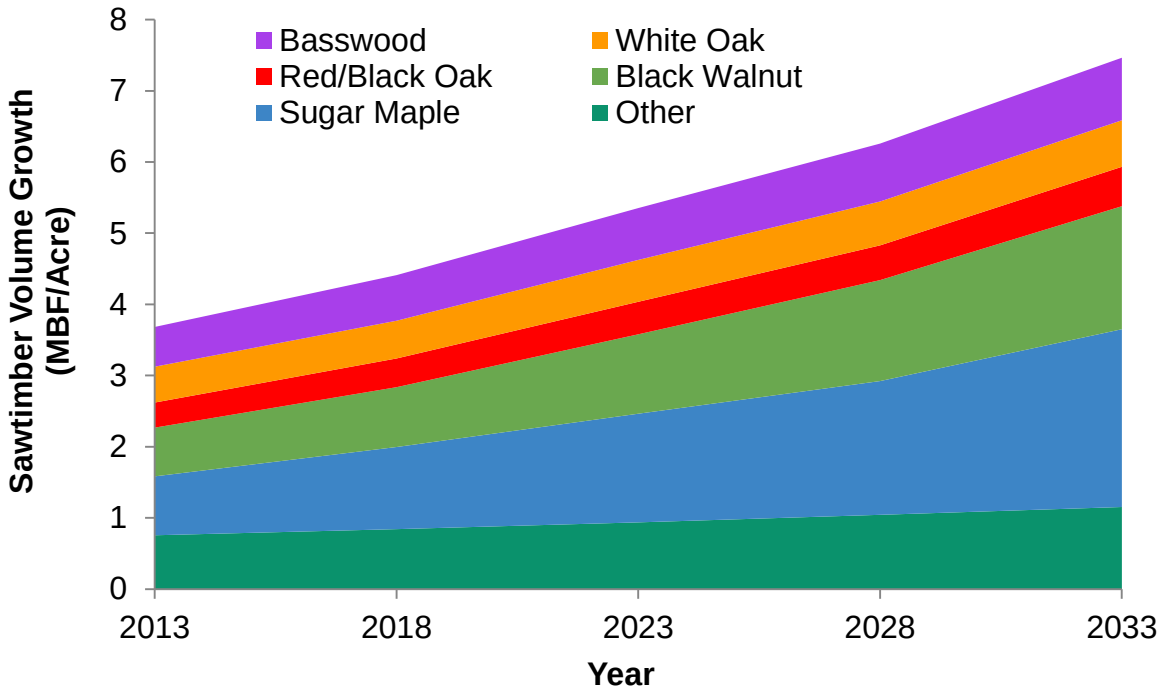


Figure 29. Predicted sawtimber volume growth for the entire property under a no active management scenario over a 20 year period. Volumes of the dominant species are presented in thousand board feet (MBF) per acre. Other species include aspen, bur oak, black ash, black cherry, American elm, hickory and green/white ash.

With a more mature-looking forest structure, early successional species will be the most adversely impacted. Without the creation of gaps in the forest, the opportunity to maintain or increase habitat for early successional forest species like ruffed grouse, pheasant, and various migratory songbirds will not be attained. These species rely on the habitat and cover provided by younger forests and higher quality forage and food sources that are characteristic of early successional habitat. On the other hand, the predominance of mature forests may be beneficial to many other wildlife species. According to the Minnesota DNR (2013), snags found in mature forests provide habitat for more than 40 species of birds and mammals. Additionally, the accumulation of coarse woody debris creates shelter for herptiles and small mammals. An abundance of older trees on the property may also serve as suitable nesting trees for many different species of raptors such as hawks, owls, and the possible bald eagle(s) inhabiting the forest.

Timber Stand Improvement

Timber stand improvement (TSI) involves enhancing the stand by improving species composition, growth rate of remaining trees, structure, tree form, and invasive species removal. Some TSI projects have already been completed on the property, which have mostly involved hinge cuts. Typical TSI projects may involve identifying trees of greatest potential economic value (crop trees) and freeing these trees from competition.

TSI can be done through various methods such as herbicide treatments, and felling or girdling trees. The use of basal bark herbicide treatments, such as Garlon (triclopyr), to kill poorly formed trees and eliminate undesirable species is the most cost effective way to quickly remove undesirable species. This practice may leave a number of standing snags that will improve wildlife habitat without competing for light, nutrients, and water with crop trees. Girdling is another effective way of quickly eliminating undesirable species. This process involves removing the bark of a tree in a band around the trunk either manually or with the use of a chainsaw. The saw should not cut into the tree too deeply, but rather just enough to penetrate the bark and the cambium, which is typically within a half inch of the bark. Felling of trees may also be used to achieve TSI goals. These trees provide opportunities for revenue from firewood sales. The landowner may desire removal of slash after TSI activities are completed. Scattering of slash is typically the most cost effective; however, if complete removal is desired then piling slash and burning can be another option. A landowner may also prefer to leave these piles on site. Piles provide excellent habitat for a number of small mammals such as coyotes, foxes, and rabbits.

TSI projects on the Grunow property should remove/kill elm and ironwood trees because they are not desirable sawtimber species. Targeting poorly formed, smaller diameter trees throughout the forest can increase the quality of nearby crop trees. Excessive thinning, however, may increase epicormic sprouts on the trunk which will reduce timber value. Trees that show fungal growth on the trunk are good indicators of wood decay. These trees should also be removed with TSI practices. Crooked trees as well as trees with burn scars and low forks are also good candidates for removal.

Scouting the black walnut plantations during TSI activities may also promote the growth of black walnut crop trees. The tree defects described above should be used as a proxy for selecting trees for removal in the black walnut cover type. Additionally, black walnut trees are very economically valuable, so larger trees removed during TSI may still be valuable enough to sell for a profit.

Cover Type Management

Sugar Maple/Basswood

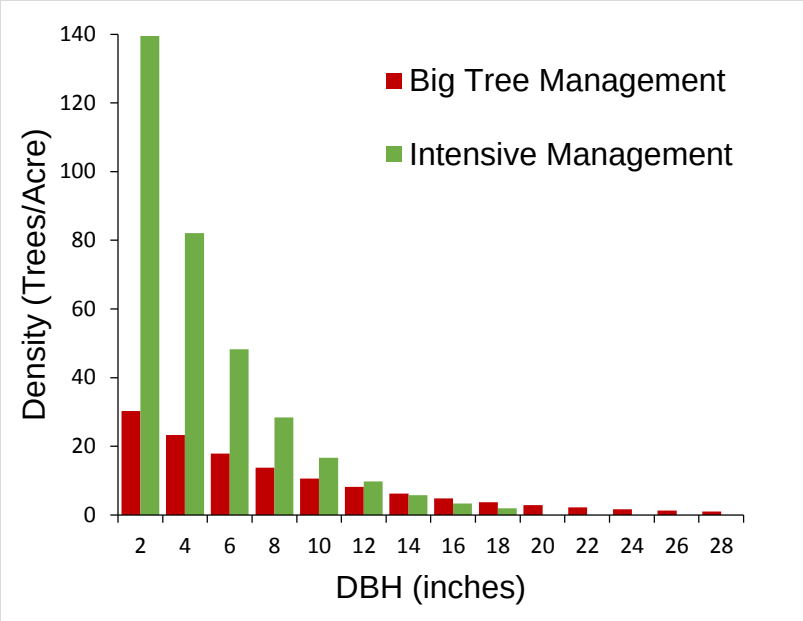


Figure 30. Comparison of target residual DBH distributions under big tree and intensive management scenarios.

A top management priority is maintaining adequate growth form and sustainable timber production throughout the maple/basswood cover type. Silvicultural prescriptions utilizing uneven-aged management will best achieve these goals. Timber stratified across several DBH classes will be harvested to create a mosaic of differing size and age classes to promote diversity in the cover type. No DBH class will be void of trees. This approach could be attained using two different harvest regimes. One approach mimics an old growth structure and keeps larger trees on the landscape. This approach would cut all trees greater than 28 inches DBH to "capture" any mortality of large old trees (Figure 30). It will maintain a few large trees per acre greater than 20 inches in DBH. Another approach follows an intensive cutting regime in which all trees greater than 18 inches DBH are harvested (Figure 30). This results in a greater volume being harvested in the first cutting, and a greater distribution of trees in smaller size classes. Trees will be harvested with single-tree and group-selection methods, with individual trees and small groups of trees dispersed throughout the stand. Single-tree selection should allow for superior sugar maple regeneration, while group-selection with openings up to a quarter of an acre in size may allow some mid-tolerant species such black cherry to maintain a presence in the stand.

Mixed Hardwood

The mixed hardwood cover type will follow an uneven-aged management scenario similar to the sugar maple/basswood cover type, but will favor more quarter-acre openings and maintain a higher diversity of hardwood species. At least three openings per twenty acres will be cut to allow enough light to increase the likelihood of successful oak regeneration. To ensure that oak and other hardwood regeneration will succeed in colonizing gaps, group openings should be fenced. We recommend installation of a seven-foot polypropylene fence around the opening perimeters to exclude deer and protect healthy seedlings. Fencing will require either utilizing small and low quality trees around the edges of the opening, or installing metal t-posts every ten feet. Appropriate

fencing can be purchased from Agriculture Solutions[1] and ten-foot fence posts from Deer Busters[2]. This will cost approximately a maximum of $16.58 per ten feet of fencing, ignoring installation costs. Thus, it will cost about $613 to fence one quarter-acre circular group-selection opening, excluding labor costs. For openings with enough low quality and small trees present to remove the need for t-posts, costs could be as low as $60 per quarter-acre opening. Maintenance of the fencing will be required periodically, incurring additional cost. Once oak and other regeneration exceeds the deer browse line, approximately five feet in height, the fencing can be re-utilized for another opening.

Small clusters of aspen interspersed throughout the mixed hardwood cover type provide an opportunity for aspen management. Patch-cutting these areas in one-acre openings will allow the aspen to root sucker and increase the cover type diversity while creating habitat for grouse and other early successional wildlife species.

Riparian

Riparian management will also consist of uneven-aged silviculture. WDNR best management practices require a 100-foot buffer along trout streams. Other requirements for the riparian management zone include: leaving fine woody material within 50 feet of the stream, only operating with wheeled and tracked equipment within 50 feet of the stream when the ground is frozen, and leaving a basal area of at least 60 square feet per acre after harvest. A second option is to not harvest trees in the riparian forest and allow for natural mortality and regeneration to occur. No harvesting will result in the least erosion, but severely reduce the amount of volume that can be extracted. When harvesting in the riparian cover type, it is recommended that trees be felled manually with skidding concentrated to areas where erosion will be limited. The best practice for preventing compaction and erosion of soil in sensitive areas is to harvest during winter months, when the ground is frozen.

Black Walnut

Black walnut will be managed by a diameter-limit cut that harvests all trees over a specified DBH. Harvesting all trees over 18 inches in DBH is the recommended practice to maximize economic returns. At this size, trees have reached economic maturity. This means that the income gained from increased growth in other trees due to reduced competition, and interest earned from the sale, will be greater than the increase in value by letting the tree reach a larger size (Beyer 2013). Another option is to leave trees up to 28 inches in DBH in the black walnut cover type, since trees will continue to increase in value with size beyond 18 inches. However, the chance of damage to economically mature trees, reducing their value, makes this an economically risky practice.

Black Walnut Management

[1] http://www.agriculturesolutions.com/
[2] http://www.deerbusters.com/

Black walnut is interspersed throughout the various cover types, and 140 acres of black walnut cover type. These trees will be managed separately from the sugar maple/basswood, mixed hardwood, and riparian forest types. To coincide with the additional harvests, a diameter-limit cut removing all walnuts over 18 inches on the property will be conducted every five years. Periodic thinning will also take place to ensure that spacing and competition allow for maximum growth rate and desirable form. Estimated yields at five-year intervals are shown in Table 3. Figure 31 depicts the DBH distribution of black walnuts on the entire property after each harvest. The Figure indicates that there is an overall shift in black walnut density towards the larger size classes over time, and a deficiency in the smaller size classes. Planting in the black walnut cover type to coincide with harvests will keep this method of diameter limit cutting sustainable for the long term. In 2033 there is a substantial dip in the amount of volume in the greater than 18-inch trees, but projections past that year show that there is still an influx of trees into the 18-inch class. After the harvest in 2018 a slight dip can be seen in the number of trees in the 12-inch class (Figure 31). This most likely coincides with the low volume being harvested in 2033.

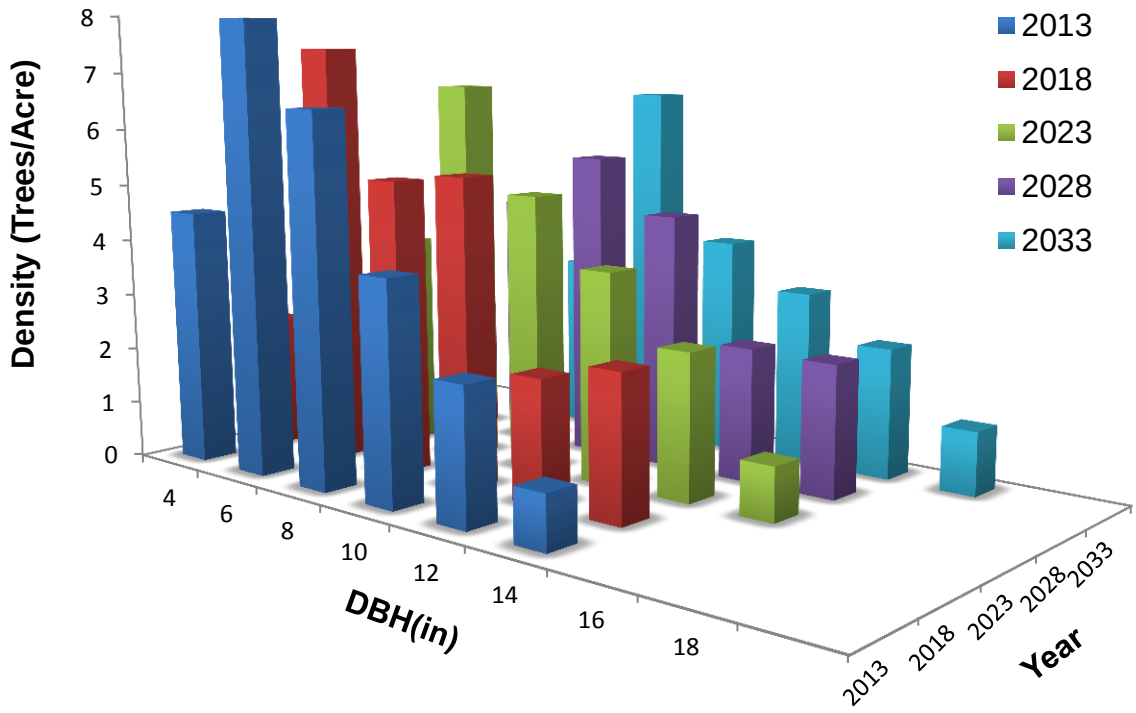


Figure 31. DBH distribution after black walnut harvesting at each five-year interval

Table 3. Estimated black walnut yield at five-year intervals, cutting all trees over

18 in. DBH. Stumpage rates obtained from Rockbridge Sawmill.

Black Walnut Management	2013	2018	2023	2028	2033
Estimated Number of Trees	560	230	340	430	150
Estimated Sawtimber (MBF)	110	40	47	77	18
Total Economic Return	$176,000	$64,000	$104,000	$121,600	$28,800

Harvest Options, Schedules, and Growth Projections

2018 Harvest Unit

Based on current tree density, stocking level, or optimal growing space, harvests are projected for the property at five-year intervals (Figure 33). Projected stocking levels indicate that a 157-acre tract in the northern portion of the property will be ready for harvest in 2018 (Figure 32). The harvest area will span multiple cover types: 62 acres of the harvest will cover sugar maple/basswood cover type, 67 acres will cover mixed hardwoods, and 28 acres will cover riparian cover type. Each of these areas will be harvested according to the guidelines outlined above. Under big-tree management, a maximum DBH of 28 inches will be allowed, and an estimated 183,000 board feet of sawtimber would be removed (Table 4). The post-harvest DBH distribution and allowable cut are shown in Figure 34, while projected sawtimber volume growth is shown in Figure 35. Under intensive management, all trees with a DBH greater than18 inches will be harvested, yielding an estimated 573,000 board feet of sawtimber (Table 4). The post-harvest DBH distribution and allowable cut are shown in Figure 34, and projected sawtimber volume growth is displayed in Figure 35. The target basal areas are 60 square feet per acre under intensive management, and 70 square feet per acre under big tree management. This is based on the USDA Forest Service stocking chart for northern hardwoods. The stocking chart and estimated stocking levels following the harvest can be found in Appendix VII.

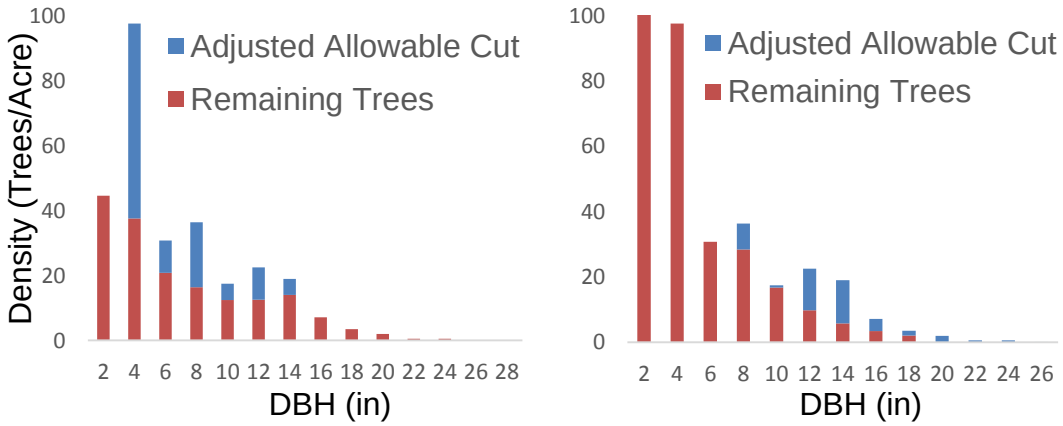


Figure 34. 2018 harvest unit post-harvest DBH distribution and allowable cut in each diameter class for big-tree management (left) and intensive management (right).

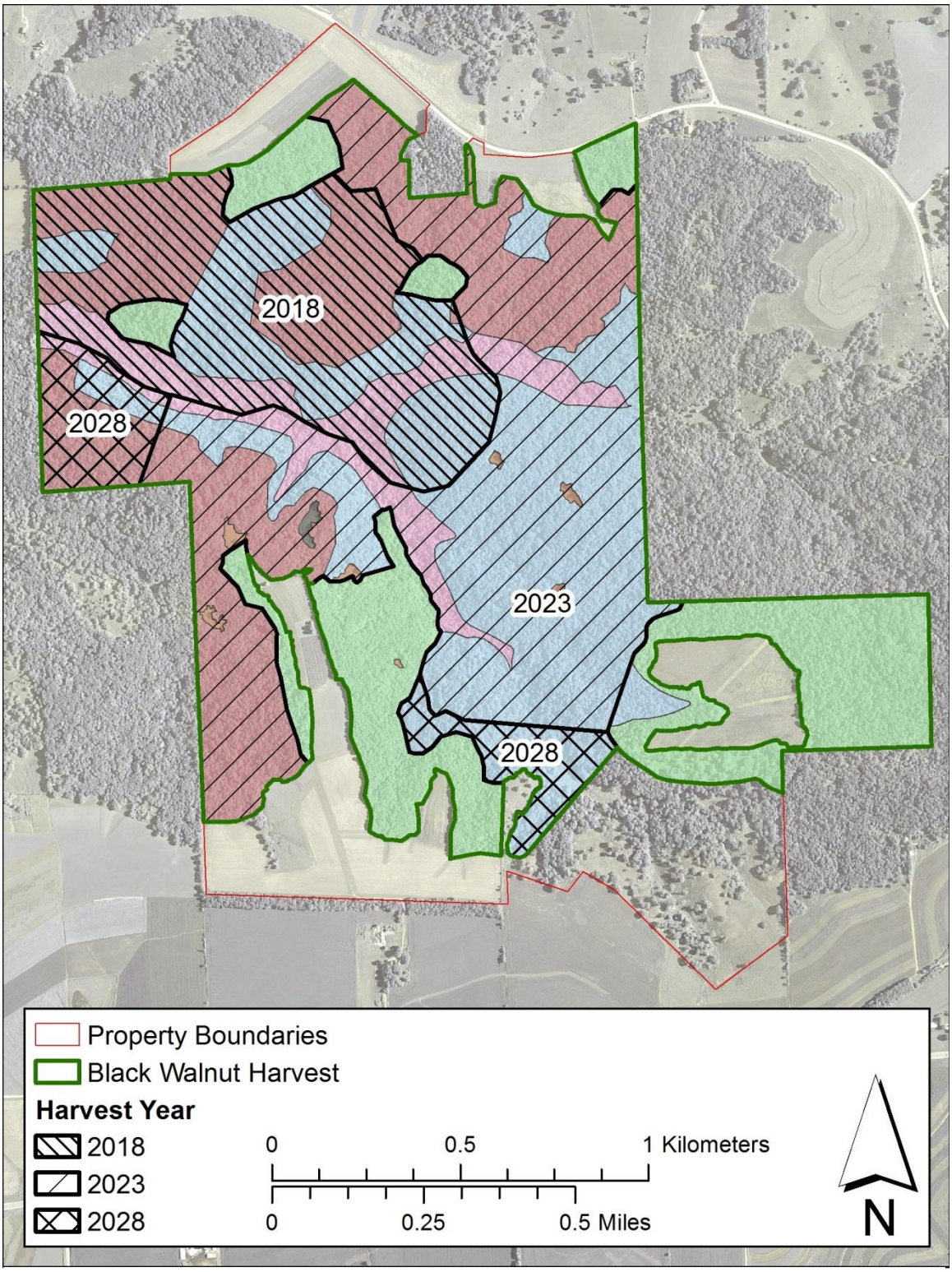


Figure 32. Harvest area map for the proposed 2018, 2023, and 2028 selection harvests.

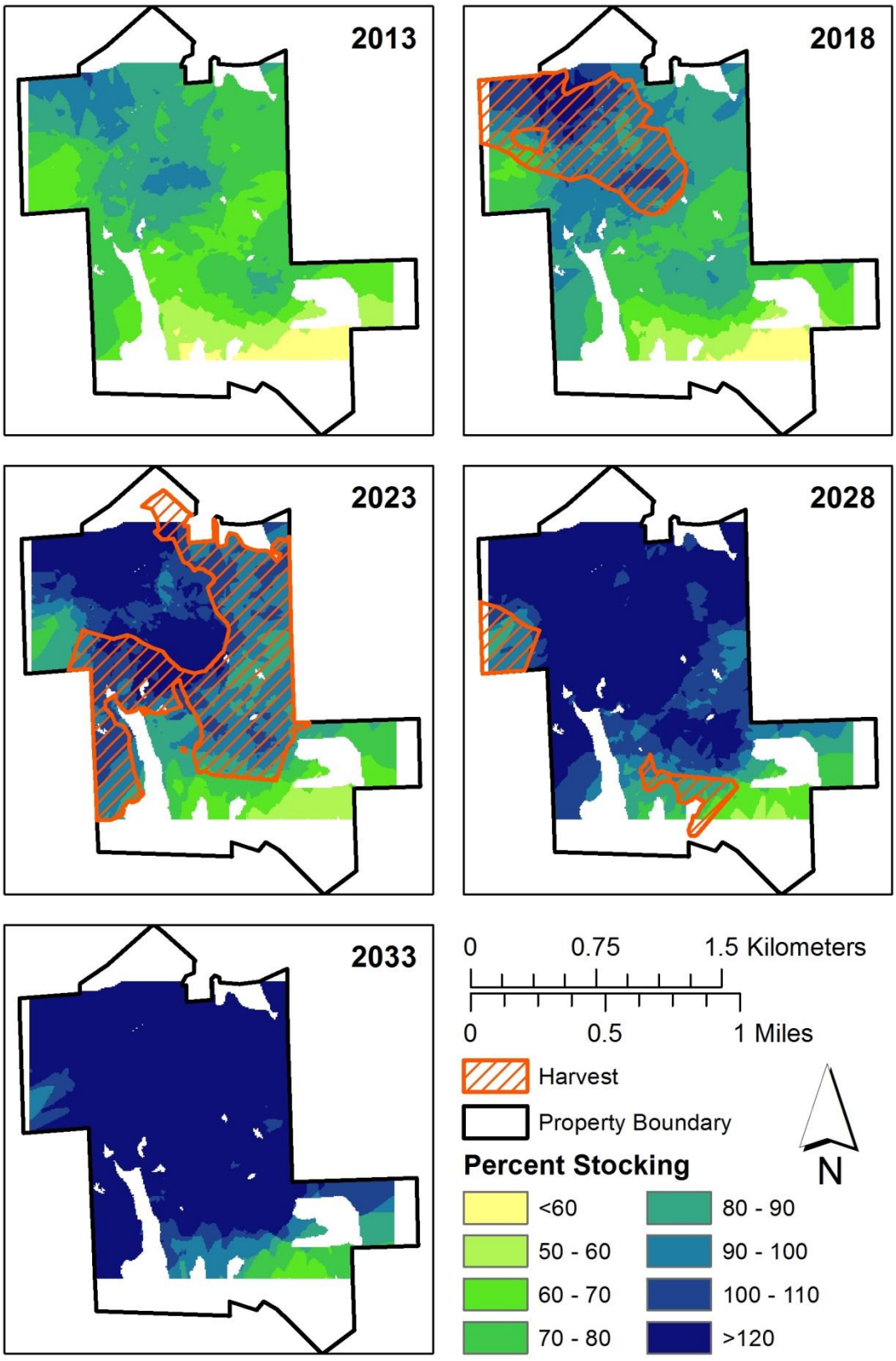


Figure 33. Projected stocking levels at five-year intervals from 2013 to 2033, with recommended harvest units.

Table 4. 2018 harvest unit sawtimber volume per acre and value per acre by species. Stumpage rates found in Appendix VIII.

Species	Volume (BDFT)		Value	
	Big Tree Management	Intensive Management	Big Tree Management	Intensive Management
American Elm	106	247	$11	$25
Black Cherry	21	43	$9	$11
Basswood	139	325	$60	$520
Red Maple	0	12	$0	$4
Red Oak	61	289	$27	$126
Hickory	66	188	$23	$54
Sugar Maple	388	1040	$186	$499
White Ash	122	315	$30	$76
White Oak	246	549	$71	$175
Other	20	62	$5	$12
Totals	1,170	3,650	$421	$1,502

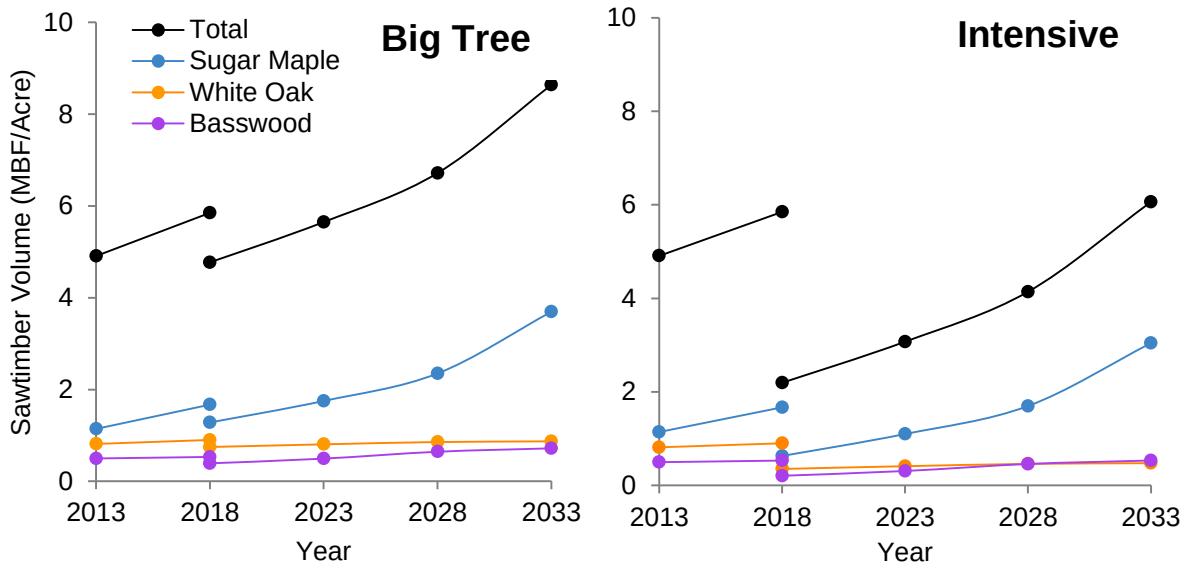


Figure 35. Comparison of predicted sawtimber volume growth for the 2018 harvest unit using big-tree (left) and intensive management (right). Sawtimber volume of the dominant timber species is given in thousands of board-feet per acre.

2023 Harvest Unit

A 282-acre portion of the property will reach adequate stocking for a harvest in 2023 (Figure 33). This harvest comprises the eastern portion of the property and reaches to the southwest corner of the property (Figure 32). The harvest will cover 138 acres of sugar maple/basswood, 115 acres of mixed hardwood, and 26 acres of riparian forest. The harvest will follow the same guidelines as the 2018 harvest unit for each cover type. Under the big-tree management scenario we estimate 659,000 board feet of sawtimber can be removed. Estimated yields are shown in Table 5. The DBH distribution following the harvest and allowable cut are shown in Figure 36, while projected sawtimber volume growth is shown in Figure 37 for this scenario. Under the intensive management scenario we estimate 1,087,000 board feet of sawtimber can be removed. Estimated yields are shown in Table 5, along with a value for each species. The DBH distribution following the harvest and allowable cut are shown in Figure 36, and projected sawtimber volume growth is displayed in Figure 37 for this scenario.

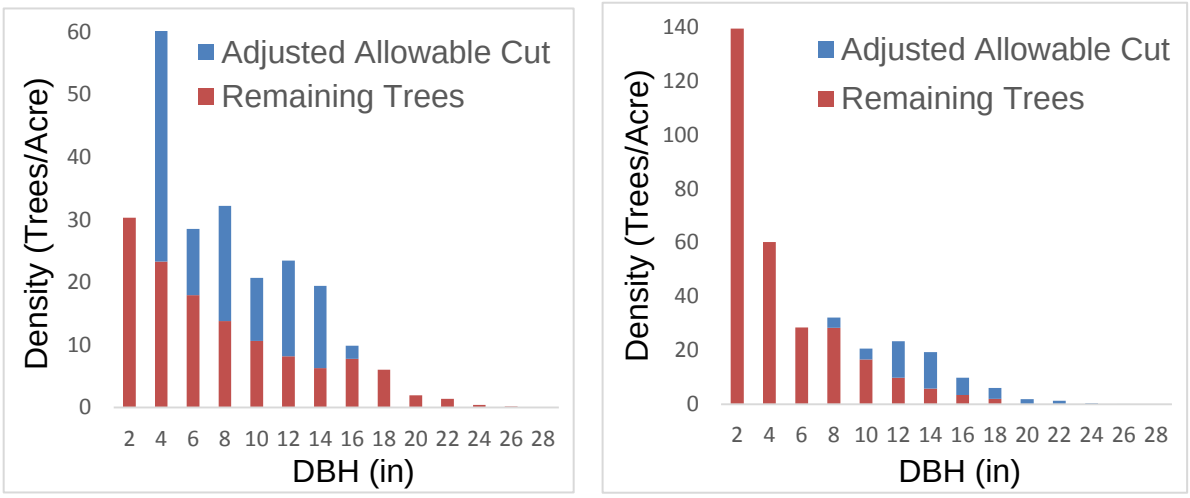


Figure 36. 2023 harvest unit post-harvest DBH distribution and allowable cut in each diameter class for big-tree management (left) and intensive management (right).

Table 5. 2023 harvest unit sawtimber volume per acre and value per acre by species. Stumpage rates found in Appendix VIII.

Species	Volume (BDFT)		Value	
	Big-Tree Management	Intensive Management	Big-Tree Management	Intensive Management
American Elm	20	40	$2	$4
Black Cherry	51	74	$21	$30
Basswood	527	744	$226	$319
Red Oak	130	446	$57	$195
Hickory	219	265	$76	$92
Sugar Maple	859	1436	$412	$689
White Ash	177	328	$44	$82
White Oak	247	391	$71	$113
Black Ash	55	60	$15	$16
Bur Oak	24	39	$8	$12
Other	14	16	$4	$4
Total	2,300	3,850	$935	$1,556

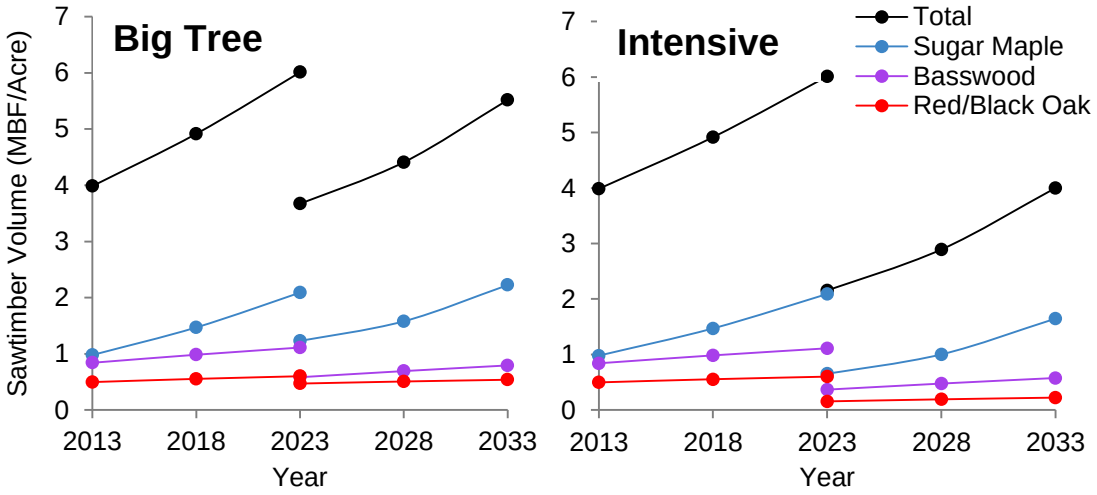


Figure 37. Comparison of projected sawtimber growth for the 2023 harvest unit under big-tree (left) and intensive management (right). Sawtimber of the dominant timber species is given in MBF per acre.

2028 Harvest Unit

An additional 47-acre portion of the property (Figure 33) will reach adequate stocking to support a harvest in 2028. The harvest will cover 25 acres of sugar maple/basswood, 19 acres of mixed hardwood, and 3 acres of riparian forest (Figure 32). The harvest will follow the same guidelines as the 2018 and 2023 harvest units for each cover type. Under the big-tree management scenario we estimate 170,000 board feet of sawtimber can be removed (Table 6). The DBH distribution following the harvest and allowable cut are shown in Figure 38, while projected sawtimber value growth is shown in Figure 39. Under the intensive management scenario, we estimate 283,000 board feet of sawtimber can be removed (Table 6). The DBH distribution following the harvest and allowable cut are shown in Figure 38, along with projected sawtimber volume growth in Figure 39.

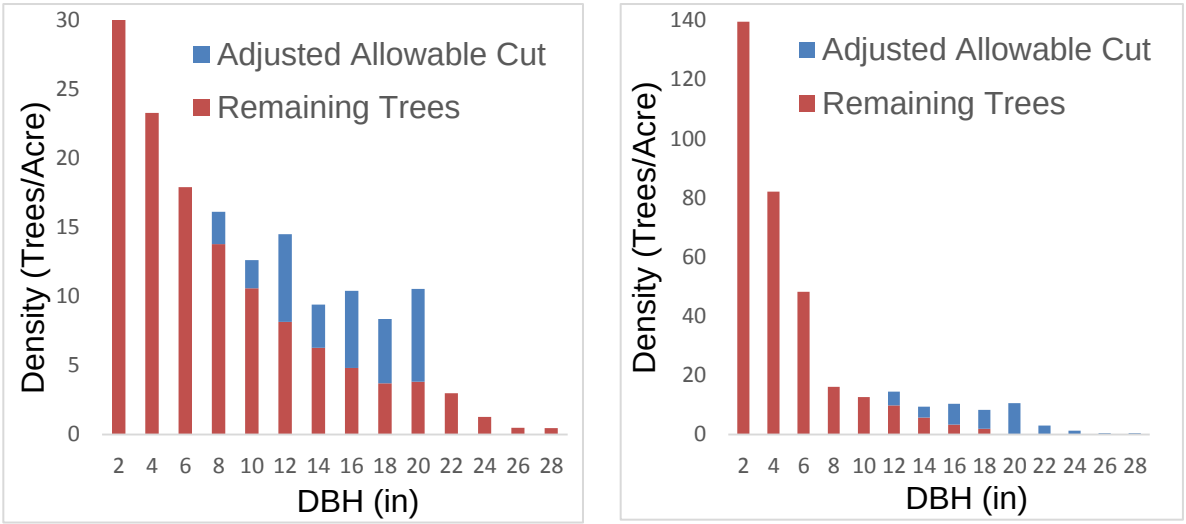


Figure 38. 2028 harvest unit post-harvest DBH distribution and allowable cut in each diameter class for big-tree (left) and intensive management (right).

Table 6. 2028 harvest unit sawtimber volume per acre and value per acre by species. Stumpage rates found in Appendix VIII.

Species	Volume (BDFT)		Value	
	Big-Tree Management	Intensive Management	Big-Tree Management	Intensive Management
Black Cherry	90	92	$37	$38
Basswood	517	945	$221	$404
Red Oak	785	1440	$343	$629
Sugar Maple	1915	3052	$919	$1,465
White Ash	81	83	$20	$21
White Oak	179	254	$52	$73
Total	3,600	5,970	$1,593	$2,631

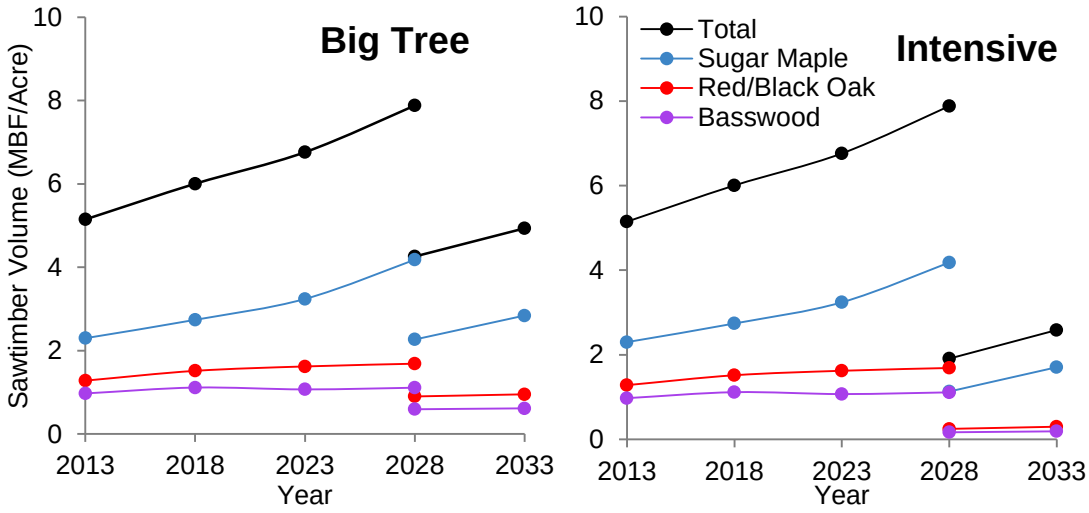


Figure 39. Comparison of predicted sawtimber volume growth for the 2028 harvest unit using big-tree (left) and intensive management (right). Sawtimber volume of the dominant timber species is given in thousands of board-feet per acre.

General Notes on Timber Harvesting

The exact dates of each harvest should be contingent upon current trends and stumpage prices of standing timber. The projections of future economic returns are based on current stumpage values (October 2013), and are subject to change. If economic trends indicate a future change it may be more economical to harvest a year earlier or later than the established date. To reduce the risk of spreading invasive species further throughout the property, harvesting should begin in the riparian area and work uphill toward the edges of the property. This should reduce the possibility of harvesting equipment carrying seed down to the riparian area where invasive species are not as prevalent. If possible, harvesting should be conducted in winter to further reduce the risk of spreading invasive species, reducing erosion and soil compaction. Winter harvesting will also reduce the risk of disease introduction. Oak wilt is not present on the property; however, oak wilt is present in Iowa County. There is a possibility of infection after a harvest resulting in substantial loss of oak, a major component of the property. The UW-Extension[3] provides guidelines for managing and preventing oak wilt.

Conservation Reserve Program

Areas currently enrolled in the Conservation Reserve Program (CRP), which aims to enhance ecosystem services on environmentally sensitive agricultural land (Appendix III), are well-established with indiangrass and big bluestem. These areas (Figure 40) are expected to stay in CRP through the duration of the current contracts because of the high costs associated with removing them from the program. Once the CRP contractual obligations are completed, this acreage could be used as additional forage land. Another option would be to leave the CRP grasses and to plant additional forb species after burns to enhance wildlife habitat, forage quantity, aesthetics, and increase overall biodiversity in these fields. The latter will provide additional wildlife refuge once the forage plantings are cut for hay.

Prescribed Fire

Prescribed fire in late spring favors warm-season grasses over cool-season grasses. Woody invasive species that threaten CRP fields include: multiflora rose, autumn/Russian olive, honeysuckle, prickly ash, and sumac. Prickly ash and sumac are not invasive species; however, all woody shrubs growing in CRP fields must be removed because of contractual obligations. Prescribed fire may weaken woody species CRP fields, but additional controls methods are generally required to kill woody shrubs. Another advantage of prescribed fire in prairie ecosystems is that bare soil becomes exposed afterwards. This bare soil creates an ideal opportunity for spreading additional forb seeds either by hand or with no-till drills. The estimated cost of preforming a prescribed fire in the CRP areas is $40 per acre.

[3] http://learningstore.uwex.edu/assets/pdfs/G3590.pdf

Herbicide Use

Herbicide use should be minimal in the CRP fields because they appear to be well established. If invasive plants become a problem, a selective herbicide such as Escort (metasulfuron) or 2,4-D (2,4-dichlorophenoxyacetic acid) should be used to kill broadleaf invasive plants without harming the abundant big bluestem and indiangrass. Areas that contain undesirable invasive grasses or forbs that are becoming established may need to be sprayed with an appropriate herbicide (selective or non-selective) depending on invasion.

Mowing

Mowing is not typically done in CRP fields because invasive prairie plants that should be controlled have usually set seed before contractual mowing restrictions end. Spot mowing can be done with a brush-cutter which is very effective at controlling parsnip, burdock, thistles, and spotted knapweed, provided they are cut at the soil surface during flowering.

Oak Savanna Restoration

The oak savanna in the southeast corner of the property (Figure 40) is a great opportunity for further restoration. This area already includes many species of native grasses and forbs. Big bluestem, indiangrass, little bluestem, sideoats grama, and switchgrass are all well established in the oak savanna. These native grasses have populated most of the south-facing slopes. Hand-collecting some of the savanna grass seed as well as collecting seed from CRP fields would be a great way to save some money and spread seed into new areas where native grasses are desired but not present. Some native forbs in the oak savanna include bergamot, purple hyssop, field mint, and aster.

Invasive species are the largest threat to the oak savanna and prairie ecosystems. The most prevalent invasive grasses and forbs include: smooth brome, wild parsnip, Canada thistle, garlic mustard, spotted knapweed, and burdock. Other common yet undesirable plants include: nettle, mullein, brambles, and Queen Anne’s lace. Invasive shrubs include prickly ash, honeysuckle, multi-flora rose, barberry, and autumn/Russian olive. Prickly ash is a native species to Wisconsin, but is often thought of as an invasive species due to its colony-forming habit and abundance of thorns. Smooth brome is a non-native, undesirable cool-season grass. Because smooth brome is a common grass throughout the savanna, eradication of brome may not be possible without killing all plants in the area with a non-selective herbicide.

Prescribed Fire

We recommend controlled burns in oak savanna to enhance restoration efforts. Prescribed fire could eradicate garlic mustard over time. Another benefit is that

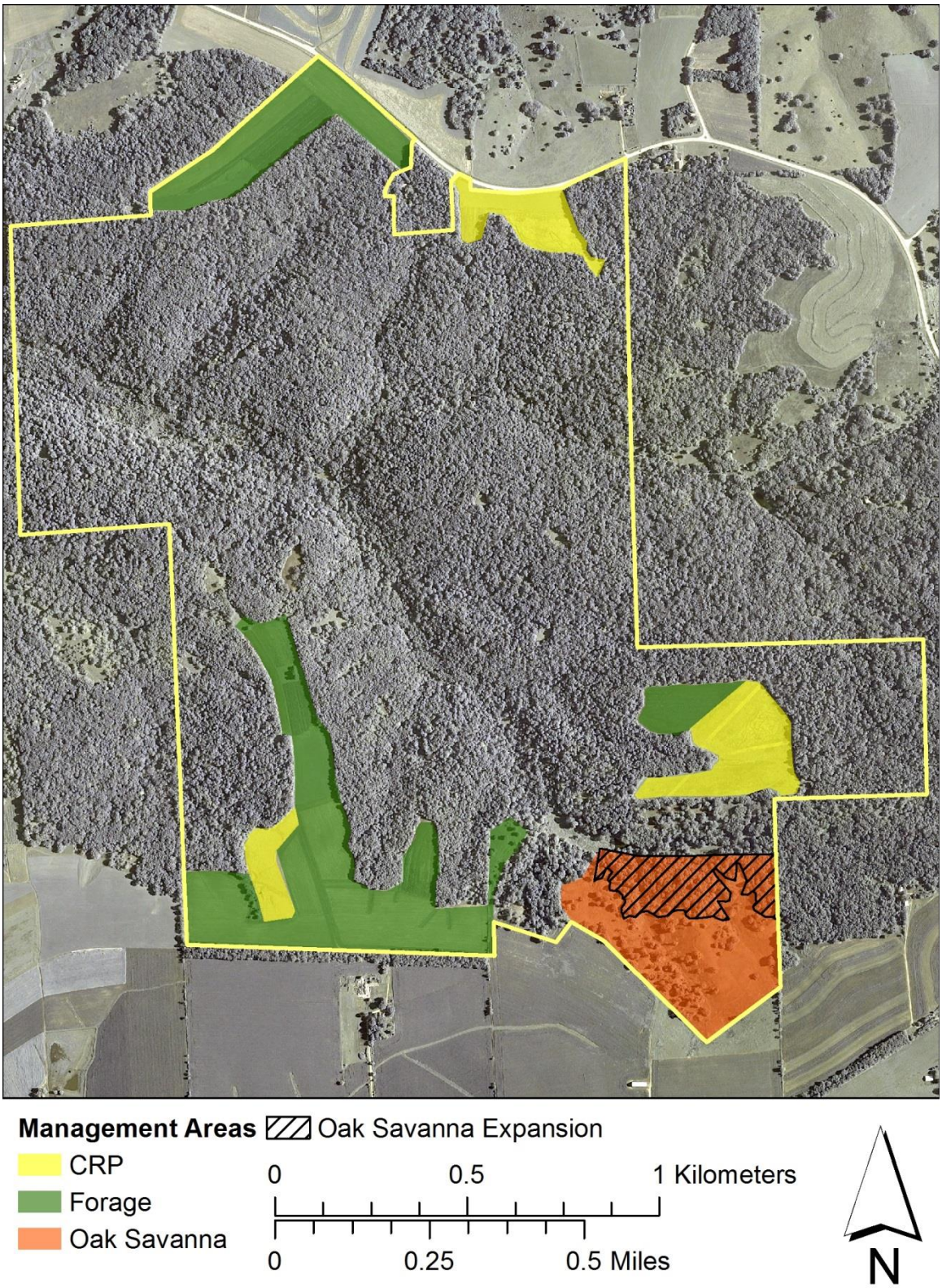


Figure 40. CRP, forage, and oak savanna management areas.

prescribed fires promote native grasses. Prescribed fire will also reduce invasive shrubs by top-killing them, however, most shrubs will resprout even after many years of burning. Many invasive shrubs do not produce seed in their first year of growth and thus prescribed fire may keep these plants from reseeding into the savanna or further invading the woodland. Prescribed fire may not set back all of the unwanted shrubs; however, some physical or chemical control may be necessary to completely eradicate these species.

Mowing

Unfortunately, some invasive plants will not be successfully controlled in the oak savanna with the use of prescribed fire. Invasive plant species that cannot be controlled with fire include: Canada thistle, wild parsnip, burdock (some control), and spotted knapweed (some control). In areas on flat ground, a brush mower may be used to control woody species. However, plants will vigorously resprout without chemically treating the stems afterward. Thistle, parsnip, and burdock may be controlled through a mowing regime that occurs pre-flowering and seed head production. Parsnip can be controlled successfully by brush cutting the stem as low to the ground as possible when the plant is flowering and beginning to set seed. Past control of parsnip was typically around the fourth of July, however, over the last few years flowering has occurred in early June. For this reason, diligent scouting is needed to correctly time mowing operations. It is important that parsnip is cut before any seed is viable. Thistle and burdock both resprout throughout the season and need to be mowed a few times over the course of the summer season. A tractor or plant puller may also be used to pull some invasive species such as honeysuckle, autumn olive, and Russian olive out of the ground. However, by pulling the plants out of the ground, exposed soil may provide an area for fresh seed to establish.

Herbicide Use

Myriad herbicides are available that selectively kill specific functional plant groups. Broadleaf herbicides, as the name implies only kill broadleaf forbs and do not harm grasses. Such herbicides are routinely referred to as 2-4 D (2,4-dichlorophenoxyacetic acid). Foliar sprays should be used in spring and early summers, before seed production and while the plants are actively growing. These sprays can be used when large areas of infestation are present for a relatively quick and easy control option. Cut stumps of woody invasive species will need to be chemically treated for best results, resulting in little to no resprouting. Round-up (Glyphosate) is one of the least expensive herbicides that can be used for cut stump treatments provided it is mixed to a proper concentration. A 20 percent active ingredient of Glyphosate solution is recommended (usually a 50-50 ratio if bought in concentrate). Glyphosate has also been found to be extremely effective on prickly ash stumps. Garlon 4 (triclopyr) remains the standard for cut stump treatments. It is especially useful during winter months because it is an oil-based herbicide and will not freeze. Garlon 4 is expensive, which is why Glyphosate is recommended for most applications. It is not recommended to use cut-stump treatments in spring because spring sap flow inhibits the uptake of chemicals.

Oak Savanna Expansion

The north-facing slope on the north side of the oak savanna could be expanded to Harker creek, which is an additional 15 acres. Historic vegetation maps of the Grunow property show that this area was formerly oak savanna. The Grunow property contains many savanna remnants from pre-settlement times. These oak savanna remnants are far less common today than in pre-settlement times, and thus restoration of this ecosystem is an opportunity for conservation. Specifically, the red-headed woodpecker may benefit from the additional habitat provided by the oak savanna expansion. Management of this area will be largely completed by harvesting all species that are not associated with oak savanna ecosystems. This includes harvesting black walnut, sugar maple, basswood, and some black cherry and hickory. The economic value of this one-time harvest is estimated in Table 7.

Table 7. Volume (MBF) and economic return on future Oak Savanna expansion.

Species	Volume	Value
Basswood	13	$5,545
Sugar Maple	8	$3,861
Ash	7	$1,745
Black Walnut	5	$8,611
Totals	33	$19,762

Oak Savanna Restoration

The total cost of restoring the oak savanna is estimated to be $8,408 in the first year (seeding, fire and other labor, Table 8 and 9). Seeding the 15 expanded acres of oak savanna is recommended. Species to consider for planting are little bluestem, sideoats grama and Virginia wild rye. Other species that could be planted are listed in Appendix IV. Seeding costs vary with species, but are only a one-time cost . The costs of savanna restoration are expected to diminish at year three. Beyond year three, occasional burning will account for most of the cost to sustain to oak savanna ecosystem. Each year afterward, the site will need to be monitored to determine additional restoration measures. The total cost includes labor, herbicide, and expected machinery needed to complete the restoration project.

Table 8. Cost of oak savanna restoration.

Task	Cost
Prescribed Fire	$ 2,000
Other Labor Cost	$4,150
Total Cost	$6,150

Table 9. Seeding cost in oak savanna expansion.

Species	Lbs per acre	Cost per Lb	Acres	Total seed price
Little bluestem	3.5	$15	15	$788
Sideoats grama	3.5	$18	15	$945
Virginia wild rye	3.5	$10	15	$525
Total				$2258

Forage Planting

Dr. Grunow currently leases his agriculture land (Figure 40) to a local farmer who grows row crops; however, row crops make the erosion-prone soil more susceptible to soil loss. By converting all agricultural fields from corn and soybean to native grasses for forage, revenue can be generated with the added benefit of reduced soil erosion. Other indirect benefits result from the conversion of row crops to forage, including water quality protection and biodiversity enhancement. From 1966 through 1993, grassland bird species have exhibited a greater decline in population compared with other bird species (Herkert 1995). Species such as woodcock, pheasant, bobolink and other grassland birds may benefit from forage plantings of indiangrass. Many more species that benefit from grassland habitat can be found through the United States Geological Survey (USGS) Northern Prairie Wildlife Research Center. There have been some attempts to reintroduce bobwhite quail in southern Wisconsin and these forage plantings may provide an opportunity for this activity if the landowner wishes to do so. Current income from crop rent is calculated for 77 acres at $300 per acre for a total income of around $23,000 per year. There will be an initial cost in establishing indiangrass along with a loss in rent from agricultural lands. Tables 10, 11, and 12 show the economic analysis behind this management opportunity.

Table 10. Cost associated with planting indiangrass as forage.

Seed (lbs/acre)	No-Till Drill ($10/acre)	Acres	Seed cost ($/lb)	Total cost($)
15	$833	83.3	$15	$19,576

Table 11. Cost associated with harvesting indiangrass as forage.

Cutting costs ($10/acre)	Raking costs ($15/acre)	Yield (tons/acre)	Total cost of bailing	Total expenses
$833	$1250	3	$9,371	$11,504

Table 12. Potential profit from harvesting indiangrass as forage.

Yield/year	Expenses/year	Profit/year
$52,479	$11,504	$41,025

The cost of planting indiangrass is expected to be around $19,580. This includes the price of indiangrass seed at $15 per pound, rental of a no-till drill, tractor rental and fuel. Fifteen pounds per acre is the recommended seeding for indiangrass based on information obtained from the State of Missouri agriculture extension office (Henning 1993). These costs do not include the equipment and time spent on planting. The minimum projected yield for indiangrass is three tons per acre, however, new cultivars exist that may increase this estimated yield. No profit will be realized for the first two years to ensure the indiangrass is well established. Furthermore, mowing is recommended multiple times during the first season at a height no lower than six inches to control weeds. This cost is expected to be around $100 per hour and is also not included in the calculations.

Most of the forage plantings will be a monoculture of indiangrass. Forbs should be excluded from forage areas, although they could be included as pollination buffers along the edge of the indiangrass fields to attract pollinators such as bees and butterflies.

Herbicide

The indiangrass forage field will require an annual broad-leaf emergent spray in each of the first two springs to control unwanted weeds. The family of selective herbicides that kill broadleaf plants and not grasses are recommended. Herbicides should be applied in late spring, generally at a rate of 1 to 1.5 quarts per acre; however, the rate of application depends on the label requirements of the specific brand of herbicide used. Ideally, a surfactant should be added to increase the effectiveness of the herbicide.

Fertilizer

Fertilizer can be added to the established indiangrass fields to maximize yields. A single application of 80 to 100 pounds per acre of nitrogen is recommended in late May, or after the warm-season grasses are actively growing. Before any fertilizer is added, a soil survey should be performed by a soil scientist to determine the chemical composition of the soil, which will determine the fertilizer requirements. At this time, the pH of the soil will also need to be measured to determine if the addition of lime is necessary. If the pH is below 6.0 liming should be considered before fertilizer applications. Timing of fertilizer applications should be done after grass has emerged and become established. Applying fertilizer prior to vigorous growth of indiangrass will only stimulate the growth of cool season grasses and weeds.

Economic Analysis

All economic returns are calculated as net present value. Net present value is used to account for interest rates and/or inflation. Based on recent observations, timber price increases seem to be keeping pace with the rate of inflation and loan interest rates. Therefore, net present values were assumed to be equivalent to potential future values. Economic returns for the intensive management scenario will generate more income and maintain a more uniform and younger forest characterized by less structural diversity. Big tree management will produce a more mature appearing forest that is characterized by a more diverse canopy structure. Both scenarios should be sustainable – in other words, another 15-year cutting cycle for the entire property can occur after the first three selection harvests. Table 13 summarizes the economic returns of all harvests from 2013 to 2028. Maps showing suggested harvest dates and areas as well as projected stocking levels over time are shown on Figures 32 and 33. Figures 41 and 42 depict economic returns from all income sources compared to returns under no management. The return from the current agricultural lease is deducted from forage to more accurately reflect net returns that will be achieved by the forage conversion. In addition, CRP is not included because CRP income is the same with or without active management. Over the 15-year period (2013 to 2028) the estimated annual average returns including all income sources are: $122,907 for intensive management with conversion from agricultural row crops to forage, $96,667 for big-tree management with prairie conversion to forage, and $23,200 for no management with only an agricultural lease.

Table 13. Comparison of net economic returns for all harvests from 2013 to 2028 for big-tree and intensive management. Stumpage rates found in Appendix VIII.

Big-Tree Management					
Year	2013	2018	2023	2028	Total
Selection Cutting (NPV)	$0	$66,100	$263,700	$74,900	$870,300
Black Walnut (NPV)	$176,000	$64,000	$104,000	$121,600	
Intensive Management					
Year	2013	2018	2023	2028	Total
Selection Cutting (NPV)	$0	$235,900	$438,800	$123,600	$1,263,900
Black Walnut (NPV)	$176,000	$64,000	$104,000	$121,600	

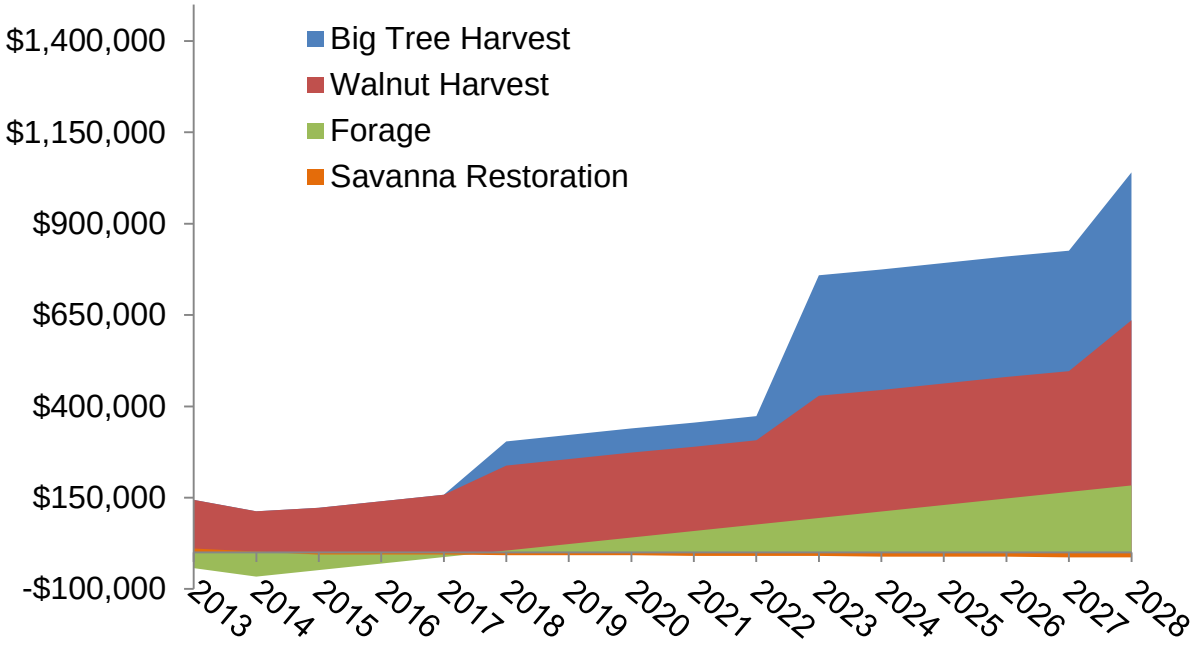


Figure 41. Difference between cumulative economic returns under big-tree management scenario and no management (agriculture lease and CRP only) from 2013 to 2028.

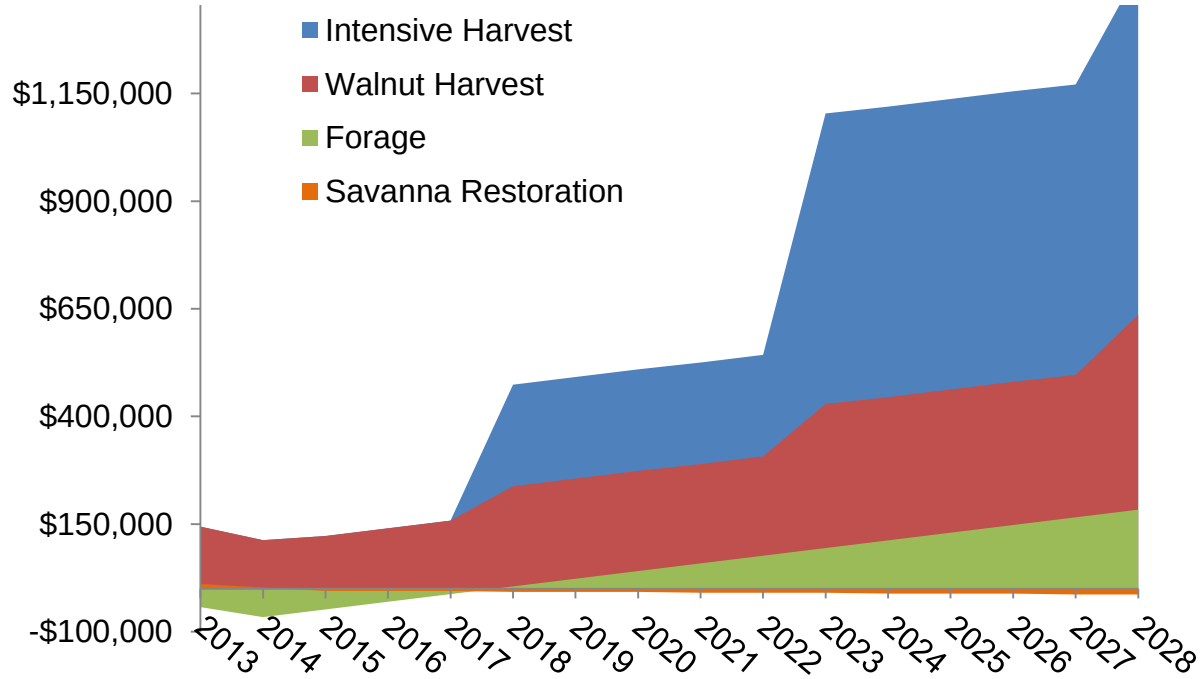


Figure 42. Difference between cumulative economic returns under the intensive harvest scenario and no management (agriculture lease and CRP only) from 2013 to 2028.

Other Restoration Opportunities

This section discusses various restoration options in the mixed hardwood, sugar maple/basswood and walnut cover types. Prescribed fire is only recommended for the mixed hardwood cover type, while herbicide use can be implemented across the three cover types.

Prescribed Fire

There are three areas in the mixed hardwood cover type where prescribed burning is potentially beneficial. The prescribed fire in the mixed hardwood cover type should favor regeneration of fire-tolerant tree species (i.e. oak and hickory) over fire-intolerant species (maple, ash, ironwood, etc.), promote grasses and sedges, and control garlic mustard. However, burning in the mixed hardwood cover type can lead to conversion to an even-aged stand.

As few as three to five consecutive years of prescribed fire could produce the desired results. Burning will release garlic mustard seeds, which is why consecutive fires are recommended (Czarpata 2005). Consecutive fires, however, may not be feasible with low fuel loads. For best results, the use of fire should be used when there are adequate fuel loads. Garlic mustard is a biennial plant that seeds in its second year and survives through winter in a rosette stage. By burning annually or biennially, garlic mustard may be effectively controlled with the use of fire. In order to use prescribed fire in the mixed hardwood burn units (Figure 43), burn breaks/trails will need to be constructed along the edges of the units. At minimum, burn breaks should be wide enough to accommodate all-terrain vehicle access. Existing trails can be used for these breaks where feasible. However, additional consideration will need to be taken to identify forest types inside the burn units that are not tolerant to fire. Furthermore, substantial preparation before the burn will need to be administered so that unintended damage to residual trees is minimized. Sugar maple, basswood, and walnut species should be raked (leaf blown) around before each fire, as these species are not tolerant of fire. For this reason it is not recommended to burn in the sugar maple/basswood and walnut cover type. In areas where substantial sugar maple regeneration is present and unwanted, prescribed fire may be a cost-effective option for control.

The cost of preparation work before a fire is not trivial (Table 14); however, good preparation work can reduce the costs of post fire mop-up. Mop-up, i.e., extinguishing burning and smoldering materials, is typically the most costly aspect of using prescribed fire in woodlands (included in fire cost in Table 14).

Table 14. Costs associated with performing prescribed fire in woodland areas.

Fire Cost /Acre	Preparation Cost/Acre	Total Cost/Acre
$40	$20	$60

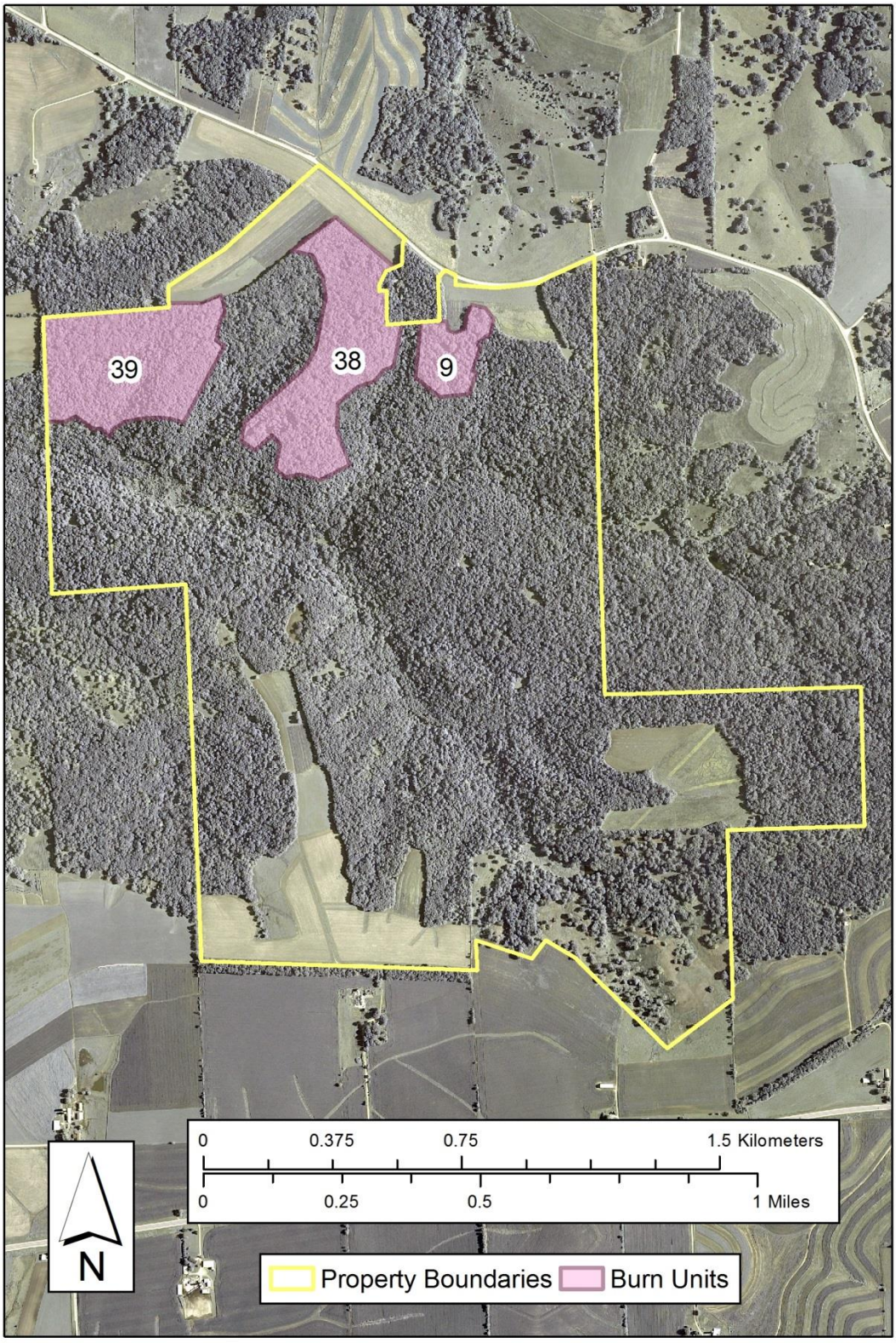


Figure 43. Proposed burn units (with acreages) in the mixed hardwood cover type.

Herbicide

Garlic mustard, multi-flora rose, and honeysuckle pose the greatest risk to the sugar maple/basswood, and black walnut stands. Garlic mustard is the number one concern for management in these ecosystems. Garlic mustard requires the continuous need for scouting and control. Typically, the most effective form of control is with the use of herbicides. Certain selective herbicides will have minimal damage to non-target plants. However, it should be noted that excessive spraying of large areas with these selective herbicides dramatically increases costs of chemical control. Glyphosate, one of the least expensive chemical options, can be used for foliar spraying of garlic mustard. However, Glyphosate is a non-selective herbicide and will damage or kill non-target plants in the spray zone.

Since garlic mustard was not detected in the riparian zone, preventing seed from entering this area is critical. If garlic mustard is found in the riparian zone near the water, special herbicides must be used to avoid water contamination. AquaNeat, a form of glyphosate which is safe for use near aquatic environments, is one option in these sensitive areas. Careful scouting will need to be undertaken to identify areas where garlic mustard is present. Scouting and control should start on the edge of the riparian zones and work up the hills. Special consideration should be paid to the drainage ravines around the property because seed that falls in the ravines is very mobile. All ravines should be scouted and control should be applied to any infestation in ravine areas all the way from the lowest elevation to the highest. As a general goal for garlic mustard, the property should be worked from the middle outward toward the edges. Big areas of infestation should also be recorded on a GPS device to allow for easy relocation and re-entry. In areas that are heavily infested it is practical to consider $1000 to $1200 per acre for complete control over time. Garlic mustard that is sparse will cost less, but these costs are variable depending on cover and ease of access.

Wildlife Management Opportunities

Estimates from trail camera show there are up to 53 deer per square mile on the property (Table 15). This deer population is two times greater than the DNR goal of 25 deer per square mile. Both deer and turkey seem to be abundant on the property, but there are areas for improvement with respect to other species. Managing wildlife and habitat go hand-in-hand. Vegetation management scenarios geared toward improving wildlife habitat include selection harvests, invasive plant treatments, and restoration opportunities.

The planting of indiangrass may benefit songbirds, while oak savanna restoration will benefit deer and turkey with acorn and bud food sources and desirable habitat. Oak savanna and floodplain forests aid in red-headed woodpecker conservation. The restoration of aspen cover types in some areas could greatly benefit ruffed grouse and white-tailed deer on the property, as well as other mammals and ground-nesting birds. Trees favorable for turkey include red oak, cherry, and hickory for food sources. In addition, selection cutting and thinning of stands can increase light in the understory, creating more vegetation and browse food sources. Leaving dead trees standing or low, dead limbs after harvest is valuable for wildlife as well, as species like the pileated and red-headed woodpecker are recommended to have six cavity trees per two acres (Smith et al. 2000).

Table 15. Deer population density, age, and sex ratio on the Grunow property estimated from game-camera monitoring data.

Grunow Property Deer Monitoring				
Population Density	53 Deer per square mile			
Sex Ratio	7 : 13 35% Male, 65% Female			
Male Buck Age	Fawn	1.5-2 years	2.5-3 years	3.5-4+ years
Male Buck Age (%)	5.5%	30.5%	23.6%	40.4%

Adaptive Deer and Wildlife Management Plan

Additionally, a deer management plan is needed to qualify for either Certified or Legacy Lands. This specific type of plan involves continual monitoring used to modify management of the deer herd on this property. We have used 10 trail cameras located on random plots on the Grunow property to gather data required for Quality Deer Management. This sampling program was used to generate data on the required "antlerless deer and antlered buck management, adult sex ratio, deer density and fawn management" as well as age and lactation status of deer on the property. These measures must be taken according to Standard 7: Performance Measure A and Standard 8: Performance Measure A in the QDMA Land Certification Standards.

The steps needed to complete a Quality Deer Management Legacy Lands Application follow a list that incorporates multiple rules for Pledged, Certified, and Legacy Lands. Examples of these steps are 20 hours of QDMA education, development of deer and forest management plans, and having emergency procedures and routes in place. Some of the deer and wildlife management activities are recommended for preparation

by a wildlife biologist. In addition, a qualified property inspector must visit the land for an on-site interview.

Costs incorporated are membership, training, an application fee, and a renewal fee (Table 16). Other costs to be incorporated would be designation of trail heads, payment for outside services for management plans and data collection, and materials involved in data collection and herd management.

Table 16. Costs incurred while setting up a property as "Legacy Land" in QDM.

Costs for Quality Deer Management Association				
QDMA Membership		QDMA Training Session	Application Fee (Legacy)	Renewal Fee (Legacy)
1 year	3 year			
$30	$80	$50	$400	$300

A significant amount of time each year must be allocated to data collection on deer and plant monitoring. This can be done through use of trail cameras and hunter observations, but natural resource professionals should evaluate the data.

Another important step to qualify for Certified or Legacy Land is to have a meeting with a Qualified Property Inspector through the QDMA. The current Wisconsin property inspector is Brian Dart of Wildlife Enhancement, LLC located in Waukesha, Wisconsin. He can be contacted at 920-960-5605. These inspectors are referred to by the Quality Deer Management Association as Land Certification Program (LCP) Inspectors. Additional costs are possible from the inspection process. Inspectors may be free, or may charge travel costs or a daily rate. Other inspectors can be found on the QDMA webpage. Any other QDM questions can be referred to on the webpage[4] or in Appendix IX.

Cold Water Streams

Woodland streams are an important niche, not only for trout, but for the overall quality of the local watershed. Trees reduce erosion and sedimentation by clinging to soil with their vast root systems. Twigs and leaves that fall into the stream are key food sources for insects, which are the base of the food chain in streams (WDNR, 2007). Large pieces of woody debris are also important because they provide resting places, protection from predators, and increased food availability for fish and their food sources (WI DNR, 2007). Although large woody debris is good in certain circumstances, log jams can impede the natural flow of the stream. Retaining large overstory trees is vital to maintaining cool summer water temperatures, as well as insulating streams from becoming too cold in winter. In addition to large overstory trees, streams need low overhanging cover to provide fish habitat. This cover can be in the form of grasses and low shrubs. Areas in non-wooded sections of the stream can be managed to restore eroding banks and increase the amount of annual grasses and low shrubs. Shrubs such

[4] http://www.qdma.com/

as willow and alder can provide overhanging cover for trout (White and Brynildson, 1967).

Stream crossings can be a major source of erosion and sedimentation. Three widely used practices for managing stream crossings are culverts, bridges, and fords. Implementing culverts is not desirable because they alter stream flow and can block trout movement. A bridge should be used in areas with steep banks and should extend far enough past the bank edge to prevent damage to the bank's structure. Bridges and culverts are both susceptible to being washed away in extreme rainfall events. Fords are suitable crossings in areas where banks are very small and the approaches are low and stable. The approach should consist of non-erodible materials and should extend 50 feet or more on both sides of the crossing (Connecticut Department of Environmental Protection, 2007). Materials such as crushed rock, riprap, rubber mats, or geotextiles should be put within the stream at crossings to prevent heavy sedimentation downstream (Connecticut Department of Environmental Protection, 2007). Fords are low-impact crossings that should be used on a minimal basis.

The USDA offers the Environmental Quality Incentive Program (EQIP), which provides financial and technical assistance to help plan and implement conservation practices that address natural resource concerns. Landowners engaged in forest production may be eligible for EQIP (USDA 2012). See Appendix III for more detail on EQIP. Trout Unlimited and its Driftless Area Restoration Effort (DARE) can also provide financial assistance to increase trout habitat. DARE was created in 2006 as a collaborative effort to restore watersheds, streams, and fish populations to benefit the environment and local communities (Trout Unlimited 2013).

Final Recommendations

For black walnut management, we recommend the 18-inch diameter-limit cut that harvests all black walnut trees greater than 18 inches DBH on the entire property. At this point trees have reached economic maturity, and greater returns can be made by harvesting these trees and opening space for others. Planting and protection of black walnut seedlings will be required in the future due to the lack of adequate natural regeneration. After 2033 there is a projected lack of recruitment into the smaller size classes which will require compensation with planting.

In addition to the proposed black walnut harvests, we recommend a combination of big-tree and intensive management to achieve a balance between higher economic returns and the landowner's desire to maintain a forest that has a "mature" appearance. Specifically, we recommend an intensive selection harvest in 2018 because it will generate approximately 300 percent higher return than under the less intensive, big-tree harvest scenario. To maintain large trees on a majority of the landscape, the big-tree management harvest is recommended for 2023. The return for this harvest is approximately 63 percent of the return under intensive management, but it covers the greatest area of the property, and some big-tree management meets landowner goals. The 2028 harvest covers the smallest portion of the property, and an intensive harvest

will generate revenue of approximately $50,000, or 165 percent, more than less intensive harvesting. For this reason, we recommend the intensive harvest for 2028.

We also recommend the conversion of land currently under agricultural lease for row crops to warm-season indiangrass for forage. This recommendation will result in greater economic return and significantly reduce soil erosion. The initial conversion will result in a negative return over the next two years, but after two years, returns from harvesting forage should be approximately 170 percent higher than the current lease.

Savanna expansion is also recommended for the benefit to wildlife and aesthetics. The amount of timber harvested on the land proposed for savanna expansion will help cover some of the costs, but will not account for the total cost of planting and continued

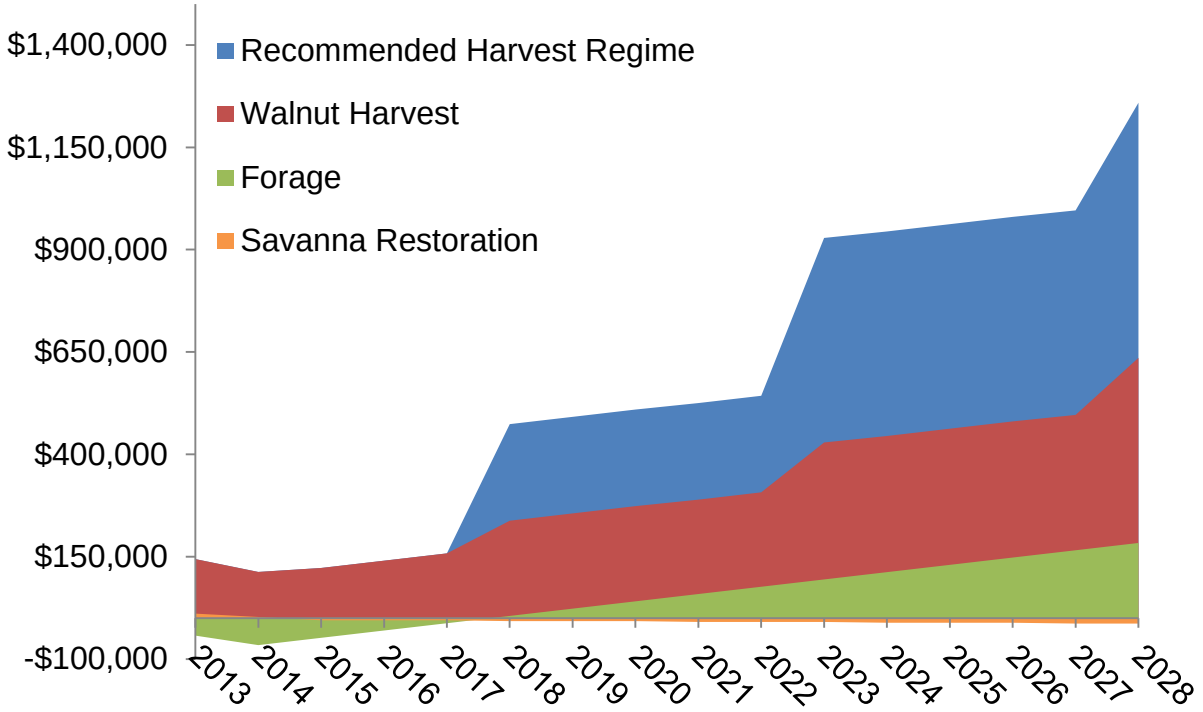


Figure 44. Difference between cumulative economic returns under the recommended management scenario and no management (agriculture lease and CRP only) from 2013 to 2028.

suppression of tree encroachment through burning. Despite the cost, we believe returning the land to pre-settlement condition, as well as the benefit to wildlife and aesthetics, would be an important part of the conservation of the property. Another important aspect of conservation will be removal of invasive species. We recommend mechanical removal with herbicides and burning to reduce their prevalence on the property.

The expected return for the recommended management scenario for the next fifteen years, including the costs of savanna restoration and agricultural conversion, is approximately $1,668,500. This is two-hundred thousand dollars less than using only

intensive management and two-hundred thousand more than using only big-tree management. It provides a good middle ground between the landowner goal of growing big trees on the property and maximizing economic productivity. The conversion of row crops to forage provides greater erosion control and net economic return. Figure 44 depicts forage as the cumulative difference between the return from forage and the return that would be attained under the current agricultural lease. Our analysis suggests that the economic benefit from conversion to forage will surpass that of the agricultural lease. Wildlife and conservation objectives will also be met through the conversion to forage and savanna restoration.

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Photo 13. Back row from left: Hayden Elza, Brian Zweifel, Devin Schlapbach, Jeff Grad, Joe Sullivan. Middle row from left: Adam Bontje, Matt Reynders, Ben Mussehl, Patrick LaPhilliph, Gregor Wilke, Josh Wilke, Pete Schneider. Front row from left: Ethan Lee, Sadie Brown, Dylan Willis, Aaron Streicher, Clint Gilman.

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Appendix

Appendix List

Appendix I

Data Collection Methods

Timber volume was estimated using variable-radius plot sampling. At plot center, a wedge prism was used to count trees “in” or “out” of a variable-radius plot. For a tree to be counted “in”, the offset image of the tree looking through the prism must overlap the actual bole of the measured tree at breast height (approximately 4.5 ft. above ground level). Dependent upon stand density, either a basal area factor (BAF) 5, 10 or 20 prism is used to assign square feet of basal area per acre. In this timber cruise, a prism with a BAF of ten was used. Thus, all trees that were counted “in” represented 10 square feet of basal area per acre. Each “in” tree was measured with a logger’s tape to estimate diameter at breast height (DBH). Also, “in” trees were measured for number of sawlogs (sixteen foot logs) or bolts (eight foot logs) one chain (66 feet) away from the tree with a Biltmore stick. Trees of merchantable DBH (greater than 11 in.) were given a grade based upon the quality of the butt log using the field procedure outlined in *Hardwood Tree Grades for Factory Lumber* (Appendix VI). Trees with potential to improve their grade were also noted to help project future value of timber on the property.

Coarse woody debris data was collected to determine the volume of wood laying on the ground across the Grunow property. Two 50-foot transects were established at each plot radiating from plot center at perpendicular angles. In both transects any coarse woody debris that fell within a half meter of either side of the transect center was measured for diameter at both the large and small ends, as well as total length within the transect area.

Abundance of tree regeneration and native and invasive plant cover were measured on the same transects as coarse woody debris. Regeneration data were collected at milacre (1/1000 of an acre) plots along transects at 0, 20, and 40 feet. At each milacre plot tree regeneration was recorded by height class and level and type of browse. Native and invasive plant cover was measured by the percent ground cover observed in the milacre plot.

Tree growth cores and soil depths were taken at the same plot to measure productivity of dominant tree species relative to soil depth. Productivity cores were taken with a tree corer at breast height in order to find annual growth over the last five years.

In order to justify timber harvesting in the future, an empirical growth model was used to predict sawtimber and pulpwood growth over a 20-year period. This model factors in tree core data, in addition to soil depth and other environmental variables. This model also predicts variables that can be used to calculate stocking levels, which provide a basis for our proposed harvesting schedules. While the model takes into account observed tree growth rates, it does factor in growth response to stand thinnings. Therefore, we assume that trees resume the same volume growth rates following a thinning. As one of the major goals of a selection thinning is to accelerate stand growth, we then suggest that growth rates projected beyond the harvest year are conservative estimates. Considering that regional sawmills may have different dimensional

requirements for sawtimber, it is important to note that trees used in this model had a DBH of at least 11 inches in order to qualify as sawtimber.

Appendix II

Soil Descriptions

Map Unit Symbol	Map Unit Name	Percent of AOI
DhB2	Dodgeville silt loam, deep, 2 to 6 percent slopes, moderately eroded	0.0%
DsC2	Dubuque silt loam, 6 to 12 percent slopes, moderately eroded	6.4%
DsD2	Dubuque silt loam, 12 to 20 percent slopes, moderately eroded	9.6%
DtB	Dubuque silt loam, deep, 2 to 6 percent slopes	0.8%
DtB2	Dubuque silt loam, deep, 2 to 6 percent slopes, moderately eroded	2.3%
DtC2	Dubuque silt loam, deep, 6 to 12 percent slopes, moderately eroded	7.5%
DtD2	Dubuque silt loam, deep, 12 to 20 percent slopes, moderately eroded	4.5%
FeE2	Fayette silt loam, valleys, 20 to 30 percent slopes, moderately eroded	0.0%

La	**Lawson silt loam**	**2.8%**
SoC2	**Sogn and Dodgeville silt loams, shallow, 6 to 12 percent slopes, moderately eroded**	**2.2%**
SoD2	**Sogn and Dodgeville silt loams, shallow, 12 to 20 percent slopes, moderately eroded**	**21.8%**
Ss	**Steep stony and rocky land**	**37.5%**
St	**Stony alluvial land**	**4.5%**
Totals for Area of Interest		**100.0%**

Appendix III

Explanation of State and Federal Incentive Programs

Environmental Quality Incentive Program (EQIP) is a voluntary program that provides financial and technical assistance to agricultural producer through contracts up to a maximum term of ten years in length. These contracts provide financial assistance to help plan and implement conservation practices that address natural resource concerns and for opportunities to improve soil, water, plan, animal, air and related resources on agricultural land and non-industrial private forestland. In addition, a purpose of EQIP is to let producers meet Federal, State, Tribal and local environmental regulations (USDA, 2012).

Who can apply

Owners of land in agricultural or forest production or persons who are engaged in livestock, agricultural or forest production on eligible land and that have a natural resource concerns on the land may participate in EQIP (USDA, 2012).

Payments

Farm Bill legislation provides NRCS with funds to provide financial assistance payments through EQIP to eligible producers to help implement approved practices. Additional financial assistance may be available to help producers develop conservation plans to required to support EQIP projects (USDA, 2012).

Conservation Reserve Program (CRP) is a land conservation program administered by the Farm Service Agency (FSA). In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality. Contracts for land enrolled in CRP are 10-15 years in length. The long term goal of the program is to re-establish valuable land cover to help improve water quality, prevent soil erosion, and reduce loss of wildlife habitat (USDA, 2012).

Landowner incentive program (LIP) provides federal grant funds to grant funds to the states, teh District of Columbia and insular areas to protect and restore habitats on private lands, to benefit Federally listed, proposed or candidate species or other species determined to be at-risk (USFWS, 2013).

Grant funds must be used to establish or supplement State landowner incentive programs to benefit species identified in the State's Comprehensive Wildlife Conservation Strategy (State Wildlife Action Plan) or classified as Special Concern by the State, or Federally listed, proposed, or candidate species or other species determined to be at-risk. These grant funds may also be used to provide technical and

financial assistance to private landowners for habitat protection and restoration (USFWS, 2013).

The LIP Program includes two funding tiers, Tier One (non-competitive) and Tier Two (nationally competitive). Under Tier One each state may receive funding for eligible projects up to $200,000 annually and the District of Columbia and insular areas up to $75,000 annually. If there is adequate funding in the appropriation, WSFR will rank Tier Two grants and award grants through a national competition. The competition will be announced separately (USFWS, 2013).

Source of Funds

Revenues collected from Outer Continental Shelf Oil & Gas royalties are deposited into the Land and Water Conservation Fund and appropriated annually by Congress for the LIP. The funds are awarded to fish and wildlife agencies based on a two-tiered award system (USFWS, 2013).

Wisconsin forest landowner grant program (WFLGP) assists private landowners in protecting and enhancing forested lands, prairies and waters. The program allows qualified landowners to be reimbursed up to 50 percent of the eligible cost of eligible practices (WDNR, 2013).

Who can apply

Private landowners in Wisconsin are eligible for WFLGP funding if they own at least 10 contiguous acres of non-industrial private forest but not more than 500 acres within wisconsin (WDNR, 2013).

Managed forest law (MFL) is a landowner incentive program that encourages sustainable forestry on private woodlands in Wisconsin. Together with landowner objectives, the law incorporates timber harvesting, wildlife management, water quality and recreation to maintain a healthy and productive forest. Sustainable forest management benefits Wisconsin's economy, hunting, fishing, wildlife, recreation, soils, waterways, and air quality, and renews our beautiful forests for everyone to enjoy (WDNR, 2013).

Who can apply

To participate in the MFL program, landowners designate property as "Open" or "Closed" to public access for recreation, and commit to a 25 or 50 year sustainable forest management. The plan sets the schedule for specific forestry practices which landowners must complete. In return, MFL participants make a payment in lieu of regular property taxes plus a yield tax on harvested trees. Yield taxes go to local

municipality to help offset the annual property taxes that are deferred while properties are enrolled in the MFL (WDNR, 2013).

Appendix IV

Recommended prairie seed

Recommended Forbs		
Scientific Name	Common name	$/oz.
Dalea candida	white prairie clover	$4.69
Dalea purpurea	purple prairie clover	$3.13
Eryngium yuccifolium	Rattlesnake master	$7.81
Penstemon grandiflorus	large-flowered penstemon	$11.26
Tradescantia ohiensis	Spiderwort	$11.26
Amorpha canescens	leadplant	$16.87
Aster sagittifolius	arrow-leaved aster	$5.63
Baptisia australis	blue wild indigo	$11.26
Verbena stricta	hoary vervain	$5.63
Echinacea purpurea	purple coneflower	$3.76
Heliopsis helianthoides	early sunflower	$2.26
Ratibida columnifera	long-headed coneflower	$3.76
Rudbeckia hirta	black-eyed susan	$1.87
Tradescantia ohiensis	Spiderwort	$11.26
Silphium integrifolium	rosin weed	$9.37
Silphium laciniatum	compass plant	$11.26
Silphium perfoliatum	cup plant (aggressive)	$9.37

Recommended Grasses		
Scientific Name	Common Name	$/Lb
Andropogon gerardii	big bluestem	$9.60
Bouteloua curtipendula	side oats grama	$14.40
Elymus canadensis	canada wild rye	$10.80
Elymus virginicus	virginia wild rye	$9.60
Schizachyrium scoparium	little bluestem	$18.00
Sorghastrum nutans	indiangrass	$14.40

Appendix V

Chronic Wasting Disease Map

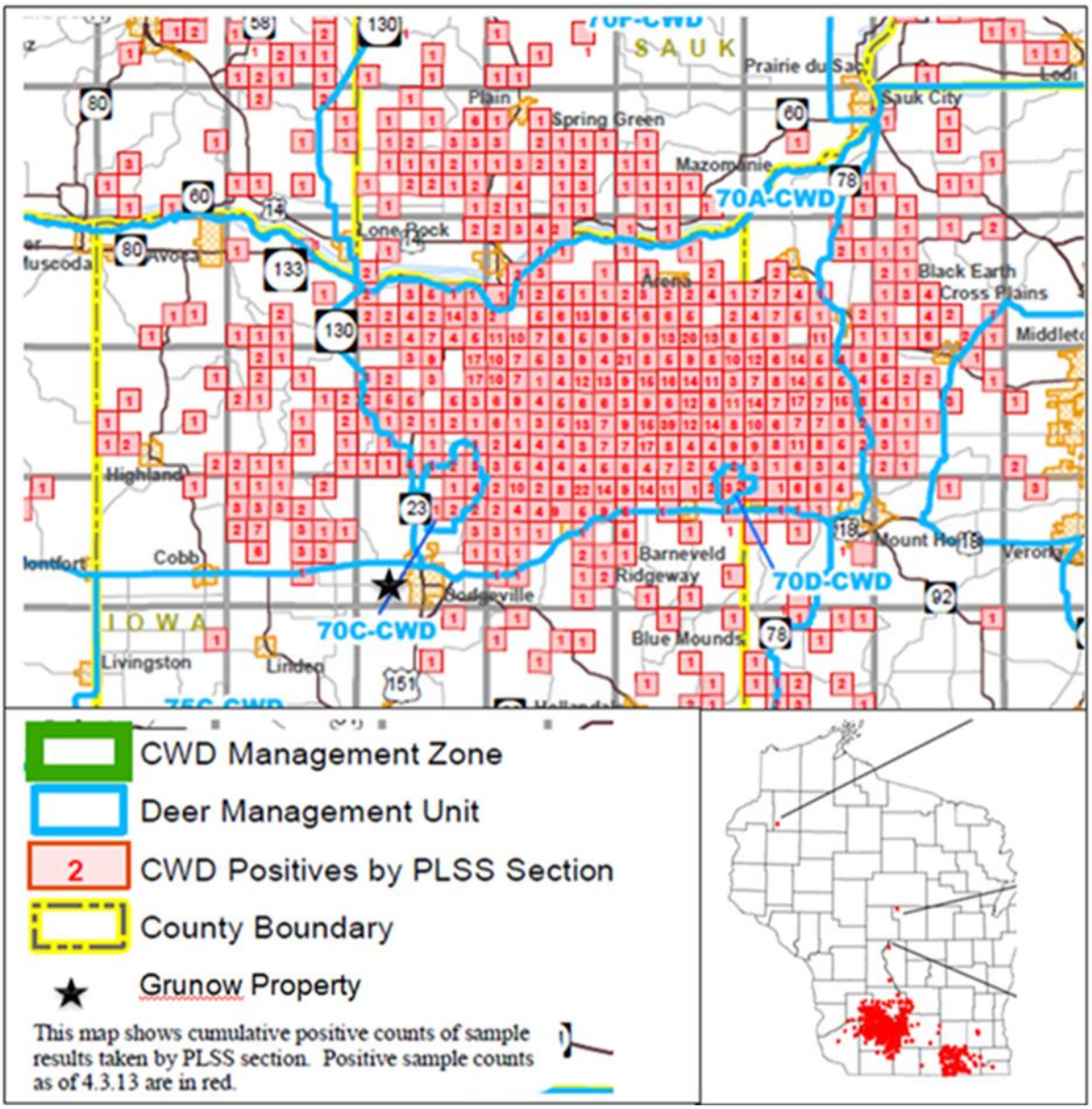
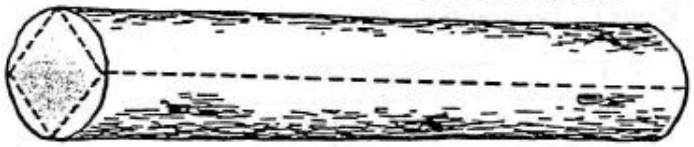


Figure 45. WDNR map of chronic wasting disease, zoomed in on Iowa county

Appendix VI

Log Grading

Figure 3.—Selecting the grading face.



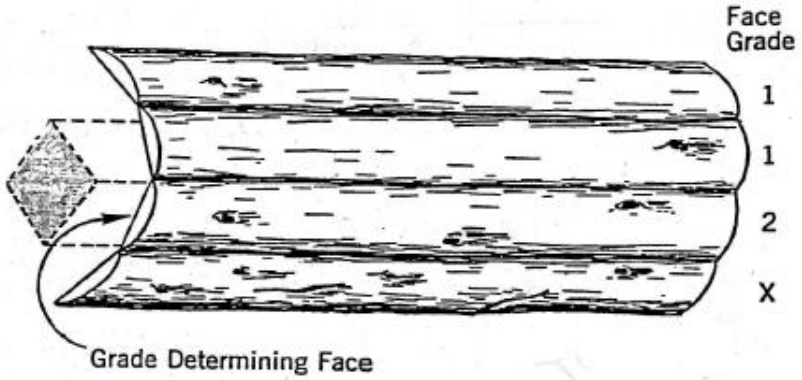


Fig. 4.—Hardwood tree grades for factory lumber

Grade factor	Tree grade 1	Tree grade 2	Tree grade 3
Length of grading zone (feet)	Butt 16	Butt 16	Butt 16
Length of grading section[a] (feet)	Best 12	Best 12	Best 12
Dbh, minimum (inches)	16[b]	13	10
Diameter, minimum inside bark at top of grading section (inches)	13[b] 16 20	11[c] 12	8
Clear cuttings (on the 3 best faces):[d]			
Length, minimum (feet)	7 5 3	3 3	2
Number on face (maximum)	2	2 3	(*)
Yield in face length (minimum)	5/6 10/12	4/6 8/12	3/6 6/12
Cull deduction, including crook and sweep but excluding shake, maximum within grading section (percent)	9	9[f]	50

[a] Whenever a 14- or 16-foot section of the butt 16-foot log is better than the best 12-foot section, the grade of the longer section will become the grade of the tree. This longer section, when used, is the basis for determining the grading factors such as diameter and cull deduction.

[b] In basswood and ash, dib at top of grading section must be 12 inches and dbh must be 15 inches.

[c] Grade 2 trees can be 10 inches ib at top of grading section if otherwise meeting surface requirements for small grade 1s.

[d] A clear cutting is a portion of a face free of defects, extending the width of the face. A face is one-fourth of the surface of the grading section as divided lengthwise.

[e] Unlimited.

[f] Fifteen percent crook and sweep or 40 percent total cull deduction are permitted in grade 2 if size and surface of grading section qualify as grade 1. If rot shortens the required clear cuttings to the extent of dropping the butt log to grade 2, do not drop the tree's grade to 3 unless the cull deduction for rot is greater than 40 percent.

Appendix VII

Stocking Chart

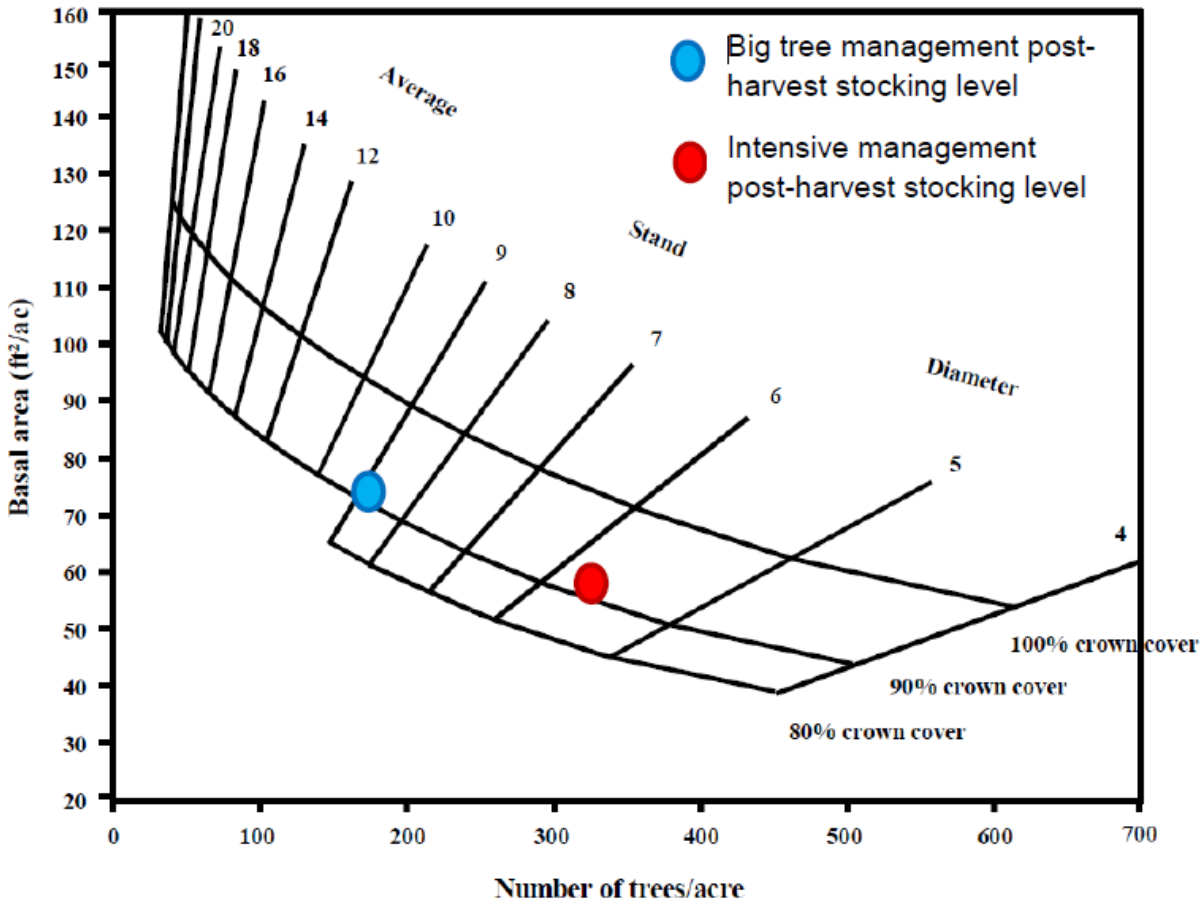


Figure 46. Stock levels following each harvest scenario.

LAKE STATES STUMPAGE PRICES

	MI	MI-1	MI-2	MI-3	MN	MN-1	MN-2	WI	WI-2	WI-3
Pulpwood ($/cd)	**$37.63**	**$36.93**	**$36.67**	**$39.48**	**$21.26**	**$21.55**	**$21.25**	**$38.35**	**$39.01**	**$37.99**
Aspen	$35.80	$26.52	$27.12	$46.23	$25.32	$23.24	$25.38	$39.22	$39.52	$39.00
Basswood	$16.35	$8.54	*	$23.74	$11.65	$9.10	$12.19	$11.59	$10.24	$12.49
Jack Pine	$41.45	$23.28	$61.86	$64.74	$23.57	$20.40	$23.57	$45.53	$43.52	$45.86
Oak	$20.78	$20.39	*	$29.31	$22.29	$21.79	$22.35	$26.65	$35.14	$23.88
Other Hdwd	$28.45	$23.00	$30.67	$32.94	$11.85	$8.71	$11.99	$36.29	$38.08	$35.41
Other Sfwd	$32.86	$20.74	$27.00	$37.98	$6.58	$31.87	$6.38	$38.86	$35.64	$42.60
Red Pine	$77.41	$77.29	$77.86	$75.12	$36.62	$36.57	$36.63	$68.58	$65.62	$69.96
Spruce/Fir	$30.28	$11.91	$26.50	$44.33	$18.10	$11.80	$18.11	$25.51	$27.90	$23.34
White Birch	$28.78	*	$20.73	$37.90	$11.99	$8.75	$12.04	$38.15	$44.72	$32.44
Sawtimber ($/mbf)	**$196**	**$141**	**$343**	**$379**	**$189**	**$263**	**$96**	**$350**	**$326**	**$365**
Ash	$104	$104	$114	$100	$26	$33	$23	$250	$124	$260
Aspen	$95	$97	$35	*	$33	$33	*	$236	*	$236
Basswood	$124	$113	$185	$114	$66	$96	$35	$428	$256	$517
Beech	$110	$109	$126	*	*	*	*	*	*	*
Black Cherry	*	*	*	*	$176	$176	*	$408	$408	*
Black Walnut	*	*	*	*	$1,179	$1,179	*	*	*	*
Elm	*	*	*	*	$41	$41	*	*	*	*
Hard Maple	$777	$539	$885	$704	$166	$292	$50	$480	$542	$455
Hickory	*	*	*	*	$138	$138	*	$345	*	$345
Jack Pine	$64	$64	*	*	*	*	*	*	*	*
Mixed Hdwd	$194	$171	$349	$209	$20	$20	*	$267	$249	$275
Mixed Sftwd	$125	$125	*	*	$75	*	$75	*	*	*
Oak Unspecified	*	*	*	*	$148	$150	$73	$319	$365	$315
Pine Unspecified	*	*	*	*	$101	*	$101	*	*	*
Red Oak	$274	$282	*	$239	$405	$437	$110	$437	$451	$425
Red Pine	$199	$190	$215	$224	$107	$46	$108	$163	$165	$115
Soft Maple	$223	$178	$196	$299	$36	$36	*	$242	$248	$239
Spruce Unspecified	$64	*	$139	$50	*	*	*	*	*	*
White Birch	$150	*	$232	$126	$20	$33	$19	$192	$192	*
White Oak	$89	$89	*	*	$250	$250	*	$289	*	$289
White Pine	$93	$84	$102	$160	$31	$31	*	$160	$144	$191
White Spruce	*	*	*	*	$88	*	$88	$110	$110	*
Yellow Birch	$340	*	$462	$242	*	*	*	$359	*	$359

Appendix IX

Quality Deer Management Association Information

Active Steps Taken to Ready Land for Legacy QDMA Certification
www.qdma.com
Pledged Lands

1. Be a current QDMA member
2. Written policy that outlines safety rules for hunters on land
3. Written emergency plan containing emergency contact info and route maps
4. Cornerstones
    a. Apply herd management strategies under QDM
    b. Apply habitat management strategies under QDM
    c. Apply hunter management strategies under QDM
    d. Commit to monitor the success of the QDM program on property

Certified Lands

5. Develop adaptive deer management plan
6. Complete on-site interview with *qualified property inspector*
7. Annually record info on antlerless, antlered deer management and sex ratio, density, and fawn management
8. Annually record info about current property composition/ latest habitat management practices
9. Written harvest guidelines for number, size, age of bucks to be harvested
10. Written guidelines to specify any other species allowed to be hunted on land
11. Ensure a release of liability is in place for other hunters on property
12. Annually record info about hunter education efforts, harvest guidelines, etc
13. Conduct monitoring program – age, sex, weight, and antler data on 75% deer
14. Collect hunter observation data
15. Conduct pre or post-hunting season population estimate every 2 years
16. Monitor habitat on regular basis
17. Monitor predator abundance and impacts/ implement control measures legally
18. Annually record info on herd - hunter observations, deer population estimates

Legacy Lands

19. Complete minimum 20 hours of QDMA educational activities in 5 year period
20. Confer with natural resource agencies on rare/ threatened plants and animals
21. Identify, map, and make effort to control invasive plants/animals
22. Dispose of waste from harvest in designated location to prevent run-off

(Landowner needs to complete all requirements for Pledged and Certified Lands to qualify for Legacy Lands as well)

Appendix X

Species Common and Scientific Names

Trees

Apple (*Malus spp.*)
Aspen (*Populus tremuloides*)
Basswood (*Tilia americana*)
Black Ash (*Fraxinus nigra*)
Black Cherry (*Prunus serotina*)
Black Oak *(Quercus velutina*)
Black Walnut (*Juglans nigra*)
Bur Oak (*Quercus macrocarpa*)
Cedar (*Juniperus spp.*)
Cottonwood (*Populus deltoides*)
Elm (*Ulmus spp.*)
Green Ash (*Fraxinus pennsylvanica*)
Hackberry (*Celtis occidentalis*)
Hickory (*Carya spp.*)
Ironwood (*Ostrya virginiana*)
Red/Soft Maple (*Acer rubrum*)
Sugar Maple (*Acer saccharum*)
White Ash (*Fraxinus americana*)
White Oak (*Quercus alba*)
Willow (*Salix spp.*)

Shrubs

Alder (*Alnus spp.*)
Dogwood (*Cornus spp.*)
Musclewood (*Carpinus caroliniana*)
Prickly Ash (*Zanthoxylum americanum*)
Sumac (*Rhus spp*.)

Forbs

Aster (*Aster spp.)*
Bergamot (*Monarda spp.*)
Currants (*Ribes spp.*)
Field Mint (*Mentha arvenis*)
Mullein (*Verbascum spp.*)
Nettle (*Urtica spp.*)
Pointed-leaf Tick Trefoil (*Desmodium glutinosum*)
Purple Hyssop (*Agastache scrophulariifolia)*
Queen Anne's Lace (*Daucus carota*)
Raspberries (*Rubus spp.*)
Virginia Creeper (*Parthenocissus quinquefolia*)
Wild Geranium (*Geranium maculatum*)

Grasses

Big bluestem (*Andropogon gerardii*)
Indiangrass (*Sorghastrum nutans*)
Little Bluestem (*Schizachyrium scoparium*)
Sideoats Grama (*Bouteloua curtipendula*)
Switchgrass (*Panicum virgatum*)
Virginia Wildrye (*Elymus virginicus*)

Invasives

Autumn Olive (*Elaegnus* umbellate)
Burdock (*Arctium spp.*)
Canada Thistle (*Cirsium arvense*)
European Honeysuckle (*Lonicera x bella*)
Garlic Mustard (*Alliaria petiolata*)
Japanese Barberry (*Berberis thunbergii*)
Multiflora Rose (*Rosa multiflora*)
Russian Olive (*Elaeagnus angustifolia*)
Smooth Brome (*Bromus inermis*)
Spotted Knapweed (*Centaurea maculosa*)
Wild Parsnip (*Pastinaca sativa*)

Fish and Wildlife

Bald Eagle (*Haliaeetus leucocephalus*)
Bobolink (*Dolichonyx oryzivorus*)
Bobwhite Quail (*Colinus virginianus*)
Brook Trout (*Salvelinus fontinalis)*
Coyote (*Canis latrans)*
Eastern Wild Turkey (*Meleagris gallopavo*)
Ring-necked Pheasant (*Phasianus colchicus*)
Pileated Woodpecker (*Oryocopus pileatus*)
Red-headed Woodpecker (*Melanerpes erythrocephalus*)
Ruffed Grouse (*Bonasa umbellus*)
Whitetail Deer (*Odocoileus virginiana*)
Woodcock (*Scolopax minor*)

Appendix XI

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