2022
NCF-ENVIROTHON
OHIO

FORESTRY RESOURCE GUIDE

ENVIROTHON
OHIO 2022

2022 NCF-Envirothon Ohio

Forestry Study Resources

Key Topic 1: Economic Benefits and Ecosystem Services of Forests and Urban Trees

1. Describe the ecosystem services provided by forests and urban trees, including benefits to water quality and wildlife.
2. Explain how forests and urban trees contribute to the Ohio economy.
3. Describe the social and communal benefits of trees and forests for humans.

Study Resources

Resource Title	Source	Located on
Benefits of Trees	*International Society of Arboriculture, 2021*	Pages 3-4
Ohio Forest Benefits	*Project Learning Tree- Ohio, 2020*	Pages 5-8
Please note that it is not required for teams to complete the activities within this document		
Ohio Forest Economy	*Erin McConnell, Ph.D; Ohio State Fact Sheet 2012*	Pages 9-15
Forests of Ohio	*USDA, 2019*	Page 16
Enhancing Food (Mast) Production for Woodland Wildlife in Ohio	*Apsley, David and Gerhrt, Stan, 2006*	Pages 17-19
Forested Buffer Strips	*Dan Mecklenburg, 2012*	Pages 20-23

Study Resources begin on the next page ➡

Benefits of Trees

Trees provide social, communal, environmental, and economic benefits.

Trees provide benefits that promote health, social well-being, and even help your home. Trees serve many purposes in your local community and throughout the entire world.

Social Benefits

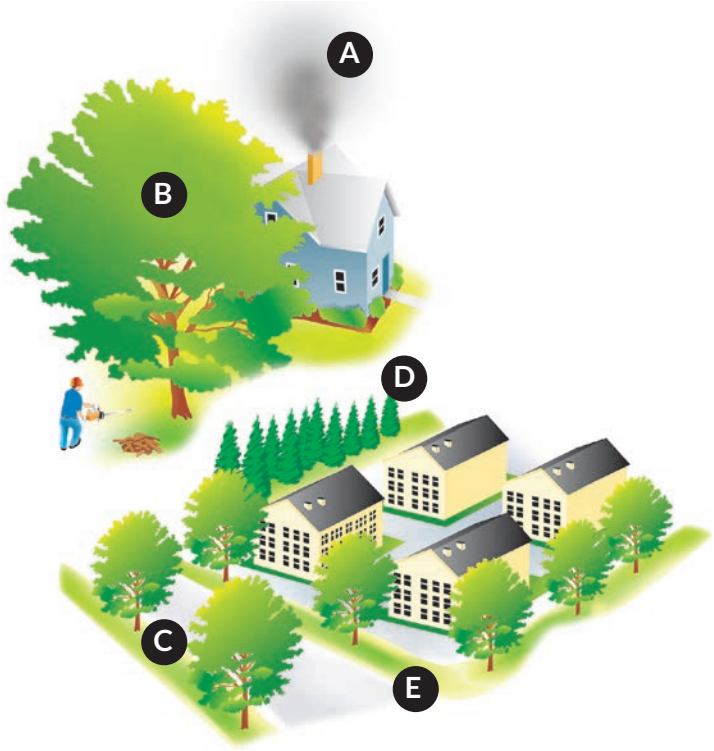
- Trees provide beauty and help people feel serene, peaceful, restful and tranquil.
- Trees significantly reduce workplace stress and fatigue and decrease recovery time after medical procedures.
- Trees may help reduce criminal activity.

Economic Benefits

- Property values of landscaped homes are 5%– 20% higher than non-landscaped homes.
- Individual trees have value that is affected by size, condition, and function. In general, the larger the tree, the greater the value.
- Air conditioning costs are lower in a tree-shaded home; and heating costs are reduced when a home has a windbreak.
- Well-maintained trees can add value to a home.

Communal Benefits

- City trees often serve architectural and engineering functions by providing privacy, emphasizing views or obstructing objectionable views.
- Trees may reduce glare/reflection or direct pedestrian traffic.
- Trees may soften, complement, or enhance architecture.
- Trees bring natural elements and wildlife habitats into urban surroundings, all of which increase the quality of life for residents in the community.



Environmental Benefits

(See figure above)

A: Leaves filter the air we breathe by removing dust and other particles; absorbing carbon dioxide and various air pollutants such as ozone, carbon monoxide and sulfur dioxide; and release oxygen.

B: Deciduous shade trees cool homes in the summer and allow the winter sun to heat homes when they lose their leaves.

C: Trees help cool the environment, working as a simple and effective way to reduce urban heat islands (pavement and buildings in commercial areas cause higher temperatures by absorbing the sun's heat).

D: Trees can serve as a windbreak. The more compact the foliage on the group of trees the more effective the windbreak.

E: Trees intercept water, store some of it and reduce stormwater runoff.

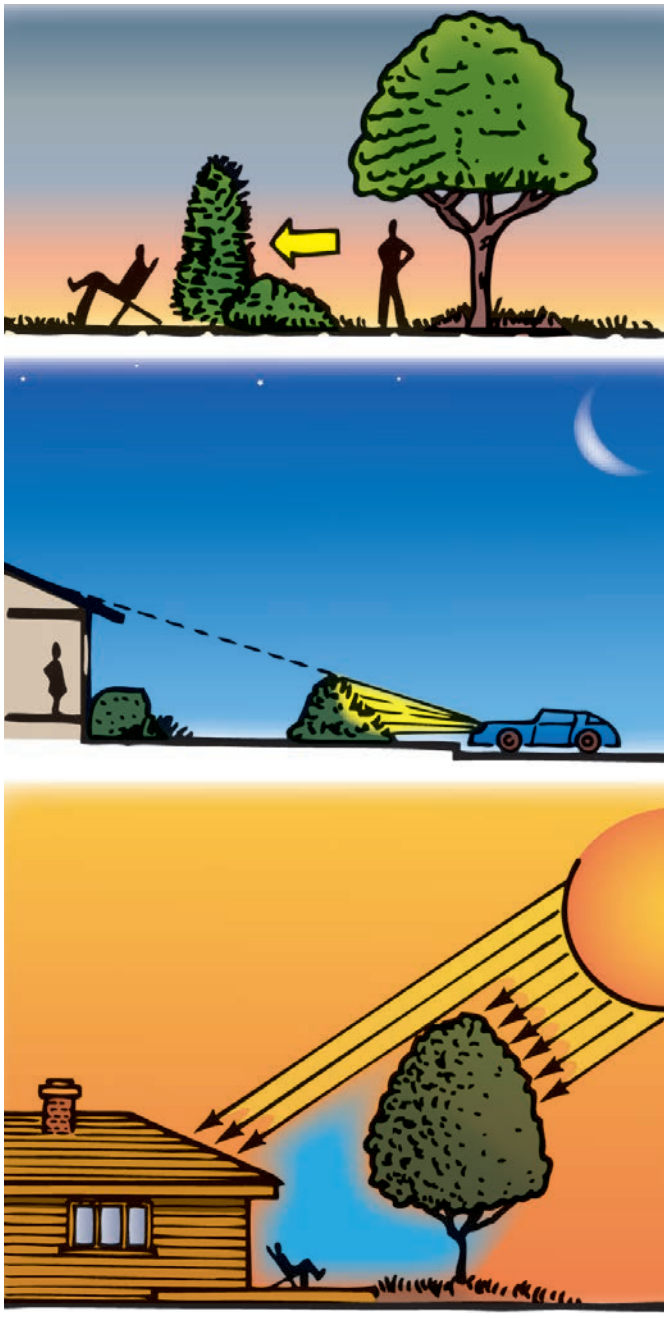
Trees Require an Investment

Trees provide numerous aesthetic and economic benefits, but can have costs. The costs associated with large tree removal and replanting with a smaller tree can be significant. In addition, the economic and environmental benefits produced by a young replacement tree are minimal when compared to those of a mature specimen.

Extending the functional lifespan of large, mature trees with routine maintenance can delay these expenses and maximize returns.

An informed home owner can be responsible for many tree maintenance practices. Corrective pruning and mulching gives young trees a good start. Shade trees, however, quickly grow to a size that may require the services of an arborist.

Your local garden center, university extension agent, community forester, or consulting arborist can answer questions about tree maintenance, suggest treatments, or recommend qualified arborists. ISA Certified Arborists® have the knowledge and equipment needed to prune, treat, fertilize, and otherwise maintain a large tree.



Selecting the right form (shape) to complement the desired function can significantly reduce maintenance costs and increase the tree's value in the landscape.

What Is a Certified Arborist?

ISA Certified Arborists are individuals who have proven a level of knowledge in the art and science of tree care through experience and by passing a comprehensive examination developed by some of the nation's leading experts on tree care.
ISA Certified Arborists must also continue their education to maintain their certification. Therefore, they are more likely to be up to date on the latest techniques in arboriculture.

Finding an Arborist

Visit TreesAreGood.org for free tools:

- The "Find an Arborist" tool can help you locate an arborist in your area.
- The "Verify a Credential" tool enables you to confirm whether an arborist has an ISA credential.

Be an Informed Consumer

One of the best methods to use in choosing an arborist is to educate yourself about some of the basic principles of tree care. Visit TreesAreGood.org to read and download all brochures in this series.

www.isa-arbor.com • www.treesaregood.org

Through research, technology, and education, the International Society of Arboriculture promotes the professional practice of arboriculture and fosters a greater worldwide awareness of the benefits of trees.

Ohio Forest Benefits

Clean Air

Trees help *mitigate* air pollution by reducing heat, intercepting *airborne particles* and absorbing *pollutants* such as carbon monoxide, sulfur dioxide, and nitrogen dioxide. Trees also absorb carbon dioxide, *sequester* carbon, and release oxygen back into the *environment*. When trees absorb carbon dioxide from the air, they are reducing the *greenhouse effect* through which atmospheric gases trap heat and warm the earth. Trees also reduce heat by creating shade. Especially in urban environments, shade from trees help cool homes and other buildings. Shaded buildings require less air conditioning and so use less electricity.

Try PLT Activity **Pollution Search** or **Air Plants** and **Teaching with i-Tree**

Recreation

Forests provide a wide variety of outdoor *recreational* pursuits that support healthy, active lifestyles. *Recreational* activities in forests nurture appreciation for the essential role that forests play in preserving the health of our planet. Ohioans enjoy many outdoor activities in the forest including hiking, mountain biking, horse-back riding, camping, hunting, and rock climbing. *Recreation* allows humans to enjoy the outdoors and take advantage of the beautiful nature of our state. If not done properly, some *recreation* can *degrade* the *environment* and cause issues like *erosion* and *pollution*. It is important to pay attention to the rules of a park or natural area, like staying on marked trails and disposing of trash appropriately, so that future *generations* of Ohioans can enjoy these places too.

Try PLT Activity **400-Acre Wood**

Healthy Soil & Water

Forests have many positive effects on water and soil quality. Trees fight soil *erosion*, conserve rainwater, and reduce water *runoff* and *sediment* deposit after storms. Leafy tree *canopies* catch *precipitation* before it reaches the ground, allowing some of it to gently drip down and the rest to *evaporate*. This lessens the force of storms and reduces *runoff* and *erosion*. *Riparian* tree roots hold soil together and help anchor stream banks to keep them from *eroding*. Forests filter the water and retain nutrients and potential *pollutants* within the soil where they break down into harmless substances.

Try PLT Activity **Field, Forest, and Stream**

Renewable Wood Resources

Forests provide us with many valuable *commodities*. Trees can be replenished since the major inputs that contribute to their growth are sunlight, air, water, and nutrients from the soils in which they grow. The many products that come from trees like paper, books, wood furniture, flooring, musical instruments, and so many more, can all be made *sustainably* because trees are a *renewable* resource. It is vital that forests are carefully managed to provide for *sustainable*, long term benefits. Ensuring that forests are *regenerated* after each harvest helps to assure that healthy forests will be around for future *generations* to use and enjoy.

Try PLT Activity **Renewable or Not**

Human Health and Wellness

Immersing oneself in nature has many health and wellness benefits. With so much of our lives spent indoors, it is critical for children to spend time outside. Nature and forest therapy are a pathway to the healing powers of nature. While in a natural area, take in your surroundings and interact with the living and nonliving things around you. You do not need to go to a forest. You can connect with nature while at a local park, a garden, walking along a sidewalk with street trees, or admiring a houseplant. Taking time to connect with the *environment* through your different senses can reduce stress, support sleep, and increase relaxation. Spending time in the forest has been shown to significantly reduce the stress hormone *cortisol*, which can suppress the *immune system*. Ohio has ample opportunities for nature therapy in the thousands of parks, forests, and natural areas throughout the state.

Try PLT Activity **Get in Touch with Trees** or **Sounds Around**

Climate Resilience

Trees absorb carbon dioxide (CO_2), *sequester* carbon, and release oxygen back into the *environment*. Through this process trees act as a *carbon sink*, storing carbon in the global *carbon cycle*. The emission of greenhouse gases such as carbon dioxide has contributed to global climate change through the *greenhouse effect*. Planting trees and effectively *managing forests* can help enhance their ability to *mitigate* climate change by increasing their ability to *sequester* carbon. By absorbing CO_2, trees and forests help reduce the *greenhouse effect*. Forests store carbon in living trees, dead trees, *understory* plants, leaf litter on the forest floor, and organic soil.

Try PLT Activity **The Global Climate** or **Our Changing World, Carbon & Climate E-Unit, Southeastern Forests and Climate Change** online module**.**

Ecosystem Biodiversity

Forests and trees provide valuable *habitat* for Ohio's wildlife. From a bird's nest in an urban tree to a tree snake in the forest, there are many types of animals that make trees their home. Having forests in Ohio is important to support *biodiversity* and keep natural *ecosystems* intact. Many of Ohio's forests are under pressure from non-native *invasive* plants, insects, and diseases. These forest invaders can negatively impact forest health and outcompete beneficial native plants and wildlife. Through appropriate *forest management*, the effects of invasive species can be *mitigated* to provide for a healthy functioning forest *ecosystem*.

Try PLT Activity **Trees as Habitats**

Green Jobs

Ohio's forests also contribute to the livelihood of Ohioans through supporting industries and providing jobs. Many people work to keep Ohio's trees and forest *ecosystems* healthy, productive, strong, and safe for all to enjoy. Forests are managed for multiple uses such as producing timber, providing food and *habitat* for wildlife, *recreation*, and improving water quality, just to name a few. Forest activities require the work of many professionals. Some examples include forest managers, loggers, forest ecologists, urban foresters, hydrologists, naturalists, wildlife biologists, and many others who dedicate their careers to working in the forest. Forests provide an opportunity for many types of scientists to conduct research on the complex forest *ecosystem*.

Try PLT Activity **Who Works in this Forest?** and PLT's **Green Jobs**

Glossary

Biodiversity- the variety of life reflected in the variety of ecosystems and species, their processes and interactions and the genetic diversity within and among species.

Canopy- the forest layer formed by the leaves and branches of trees or shrubs. There may be several canopy layers.

Carbon cycle- the circulation and recycling of carbon atoms, especially through the processes of photosynthesis, respiration, and decomposition.

Carbon sink- something in the natural environment viewed in terms of its ability to absorb carbon dioxide from the atmosphere (examples are forests and the ocean)

Commodities- a useful or valuable thing

Cortisol- a stress hormone, like an alarm system for the human body.

Degrade- Worsen, weaken, deteriorate. Environmental degradation is damage done to the environment through activities that cause harm to ecosystems and their components such as soil, water, and air.

Ecosystem- the interacting system of a biological community and its nonliving environment; also the place where these interactions occur

Environment- the sum of all external conditions and influences that affect the development and ultimately, the survival of an organism or group of organisms

Erosion- the wearing away of the land surface by wind or water. Erosion occurs naturally from weather or runoff but is often intensified by some human activities.

Evaporate- Evaporation is the physical change of state in which a liquid is transformed into a vapor of gas.

Generations- all the people born and living at about the same time

Greenhouse effect- the trapping of heat by gases, such as carbon dioxide, methane, and nitrous oxides in the Earth's atmosphere

Habitat- an area that provides an animal or plant with adequate food, water, shelter, and living space in a suitable arrangement

Immune system- the defense system in the human body that fights off foreign substances and infection

Invasive- An invasive species is a plant, animal, or other organism that is typically nonnative to a particular ecosystem and whose introduction causes or is likely to cause harm to the economy, environment, or human health.

Management- Forest management is the practical application of scientific, economic, and social principles to the administration of a forest.

Mitigate- to lessen in force or make less severe

Pollutants- any introduced gas, liquid, or solid that makes a resource less useful or unfit for a specific purpose

Precipitation- water from the atmosphere that falls to the ground as rain, snow, sleet, or hail.

Recreational- recreation is any activity done for enjoyment

Regenerated- Regeneration is the renewal of vegetation by natural or artificial means. A regeneration period can be the period required or allowed in the plan for regenerating following timber harvest.

Renewable- A renewable resources is a naturally occurring raw material or form of energy which has the capacity to replenish itself through ecological cycles and sound management practices. The sun, win, falling water, and trees are examples of renewable resources.

Runoff- runoff water is fresh water from precipitation and melting ice that flows on the ground surface intro nearby streams, lakes, wetlands, and reservoirs

Sediment- the solid precipitate or matter that settles to the bottom of a liquid. The material deposited by water, wind, or glaciers.

Sequester- to remove or separate; **carbon sequestration** is the process by which carbon dioxide (CO_2) is removed from the atmosphere and held in solid or liquid form.

Sustainable- using natural and human resources in a way that does not compromise the needs of future generations.

Understory- the layer formed by the crowns of smaller trees in the forest

THE OHIO STATE UNIVERSITY EXTENSION

FACT SHEET

Agriculture and Natural Resources

F-80-12

Ohio's Forest Economy

Eric McConnell, Ph.D.
Forest Operations and Products Specialist
Ohio State University Extension

Highlights

- The state of Ohio has approximately 8.05 million acres under forest cover, which is 30.7% of Ohio's land area.
- Nearly three-quarters of Ohio's forestland, 5.8 million acres, is held by 336,000 nonindustrial private landowners.
- The forest volume in Ohio is 96.3% hardwoods and 3.7% conifers.
- Ohio's timber volumes have increased significantly over the past 20 years. Growing stock volume has increased 37.4% and sawtimber volumes have increased 67.6%.
- The ratio of net growth (total growth minus mortality) to removals for growing stock was 2.13:1.00.
- Ohio's sawtimber grew 1.86 billion board feet of wood while 750 million board feet of sawtimber were harvested in 2010. Net growth to removals ratio was 2.49:1.00.
- Inflation-adjusted stumpage prices for many of Ohio's commercial hardwood species have been increasing since 1960. Delivered sawlog prices have largely trended upward for only the higher quality logs. Decreasing trends for some species have been reported over the past twenty years.
- Ohio's forest products industry contributed an estimated $22.05 billion to Ohio's economy in 2010. Total employment was 118,000 full-time and part-time jobs, with wages and benefits amounting to $5.69 billion.
- Forestry and logging's industrial outputs contributed an estimated $434 million in outputs to Ohio's economy. These sectors employed 4,200 people and paid $106 million in wages and benefits.
- Processors of solid wood products contributed an estimated $3.72 billion in outputs to Ohio's economy. These sectors employed 27,700 people and paid $1.12 billion in wages and benefits.
- Pulp and paper producers' industrial outputs contributed an estimated $15.15 billion to Ohio's economy. These sectors employed 65,300 people and paid $3.50 billion in wages and benefits.
- Wood furniture manufacturers' industrial outputs contributed an estimated $3.14 billion to Ohio's economy. These sectors employed 23,900 people and paid $1.05 billion in wages and benefits.
- Western Ohio's forest products industry generated the largest impacts in terms of employment and dollars. The industry's contributions as a percent of the regional economy were larger in southeast Ohio. Northeast Ohio was second in both actual and relative contributions.
- Total forest products exports in 2010 amounted to $8.20 billion. Domestic shipments (within the United States to states outside Ohio) totaled $7.24 billion while $964 million of products were shipped internationally.

Why Should Our Woodlands Be Managed?

An abundance of forested acres are present in Ohio. These woodlands provide community support by producing economic activity in 26 forest industrial sectors. Properly managing your woodland improves forest health, aesthetics, and wildlife habitat. It also provides soil stabilization, clean water, self-satisfaction, and a potential source of income.

Managing timber requires less long-term inputs compared to many other land uses. You are able to obtain cost share funds to establish your woodland, tax credits while managing your forest property, and preferable tax treatment at harvest. Moreover, standing timber is a

stable form of wealth, often comparable in performance to mutual fund investments.

Some of the many contributions Ohio's forests and its forest products industry provide to the state's economy are discussed in this fact sheet. Key figures and statistics are also provided. Figures 1–7 were constructed using data from the 2010 forest survey database provided by the United States Forest Service's Forest Inventory and Analysis. Figure 8 was obtained from the Ohio Timber Price Report. Tables 1–8 and Figures 9–11 were developed from data analyzed using IMPLAN®.

Forestland

The state of Ohio has approximately 8.05 million acres of forestland, land that is at least 10% stocked with trees and is not being used for non-forestry purposes. This is two times the number of forested acres in 1900. Forest acreages have been increasing since the 1942 forest survey. The rate of increase has slowed over the past twenty years.

Forest acreage increases from the northwest to the southeast. Most of this land area is located east and south of the glacial line in the western foothills of the Appalachian Mountains (Figure 1). Eight of the top nine forested counties are located in southeastern Ohio. Some of this forestland includes the Wayne National Forest along with several state forests.

Forestland Ownership

Most of Ohio's forestland is privately owned, 6.97 million acres or 86.4% of the total forest area (Figure 2). Much of the privately owned forestland, 5.8 million acres, is controlled by 336,000 family forest owners. Over half, 57.7%, own less than 10 acres while 35.5% own between 10 and 50 acres. The U.S. government owns 290,000 acres and the state of Ohio owns 510,000 acres. A limited number of family-owned forested acres are being actively managed.

Composition

Hardwood tree species dominate Ohio's landscape. Hardwoods make up 96.3% of Ohio's forest volume while conifers account for the remaining 3.7%. There are many types of forests found in the state, with oak/hickory being the most common (Figure 3). Ohio's forests are growing over 4.1 billion trees (Figure 4), which include approximately 100 species of hardwoods and 25 species of softwoods. The most abundant in number across diameter classes are the hard maples (sugar and black) and soft maples (red and silver), followed by ash, the red oaks and white oaks, yellow-poplar, and hickory. Maples are becoming more predominant in the lower diameter classes.

Figure 1. Ohio's forested acres.

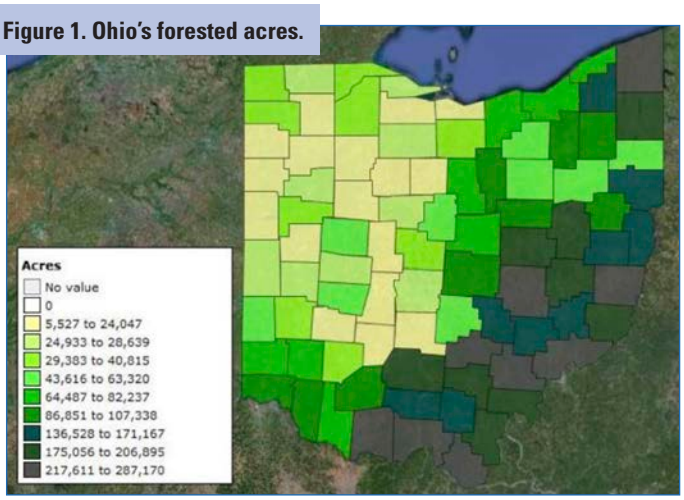


Figure 2. Ownership of Ohio's forestland.

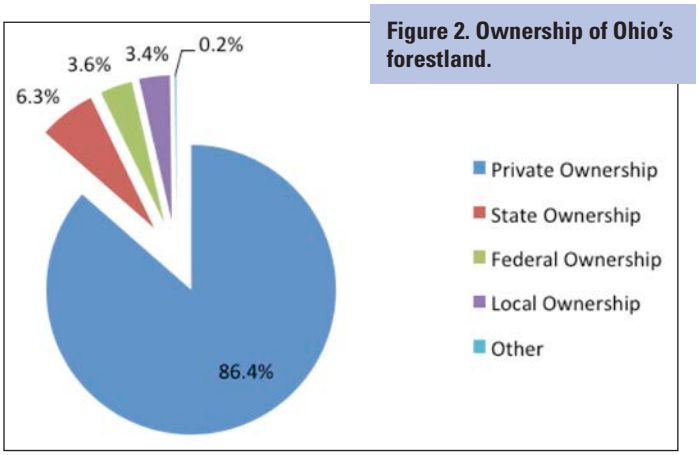


Figure 3. Distribution of Ohio's forest types.

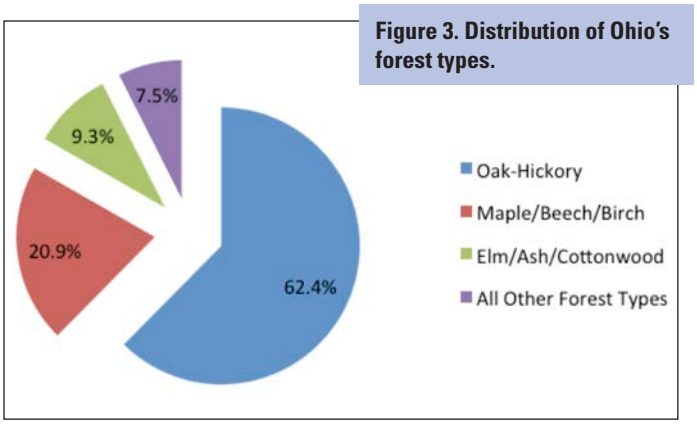
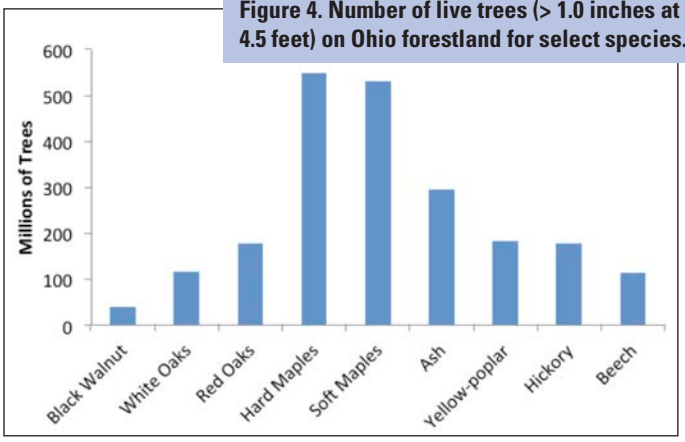


Figure 4. Number of live trees (> 1.0 inches at 4.5 feet) on Ohio forestland for select species.



Timber Volumes

Not all forestland is capable of timber production. Timberland is forestland capable of producing at least 20 cubic feet of wood per acre annually[1]. Approximately 20 tree species comprise the majority of Ohio's timber volume. Growing stock is all live trees of commercial species from seedling to sawtimber. Sawtimber is trees meeting the minimum size requirements for producing lumber. Timber volumes are often reported on a net basis, which is gross volume minus deductions for cull.

Growing stock has increased from 3.9 billion cubic feet in 1952 to 13.9 billion cubic feet in 2010. In 1952 there was an estimated 14.4 billion board feet of sawtimber. By 1991, the inventory had increased to 30.4 billion board feet. Now, it has eclipsed 50.0 billion board feet (Figure 5).

Growth and Removals

An estimated 204 million cubic feet of growing stock, including 807 million board feet of sawtimber, grew in Ohio's forests in 1952. The 1991 survey found 293 million cubic feet of wood was being grown annually in growing stock, counting 960 million board feet of sawtimber. The 2010 survey indicated the net growth of growing stock had increased by 100 million cubic feet while sawtimber net growth had doubled to 1.86 billion board feet of wood per year. Overall, the ratio of net growth to removals for all growing stock was 2.13:1.00, which means Ohio's forests are growing more than two times the volume of timber being removed (Figure 6). The ratio of net growth to removals for all sawtimber is 2.49:1.00, 33% higher than the 1991 ratio of 1.86:1.00 (Figure 7).

Timber Prices

There are ten commercial hardwood species recorded in the Ohio Timber Price Report, which dates to 1960 and is currently conducted twice annually by OSU Extension. Data are gathered for three regions (Figure 8) on the prices paid for standing timber, or stumpage, and delivered sawlogs to wood-using facilities on a per thousand board feet (MBF) basis using the Doyle Log Scale. The regions are based upon both forestland distribution (Figure 1) and prevailing local market conditions.

Participants in the Ohio Timber Price Report survey include foresters, timber buyers, loggers, wood dealers, and mills. Timber prices are generally, but not always, lower in southeastern Ohio compared to the other regions. An abundant supply is available, largely accessible, and of appropriate quality for maintaining mill production. More information regarding current prices and the timber price report can be found at **www.ohiowood.osu.edu**.

Properly managed timber can be a sound investment for landowners looking for long-term security. The real

Figure 5. Ohio timber volumes. Growing stock is represented on the left Y-axis and sawtimber is represented on the right Y-axis. Note the scales are different.

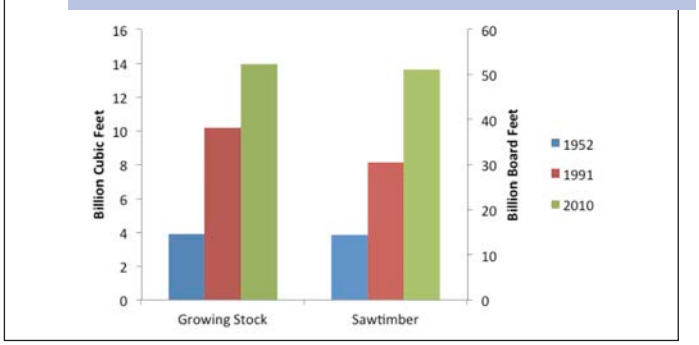


Figure 6. Annual net growth and removals for Ohio growing stock.

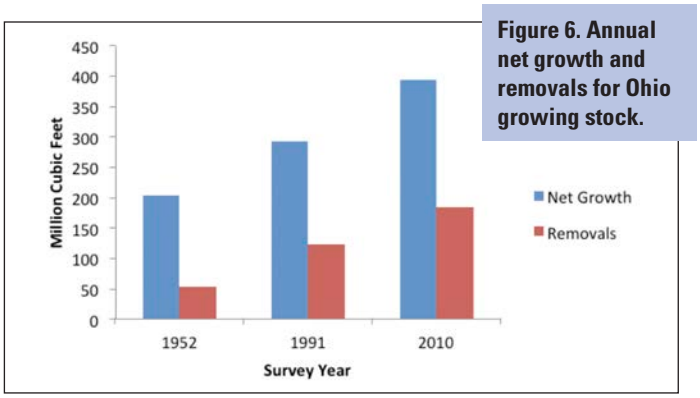


Figure 7. Annual net growth and removals for Ohio sawtimber.

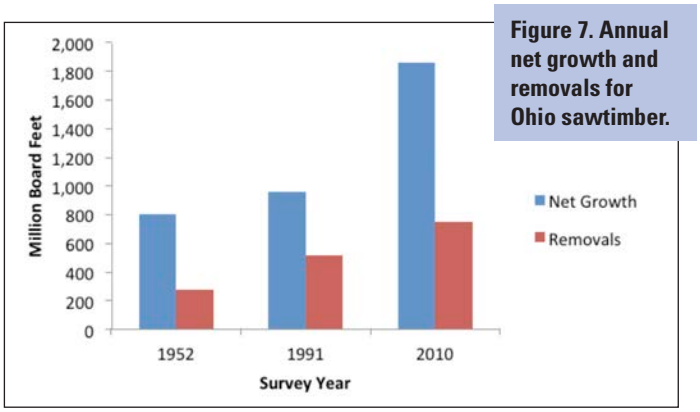
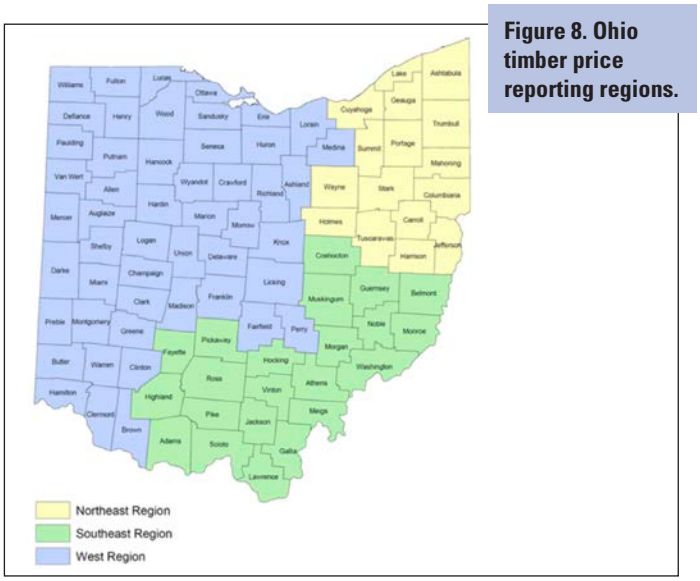


Figure 8. Ohio timber price reporting regions.



prices for stumpage, those adjusted for inflation to base year 1982, have been increasing statewide at an annual percentage rate of between 0.5 and 1.5% for many species since 1960. Regional rates of change have often been higher in southeastern Ohio over the 52 year reporting period. Real prices at the state level for some species have been declining since the mid-1990s.

Real sawlog prices across the state have largely only been increasing for the higher quality logs since 1960. This can be attributed to numerous factors, including rising harvest and delivery costs, among others. Please contact the School of Environment and Natural Resources at The Ohio State University for detailed descriptions of price trends by species.

Ohio's Forest Products Industry

The forest products industry consists of 26 individual sectors in Ohio, which can be aggregated into four groups—resource, solid wood products, pulp and paper, and wood furniture (Table 1). Tertiary sectors, such as support activities for agriculture and forestry, printing and publishing, and others, were not included due to their degree of separation from the direct production and manufacturing of wood and timber-based products.

Additional tree-based products, while important to the economic base of Ohio, were also excluded. Short rotation woody crops and Christmas trees are classified differently by the U.S. Census Bureau, as those products are generally grown over much shorter cycles than timber and use different production processes. Collecting, reducing, and concentrating maple sap for syrup is considered an agricultural food-based industry.

Determining Economic Impact

One way to estimate economic impact is through input-output analysis. Input-output analysis follows commodity flows through each stage of production from producer to consumer. This tracks how the products manufactured by one business are used as inputs in another company or industrial sector.

Four measures are used to evaluate economic impact. *Employment* is the number of full-time and part-time jobs. *Labor income* is the sum of employee compensation (wages and benefits) plus proprietor income. *Value-added* is the sum of labor income, interest, profits, and indirect business taxes, which primarily consist of sales and excise taxes paid by individuals to businesses through normal operations. *Total output* is the total value of production measured as the sum of value-added plus the cost of buying goods and services to produce the product.

Economic impacts of an industrial sector are reported three ways. *Direct impacts* are those generated by the industry of interest through employment, value-added, and industrial output. *Indirect impacts* result from the purchasing of goods and services by the industry being studied to meet its demands. This activity results in employment, value-added, and industrial output for supporting businesses. *Induced impacts* are the changes produced from the purchasing of goods and services by households as a result of changes in employment and/or production levels. Summing these effects provides the *total impacts*.

Taxes include those paid to (1) state, county, and municipal governments and (2) the U.S. federal government. These taxes are generated from labor income, indirect business taxes, households, and corporations associated within the forest products industry. State and local taxes include dividends, social security, indirect business, corporate profits, personal taxes. Federal taxes include social security, indirect business, corporate profits, and personal taxes.

Impact Analysis for Planning (IMPLAN®), an economic impact analysis software package distributed by the Minnesota IMPLAN Group, was used to conduct an input-output analysis of Ohio's forest products industry. IMPLAN® was originally used by the U.S.

Table 1. IMPLAN model forest products industrial sectors.

Industry Group	Individual Sectors
Resource	Forestry, forest products, and timber tract production; Commercial logging
Solid Wood Products	Sawmills and wood preservation; Veneer and plywood manufacturing; Engineered truss member manufacturing; Reconstituted wood product manufacturing; Wood windows, doors, and millwork manufacturing; Wood container and pallet manufacturing; Manufactured home manufacturing; Prefabricated wood building manufacturing; All other miscellaneous wood product manufacturing
Pulp and Paper	Pulp mills; Paper mills; Paperboard mills; Paperboard container manufacturing; Coated and laminated paper, packaging paper, and plastic films manufacturing; All other paper bag and coated and treated paper manufacturing; Stationery product manufacturing; Sanitary paper product manufacturing; All other converted paper product manufacturing
Wood Furniture	Wood kitchen cabinet and countertop manufacturing; Upholstered household furniture manufacturing; Non-upholstered wood household furniture manufacturing; Institutional furniture manufacturing; Office furniture; Custom architectural woodwork and millwork manufacturing

Forest Service for modeling the regional economic impacts of the national forests' management plans. It divides Ohio's economy into 440 industrial sectors. The data used by IMPLAN® for modeling are provided by agencies within the Departments of Commerce, Agriculture, and Interior.

Each industrial group, as well as the industry as a whole, was modeled collectively when determining economic contributions to prevent overestimating any indirect and induced impacts due to inter-sector transactions. Data for the year 2010 were used, and results were reported in 2010 dollars.

Industry Impacts, 2010

The direct impacts of Ohio's forest products industry are presented in Table 2. The industry employed 47,900 people and contributed $12.7 billion dollars in economic activity to Ohio's economy. New wealth created via value addition amounted to over $3.82 billion, with value-added broken into its individual components—employee compensation, proprietor income, other property type income, and indirect business taxes. Additionally, $200 million in state and local taxes and $527 million in federal taxes were directly generated.

The total effect of Ohio's forest product industry was much greater when the direct, indirect, and induced impacts of the sector on other industries were taken into account (Table 3). Over 118,000 people were employed in 372 sectors and paid $5.69 billion in labor income as a result of forest products activities. Of the total labor income, $1.70 billion was indirect and $1.40 billion was induced by industry and supply chain household purchasing. Industrial output totaled $22.05 billion, including $9.02 billion in value-added. Total tax impacts included $725 million in state and local taxes and $1.21 billion in federal taxes.

Resource Industries

The U.S. Census Bureau defines resource industries as those engaged in managing, harvesting, and delivering timber which has grown over long production cycles, that is at least 10 years. Industries in this group conduct business at varying stages of the management cycle. Timber production requires land that is available and appropriate for decades-long rotations. Nurseries grow seedlings for site regeneration. Forest management depends upon tree species, the growing conditions of the site, the production goals, and what the local forest products markets will support. Commercial logging includes businesses which harvest timber, harvest and deliver timber, and chip trees in the field for delivery. These businesses use specialized equipment to conduct harvesting operations. Resource industries initiate the forest-to-market process, and thus are critical to the overall health of Ohio's forest products industry (Table 4).

Table 2. Direct impacts of Ohio's forest products industry. Figures are rounded with dollars reported in millions.

Category	Employment	Output	Employee Compensation
Value	47,905	$12,753	$2,435

Category	Proprietor Income	Other Property Type Income	Indirect Business Taxes
Value	$153	$1,122	$114

Table 3. The total impacts of the forest products industry on Ohio's economy. Figures are rounded with dollars reported in millions.

Impact Type	Employment	Labor Income	Value-Added	Output
Direct Impact	47,905	$2,589	$3,826	$12,753
Indirect Impact	32,148	$1,702	$2,679	$5,132
Induced Impact	37,978	$1,401	$2,511	$4,164
Total Impact	118,031	$5,693	$9,017	$22,050

Table 4. The total impacts of resource industries on Ohio's economy. Figures are rounded with dollars reported in millions.

Impact Type	Employment	Labor Income	Value-Added	Output
Direct Impact	2,703	$53.9	$109	$255
Indirect Impact	820	$26.1	$56.1	$99.3
Induced Impact	725	$26.5	$47.7	$79.0
Total Impact	4,247	$106	$212	$434

Solid Wood Products Industries

These industries produce a variety of wood products. Harvested timber is normally taken to sawmills to be processed into lumber as a first step in its utilization. Lumber is often the primary raw material for other secondary manufacturing industries in this group, such as millwork and pallets. Some lumber also travels to a treating facility, where it is pressure-treated with wood preservatives.

The highest quality logs are sliced into thin sheets at a veneer plant. Lower quality logs may be minimally processed into ties and timbers. They can also be broken down into smaller wood pieces and reconstituted to form wood composite panels and beams (Table 5).

Pulp and Paper

Pulp and paper businesses are the largest industrial contributors to Ohio's forest economy. These industries thermally, chemically, and/or mechanically harvest cellulose from wood fibers, form and dry the cellulose into matted sheets, and then convert the sheets into value-added paper products. Many facilities often conduct multiple manufacturing processes to produce a variety of products. The primary subgroup obtains the pulped fibers from logs and forms the paper into sheets or paperboard while the secondary group purchases the sheets with other materials and designs and shapes them into finished products (Table 6).

Wood Furniture

Wood furniture industries are also considered secondary forest products manufacturing. Wood furniture businesses specialize in making pieces primarily from wood, although a number of other materials are required. Wood furniture is manufactured for households, offices, and institutions. Standard designs are often used but may be customized to suit individuals. Wood furniture can be upholstered, non-upholstered, and casegoods, such as cabinets and dressers.

Most furniture manufacturing facilities purchase kiln-dried lumber, although some may purchase green lumber and then dry it onsite. Production processes include working and framing wood members to the desired shapes. Consumer preferences play a large part in design and function as well as species and finish selections (Table 7).

Regional Forest Products Industry Activities

Many of the primary forest products manufacturers are located in southeastern and northeastern Ohio, nearer the forest resource (Figures 1 and 8). The industry, though, makes large contributions throughout the state's economy as secondary industries are often located closer to population centers.

The total impacts in employment and dollars were highest in the west (Table 8). Each economic indicator was at least 28% greater in western Ohio than in the other regions. The west has the largest economy of the three regions, and it includes several metropolitan areas. A greater number of transactions are captured within its regional economy and less leakage occurs out of it. Western Ohio collected $339 million in total state and local taxes; northeastern Ohio was next at $242 million followed by southeastern Ohio at $74.6 million. Western Ohio's total federal tax impact was $568 million; northeastern Ohio was next at $427 million followed by southeastern Ohio at $114 million.

Table 5. The total impacts of solid wood products industries on Ohio's economy. Figures are rounded with dollars reported in millions.

Impact Type	Employment	Labor Income	Value-Added	Output
Direct Impact	13,186	$513	$645	$1,970
Indirect Impact	7,081	$329	$481	$930
Induced Impact	7,454	$274	$493	$817
Total Impact	27,721	$1,117	$1,618	$3,718

Table 6. The total impacts of the pulp and paper industries on Ohio's economy. Figures are rounded with dollars reported in millions.

Impact Type	Employment	Labor Income	Value-Added	Output
Direct Impact	19,805	$1,410	$2,360	$8,759
Indirect Impact	22,166	$1,224	$1,938	$3,834
Induced Impact	23,340	$861	$1,543	$2,559
Total Impact	65,312	$3,496	$5,842	$15,153

Table 7. The total impacts of the wood furniture industries on Ohio's economy. Figures are rounded with dollars reported in millions.

Impact Type	Employment	Labor Income	Value-Added	Output
Direct Impact	12,211	$568	$696	$1,725
Indirect Impact	4,744	$224	$352	$649
Induced Impact	6,989	$258	$462	$766
Total Impact	23,944	$1,050	$1,511	$3,140

Table 8. Regional total impacts of the forest products industry. Figures are rounded with dollars reported in millions. Regions are based on those defined in the Ohio Timber Price Report.

Region	Employment	Labor Income	Value-Added	Output
Southeast	11,982	$511	$909	$2,564
Northeast	42,563	$2,066	$3,100	$7,431
West	54,412	$2,657	$4,275	$10,610

The industry's direct and total contributions to each region's economy, though, were largest in the southeast. The direct functions of labor income, value-added, and output in southeastern Ohio were at least two times larger than their roles in the other regions' economies (Figure 9). The industry's total measures of economic importance

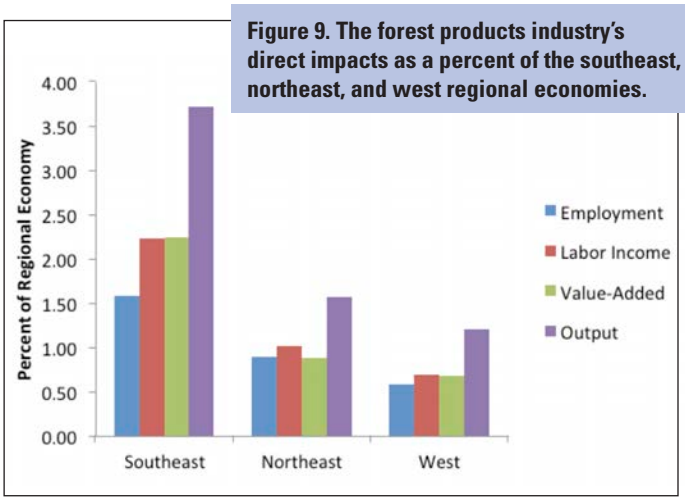


Figure 9. The forest products industry's direct impacts as a percent of the southeast, northeast, and west regional economies.

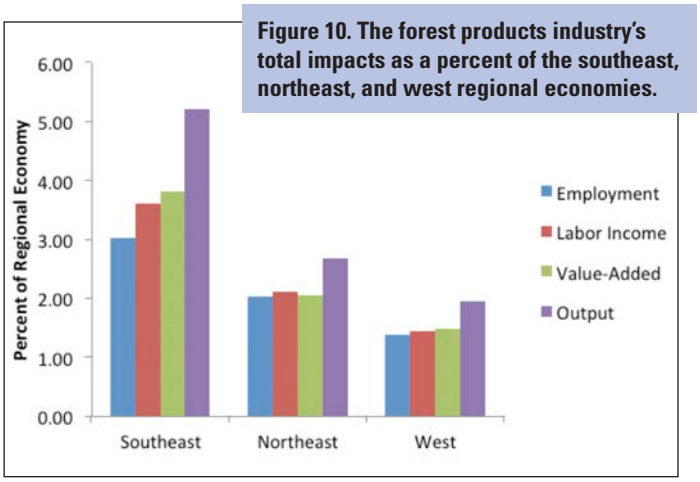


Figure 10. The forest products industry's total impacts as a percent of the southeast, northeast, and west regional economies.

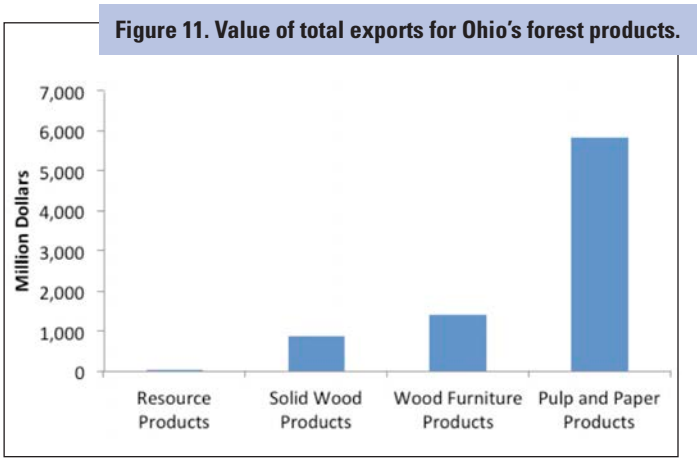


Figure 11. Value of total exports for Ohio's forest products.

in southeastern Ohio were all at least 1.5 times larger than in the other regions (Figure 10). The magnitude of these differences illustrates the significance of the forest products industry to southeast Ohio's economy.

Exports

Ohio exported $8.20 billion of forest products in 2010. Of that, $7.24 billion were exported domestically (to other states within the United States) while $964 million in products were shipped to foreign markets. Resource industries shipped $15.1 million out of state and $25.1 million out of the United States. Solid wood products processors sold $779 million to out-of-state markets and $104 million to foreign markets. Wood furniture manufacturers exported $1.27 billion domestically and $148 million internationally. Pulp and paper producers shipped $5.14 billion out of state and $685 million to foreign markets.

How Can I Learn to Better Manage My Woodland?

There are many ways to maximize the benefits our woodlands provide. Perhaps most important is to become actively involved in the stewardship of your property. Second, join your local forestry association. Discussing your strategies with fellow landowners and forestry professionals will make you more aware of the potential costs and benefits associated with particular management activities.

A good idea is to use the resources the state provides for optimally managing your woodland. Your local service forester can help you develop a management plan for your property. Your local Soil and Water Conservation District is available to provide soils information.

Preparing for a timber sale is often a once in a lifetime opportunity. Make certain you do your due diligence to ensure a successful experience. Enlist the assistance of a professional forester to help you maximize the potential of both your sale and the residual stand (**www.osafdirectory.com**). Finally, consider hiring an Ohio Master Logging Company to conduct your harvesting operation (**http://ohioforest.site-ym.com/?page=MLProgram**).

For More Information, Please Consult the Following Sources

School of Environment and Natural Resources

The Ohio State University
2021 Coffey Road
Columbus, OH 43210
Phone: (614) 688-3421
Web: **http://www.ohiowood.osu.edu/; http://woodlandstewards.osu.edu/**

Ohio Division of Forestry

2045 Morse Road, Building H-1
Columbus, OH 43229
Phone: (614) 265-6694, or toll free at 1-877-247-8733
Fax: (614) 447-9231
Web: **http://www.ohiodnr.com/DivisionofForestryHomepage/tabid/4803/Default.aspx**

USDA United States Department of Agriculture

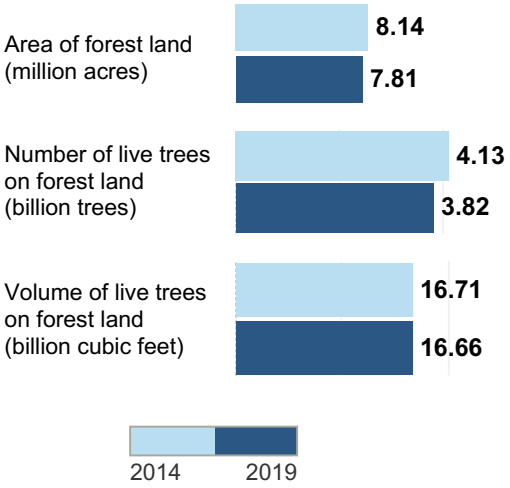
Forests of Ohio, 2019

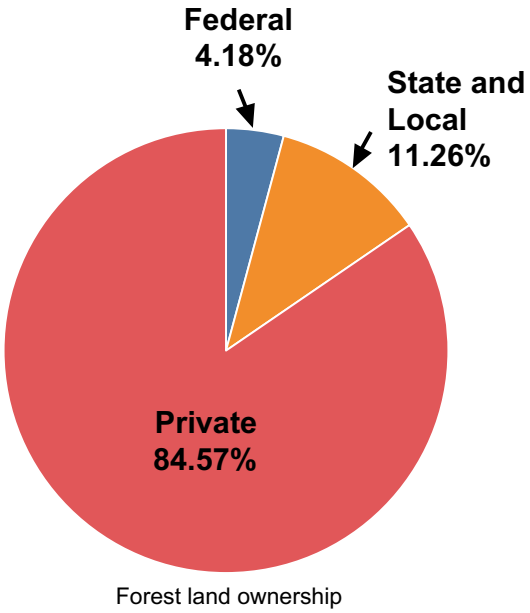
Ohio has an estimated **7,809,811** acres of forest land.

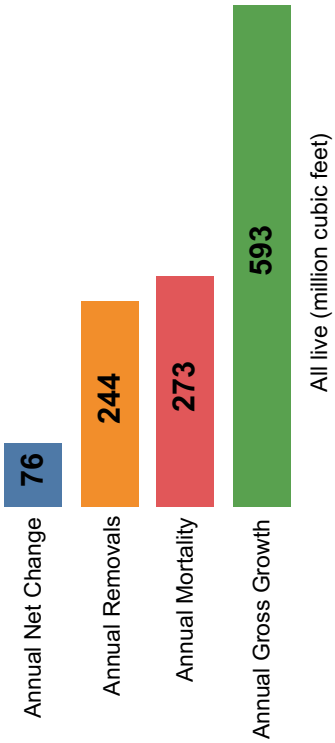
* Percent forest is forest area/total area. Percent forest with water removed from total area is 30%.

This resource update is a brief look at some of the basic metrics that describe the status of and changes to forest resources in Ohio. This information is based on field data collected using the USDA Forest Service Forest Inventory and Analysis (FIA) annualized sample design, and it is updated yearly.

Ohio has 4,206 sample plots across the State, of which 1,582 are currently forested. Each year, about 10-20 percent of these plots are visited and measured by field crews. Data used in this update were accessed from the FIA database on 09/17/2020.







25,001 acres of nonforest revert back to forest annually*

50,286 acres of forest land convert annually* to nonforest

98,216 acres of forest land are treated by cutting (harvest, thinning, etc.) annually*

1,340 acres of forest land are disturbed annually* by fire

27,033 acres of forest land are disturbed annually* by weather events

USDA Forest Service - Forest Inventory & Analysis

The estimates presented are based on data retrieved from the FIA database (09/17/2020) and may not reflect the most recent data available from the FIA program. Note – this publication does not include estimates of uncertainty. The most current data and sampling error for the estimates above can be found by visiting https://www.fia.fs.fed.us/.

*Average annual estimates are based on data collected across 5-10 years and may not be indicative of the nominal year presented in the title by itself.

F-60-06

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

School of Environment and Natural Resources, 2021 Coffey Road, Columbus, Ohio 43210

Enhancing Food (Mast) Production for Woodland Wildlife in Ohio

Dave Apsley
Natural Resources Specialist

Stan Gehrt
Wildlife Specialist

The term 'mast' was probably first used to describe a food source for domestic livestock. Webster defines mast as "the fruit of oak or beech or other forest trees used as food for hogs and other animals." When foresters and wildlife biologists use the term, they are referring to the woody plant (trees, shrubs, or vines) fruit used by wildlife for food. All tree and shrub species produce some type of fruit. The type of fruit varies greatly, but for many forest wildlife species, mast is an important source of food. In fact, the diets of squirrels and many other wildlife species consist almost entirely of mast throughout the year.

Hard and Soft Mast

Mast is often categorized as either soft or hard. Hard mast consists of hard shelled seeds that have a relatively long "shelf life" and are typically high in fat, carbohydrates, and protein. These characteristics make them a food source that is both high in energy content and available well into the winter months. For many Ohio wildlife species, hard mast is a key food source for survival during the winter months when other sources of nutrition are most limiting. Examples of hard mast include acorns, hazelnuts, hickory nuts, beechnuts, and walnuts. Table 1 provides a list of numerous Ohio hard-mast producers and wildlife that consume them.

Figure 1. Shagbark hickory nuts—A common hard mast found in Ohio forests.

Figure 2. Black cherry fruits—A common soft mast in Ohio forests.

Soft mast is fleshy, perishable fruit that is often high in sugar, vitamins, and carbohydrates. It is usually not available in great quantities in winter months. During drought years, soft mast may be a crucial source of moisture for some wildlife and their young.

Soft mast may also be a crucial energy source for some wildlife species during migration. Examples of soft mast include black cherries, persimmons, pawpaws, and blackberries. See Table 2 for a more comprehensive listing of soft-mast producers in Ohio.

The Key Is Diversity

All species of trees, shrubs, and vines produce some type of fruit, and most of these are consumed by wildlife. However, many of these tree species do not produce consistently abundant mast crops. For instance, some oaks only produce good seed crops at intervals of five or more years, while other species such as maple are more frequent mast producers. While the winged "helicopter" fruits found on maples are probably not the favorite food of any wildlife species, they are eaten by a variety of wildlife when other mast is not available. Additionally, some fruit is very perishable or readily consumed by wildlife. These fruits may only be available for a very short period of time. Serviceberry fruit, for example, is so highly preferred by songbirds that it is often gone within days of ripening.

Diversity of mast can also affect wildlife in your woodlot in other ways. For example, small mammal predation of songbird nests increases in years of bad acorn crops when there is little else to eat. Variety helps to ensure that food is available from season to season and from year to year.

Acorns from trees in the red oak group (red, black, scarlet, and pin oak) are more bitter than those in the white oak group (white, bur, chinkapin, and chestnut oaks). As a result, acorns from the white oak group are preferred by most wildlife species over those in the red oak group, and they are often quickly consumed in the fall months. Red oak acorns have a much longer "shelf life," which makes them available for consumption during late winter when other food sources are scarce. They also provide food in years when few white oak acorns are produced.

Encouraging a wide variety of tree, shrub, and woody vine species is one of the best ways to make sure there is always food available for wildlife on your property.

Enhancing Mast Production

Planting

The most obvious way to increase the variety of trees, shrubs, and vines on your property is to plant them. Planting is often a long-term proposition for many tree species (oaks may take more than 25 years to produce), but shrubs can produce mast within a few years. Since many plants are difficult to establish under shaded conditions, planting is usually most effective in open areas or on the edges of existing forestland.

Ohio's wildlife species are well adapted to utilizing mast from native plants as a food source, and there are hundreds of native trees, shrubs, and vines from which to choose. Each native plant species is well adapted to a limited range of soil and climatic conditions, but there are a variety of species to select from for nearly any site condition found in Ohio. It is important to understand the conditions found on your site and to select a species that is well adapted to that site. Take the oaks for example—pin oak and swamp white oak thrive in soils that remain saturated for much of the growing season, while other oaks such as black oak and chestnut oak do quite well under very dry conditions.

Non-native plants have evolved under different growing conditions and some are not successful in Ohio. On the other hand, there are numerous examples of non-native plants, such as multi-flora rose and Japanese honeysuckle, which have become overly aggressive and have displaced many of Ohio's native mast producers. Planting non-native species can actually have a long-term effect of reducing the diversity of mast-producing plants on your property. Native tree and shrub seedlings are available through the Ohio Department of Natural Resources (ODNR) Division of Forestry's nursery and numerous private nurseries in the region.

Mowing or Cutting

Shrubs (mostly soft-mast producers) and brambles can be maintained by cutting or mowing at approximately five-year intervals along woodlot borders. Many of these species are prolific sprouters and will regenerate rapidly following mowing or cutting.

Crop Tree Release

Another way that you can enhance mast production in your forest is by providing additional space for existing mast-producing trees that are being crowded by neighboring trees. This is an excellent way to increase soft and hard mast production in a relatively short period of time. Trees that are overly crowded grow slowly and often do not produce an abundance of flowers or fruit. Removing neighboring trees allows mast producers to expand their crowns, which provides more energy and a larger surface for mast production. See OSU Extension fact sheet F-50-02, *Crop Tree Management: A New Tool to Help You Achieve Your Woodland Goals* for information on how to increase the production potential of mast producers in your woods.

A Few Key Recommendations

Inventory your woods to determine the number and diversity of mast producers. This will help you to set realistic wildlife management goals for your property. After setting goals you can then work with a forester or biologist to determine which types of mast producers can be enhanced to help you accomplish your goals.

Strive to maintain as many hard-mast producers as practical. The ultimate goal would be to maintain 20 or more hard-mast producing trees (greater than 14 inches) per acre of woodland with a balance of about two trees in the red oak group for every one in the white oak group. When oaks and other hard-mast producing trees are limited, encourage diversity among soft-mast producers.

Maintain approximately two to three fruit-producing grape vines per acre on trees that are otherwise of little value for mast or timber production. Grapevines are often damaging to forest trees. They can rob trees of needed light, and make them more susceptible to damage from ice. However, they also provide excellent soft mast and cover for many species of wildlife.

Mow or cut approximately one-fifth of shrubby areas along woodland edges each year. This results in a range of ages of shrubby mast producers to help ensure consistent production of soft mast from year to year.

Plant a variety of native mast-producing shrubs and trees in areas where natural regeneration of these species is not likely to occur. Maintenance of newly planted seedlings by mowing and/or herbicide applications is usually needed to ensure acceptable levels of survival in the first few years after planting. In areas with high deer populations it also may be necessary to use tree shelters or other forms of protection while establishing plantings.

Control non-native invasive plants, such as, autumn olive, multi-flora rose, tree-of-heaven, and Japanese honeysuckle, when they threaten to out-compete native mast producers. Total elimination of non-native plants is often not attainable, but it is often possible to maintain a sustainable balance.

Consult with your ODNR Service Forester, ODNR Private Lands Biologist, or your Ohio State University Agriculture and Natural Resources Extension Educator for specific recommendations for your property. These natural resources professionals have experience and access to information that will help you to enhance the production of mast for wildlife on your property.

OHIO STREAM MANAGEMENT GUIDE

Forested Buffer Strips

Guide No. 13

Trees along streams are so vital to the integrity of streams in climates like Ohio's, they are given the name "forested buffer strips." This Ohio Stream Management Guide is designed to give landowners, land managers and volunteer groups general guidance on the creation, protection and enhancement of forest areas along streams.

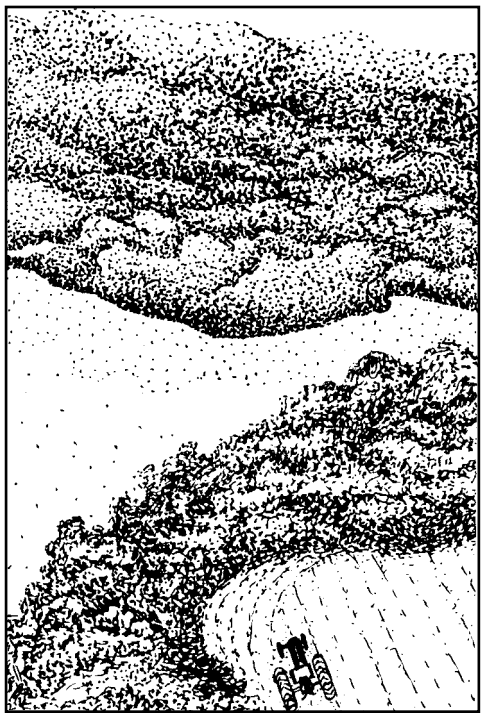


Figure 1. A forested buffer strip as seen from the air.

BENEFITS PROVIDED BY FORESTED BUFFER STRIPS

Streamside forests nurture Ohio's streams. The stream and it's adjacent land (riparian area) together form the most vital and diverse feature of Ohio's landscape. Without trees in this land-water transition zone, streams typically become wide and shallow, habitat is degraded and water quality drops.

Riparian ecosystems with forest vegetation:

- remove pollutants from stream flows during periods of over-bank flow;
- reduce water temperatures by sheltering and shading;
- provide wildlife habitat and protect and create aquatic habitat;
- provide detritus (leaves and woody debris), which is the basic source of energy for the stream ecosystem; and
- reduce streambank erosion through the high durability of tree root mass.

THREATS TO FORESTED STREAM BUFFERS

Encroachment — Meandering ribbons of trees often show up on aerial photos. Clearing trees has historically occurred last along streams and rivers leaving forested riparian strips winding through farm fields and suburbs. From a stream management perspective, we are fortunate that these areas are rough, steep and subject to flooding, making them generally less desirable for intensive land uses. However, most forested buffer strips only remain today because of decisions made independent of stream benefits. Until the importance of riparian areas is understood, forested buffer strips will be extremely vulnerable to encroachment as adjacent land uses become more intense. In fact, a major cause of buffer strip loss and stream degradation continues to be encroachment.

Overuse — Stream-side areas are often popular recreation areas, but overuse can reduce the integrity of the buffer through soil compaction and vegetation loss. High use can coexist with water quality objectives and damage limited by establishing trails and stabilized access points to the stream. Trails parallel to a stream should be set away from the banks. Provide viewing and lounging access to the stream through branches of trail which access the inside of meander bends.

Figure 2. A forested buffer between a stream and other land uses

This will minimize impacts and leave the critical vegetation on the outside banks undisturbed.

Grazing — Forested buffers are degraded by livestock. Not only is vegetation and soil damaged on the banks and uplands areas, but livestock trample and degrade the stream channel. Typical impacts include wide shallow channels with less cover, less shade, increased nitrates, increased turbidity, compacted soils and poor ground cover and understory. One Ohio study cited a 40% reduction in soil loss after livestock were fenced from a stream.

PROTECTING STEAMSIDE FORESTS

Define the Buffer Strip Width — Riparian areas are definitive land forms. They are transition zones between channels and uplands where the land influences the stream and the stream influences the land. It is in this zone that 'buffer strips' of forest vegetation have special importance for the quality of streams. Riparian areas correspond very well with the active flood plain. The active floodplain is the area that would become flooded if stream levels rose above the maximum bankfull depth (see Figure 3). Estimations of riparian area boundaries may also be based on floodplains identified on federal Flood Insurance Rate Maps. Lastly, county soil survey reports list soils 'subject to frequent flooding' which may help delineate some riparian areas.

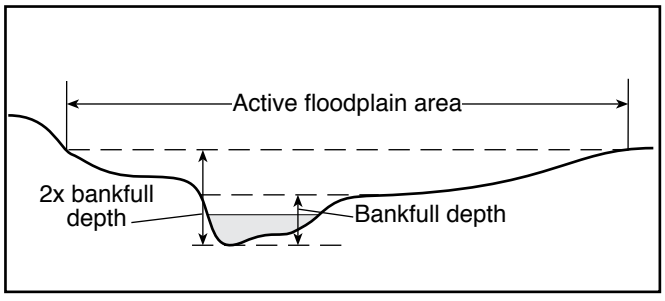


Figure 3. Buffer strip width defined by the active floodplain

It is not always feasible to base buffer strip width on the riparian area. For example, highly entrenched channels may have a riparian area hardly wider than the channel itself and in other places floodplains and riparian areas may be so extensive that encroachment is inevitable. For these conditions a generic minimum standard may be useful. One such standard is based on a dimension equal to two and one-half times the bankfull channel width or 50 feet, whichever is less (see Figure 4). This distance is then measured away from the bankfull channel to arrive at the standard buffer width.

Fence livestock from the stream — Stream fencing is a practice which keeps livestock away from the stream channel. Stream fencing projects often include stock tanks and water lines. Assistance for fencing livestock from streams may be sought through:

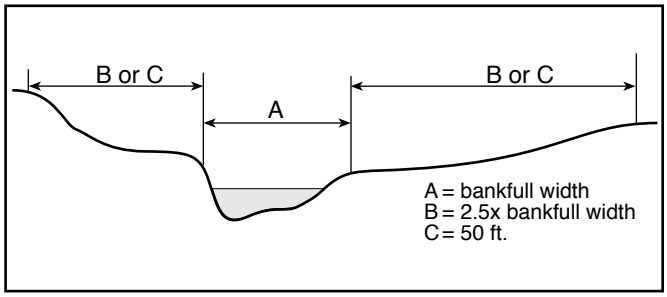


Figure 4. Buffer strip width defined by a minimum standard

- Ohio State University Extension, Grazing Coordinator, 614/ 397-0401.
- USDA-Natural Resources Conservation Service (NRCS), Grazing Coordinator, 614/ 653-1559.
- County offices for the NRCS and local Soil & Water Conservation Districts, listed under County Government in local phone directories.

Establish a Legal Easement — One of the best ways to protect riparian areas is to establish legal easements, also known as conservation easements. Easements allow you to protect your streamside forests without giving up ownership. An easement is a legal agreement that protects a land's conservation value by restricting certain actions which can be taken, even by future owners. Among other things, riparian protection easements can prohibit or restrict timber harvesting, pesticide spraying and development in the buffer strip. The landowner may receive or waive compensation. The easement is held by a legally qualified conservation organization (such as a land trust) or a government agency. Conservation easements can be tailored for each landowner and situation, so may differ from property to property.

The following private organizations and public agencies are among those who can provide you information or assistance in creating a legal easement:

- The Trust for Public Land, 612/ 338-8494
- American Farmland Trust, 202/ 659-5170
- Land Trust Alliance, 202/ 638-4725
- The Nature Conservancy, 614/ 717-2770
- Ohio Department of Natural Resources, Division of Natural Areas and Preserves, 614/265-6460
- Ohio Department of Natural Resources, Division of Soil and Water Conservation, 614/265-6637
- Soil and Water Conservation Districts, listed under County Government in local phone directories

Erect Visual Barriers — Easements alone are only lines on paper which have proven to be ineffective against encroachment. One study found that 90% of easement protected forested buffers had been encroached upon to some extent, with 45% severely degraded. Visual barriers such as fences or signs appeared to be most effective at stopping encroachment.

REFORESTATION METHODS

Allow Natural Regeneration — Simply establishing a preservation area or "no-mow" zone may be enough to allow natural forest regeneration if there are some trees nearby to provide a seed source. This may not work in areas without trees which have been farmed or have managed turf. Areas with intrusive species or dense turf may require some site preparation to improve regeneration potential.

Transplant Woody Plants — A number of sources for trees exist including commercial nurseries, the ODNR Division of Forestry, and compatible sites where you obtain permission to harvest plants. A list of flood tolerant tree species is found in Guide No. 08,Trees for Ditches. Planting dormant cuttings such as willow posts and stakes is discussed in Guide No. 07, Restoring Streambanks with Vegetation.

A combination of tree planting and natural regeneration may be a good choice for certain areas. For example, natural regeneration may be adequate for the majority of a buffer strip but trees may need to be planted adjacent to the stream to expedite streambank stabilization or to restore a tree canopy over the stream.

Species Selection:

- It is best to use a diverse mix of tree and shrub species with an emphasis on native species.
- Species should be mixed randomly across the site.
- In areas of partial shade, use a large proportion of shade-tolerant species.
- Ideally a mix of dominant tree species, understory trees and shrubs, and herbaceous plants should be planted.
- In open areas, it may be useful to mix hardier pioneer species (two-thirds) with later successional species (one-third) in recognition of the difficult environment for new plants.

Pioneer Species	Later Successional Species
Cottonwood	Swamp white oak
Box elder	Pin oak
Red maple	Black walnut
Ash (green)	Silver maple
Red osier dogwood	Hawthorn
Gray dogwood	Black haw viburnum
Silkey dogwood	Maple leaf viburnum
Sycamore	

Stocking Rates — Common reforestation stocking rates are 600 -1,000 seedlings per acre or 500 containerized stock per acre. If planting in the fall or in high use areas, seedlings are generally not recommended. Seedlings are best planted after the ground thaws and before April 14.

Soil Preparation — Depending on soil conditions, the site may benefit from pre-planting preparation, including lime and/or fertilizer, and disking or plowing.

Stabilization — A cover of annual grains such as wheat, rye or oats at 1 to 1 1/2 bushel per acre may need to be planted to temporarily stabilize soil during the establishment period. Perennial grasses are not recommended because of their competition with woody vegetation.

Maintenance — Within the first two years, monitor at least monthly during the spring and summer. Once per month in the fall and winter should be adequate. On these monitoring visits check the planted sites for soil moisture, competing vegetation, mulch and pruning needs; maintain as needed. Fertilizing is not recommended during the first two years of plant growth.

Competing Vegetation — Competing vegetation is a critical factor to monitor for during the first two years. Minimize competition from weeds and grasses through hand weeding where feasible, or mowing, mulching and use of selected herbicides.

References:

Mecklenburg, Dan, 1996, "Rainwater and Land Development, Ohio's Standards for Stormwater Management, Land Development and Urban Stream Protection," Ohio Department of Natural Resources.

Lewis, S., J. Kopec, D. Rice, 1991, "Ohio's Streamside Forests: The Vital, Beneficial Resource," The Ohio Department of Natural Resources, Division of Natural Areas and Preserves.

This Guide is one of a series of Ohio Stream Management Guides covering a variety of watershed and stream management issues and methods of addressing stream related problems. The overview Guide listed below, is intended to give the reader an understanding of the functions and values of streams. For more information about stream management programs, issues and methodologies, see Guide 05 Index of Titles or call the ODNR Division of Soil and Water Resources at 614/265-6740. All Guides are available from the Ohio Department of Natural Resources. Single copies are available free of charge and may be reproduced. Please contact:

ODNR
Division of Soil and Water Resources
2045 Morse Road, Bldg B
Columbus, Ohio 43229-6693

The guides are also available on-line as web pages and PDF files so you may print high quality originals at your location. You will find the guides on-line at:

http://www.ohiodnr.gov/soilandwater/

Prepared by the Ohio Department of Natural Resources, Dan Mecklenburg, Division of Soil and Water Conservation, principal author. Input from staff of several ODNR divisions, and local, state and federal agencies are used in the development of the Ohio Stream Management Guides. Funding for the production of the Ohio Stream Management Guides is provided in part through a federal grant under Section 319 of the Clean Water Act.

Guides are available on-line at: http://www.ohiodnr.gov/soilandwater/

2022 NCF-Envirothon Ohio

Forestry Study Resources

Key Topic 2: Tree Physiology and Ecology

4. Identify common Ohio tree species without the use of a key, and describe the species' ecological importance.
5. Define succession, and relate this process to different forest types.
6. Identify different parts of plant anatomy and describe their functions.

Study Resources

Resource Title	Source	Located on
Trees of Ohio Field Guide	*ODNR Division of Wildlife, 2019*	Pages 25-30
Leaf Shapes and Strategies	*The Pennsylvania State University, 2002*	Pages 31-32

Study Resources begin on the next page! ➡

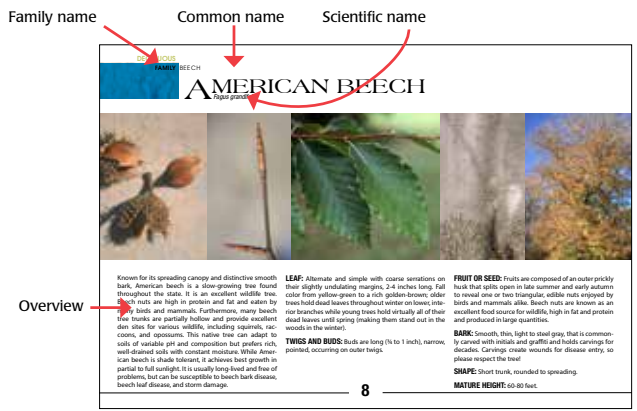
INTRODUCTION

Forests in Ohio are diverse, with 99 different tree species documented. This field guide covers 69 of the species you are most likely to encounter across the state. We hope that this guide will help you appreciate this incredible part of Ohio's natural resources.

Trees are a magnificent living resource. They provide shade, beauty, clean air and water, good soil, as well as shelter and food for wildlife. They also provide us with products we use every day, from firewood, lumber, and paper, to food items such as walnuts and maple syrup. The forest products industry generates $26.3 billion in economic activity in Ohio; however, trees contribute to much more than our economic well-being.

The more we learn about trees, the more we can understand, protect, and enjoy them.

HOW TO USE THIS BOOKLET



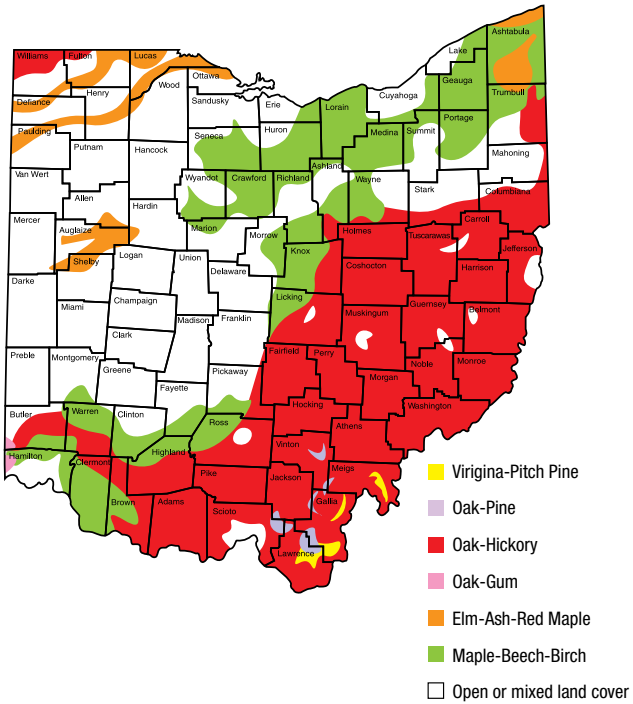
TREES OF OHIO

TABLE OF CONTENTS

THE HISTORY OF OHIO'S FORESTS

Prior to European settlement when Ohio's forests covered 95 percent of the state, it was said that a squirrel could travel from one corner of the state to the other without touching the ground. While that may be an exaggeration, forests of many types were abundant throughout the state. Elm-ash forests were dominant in the northwest Ohio swamp lands and streamside areas; mixed oak-hickory forests dominated the southeast Ohio hill country, and maple-beech forests were common in northeast Ohio and much of Ohio's current farm country. With the historical clearing of forestland followed by natural conversion of old fields back to woods, oak-hickory forests likely expanded their distribution. Currently oak-hickory forests are the most common forest type in the state at around 63 percent of all forests. A broader northern hardwood forest type that includes maple and beech is next in abundance, covering around 20 percent of Ohio's forestland. Elm-ash forests are still common in northwest Ohio and along streamside areas. However, with the introduction of the exotic beetle called the emerald ash borer into Ohio in 2003, most of Ohio's mature ash trees are dead or dying. The total area of forest land in the state has stabilized in the past two decades at around 30 percent of the total land area. The majority of forests are in the mid-successional stage and are dominated by trees that are often over a foot in diameter and 50 to 90 years old.

Significant clearing of forests occurred until the 1940s when only 12 percent of the land remained forested. Forest land has expanded to current conditions, where 31 percent of Ohio's land area is covered by forests.



WHY ARE TREES IMPORTANT FOR WILDLIFE?

SUCCESSIONAL FORESTS

Many wildlife species are reliant on forests to provide the basic habitat requirements of food, water, shelter, and space. Different species of wildlife require diverse habitat components and are dependent on various stages of forest succession, or ages, to meet their specific needs. Forests grow as plants develop and age towards maturity, and each state of succession offers different habitat assets. The early stages of a forest's life are just as important as the later stages, and provide much needed diversity in habitat.

Many people believe that older forests provide enhanced habitat opportunities for wildlife, and that the highest diversity of species would be found in these areas. While it's true that mature forests are home to many species, a variety of forest age-classes will do more to attract a wider diversity of wildlife.

Early successional, or young, forests produce an abundance of fruits and seeds, and provide shrub thickets for cover which attracts species such us common yellowthroats, eastern towhees, and bobcats. Mid-successional, or mid-aged, forests support species that use a wide range of habitats such us wild turkeys, indigo buntings, and white-tailed deer. Mature, or older, forests produce more acorns and nuts and provide snags and tree cavities for nesting which attracts species such us flying squirrels, pileated woodpeckers, and silver-haired bats. Even open areas with little woody vegetation produce seeds and insects for wildlife and provide herbaceous food and cover which attracts species such us eastern cottontail rabbits, field sparrows, and prairie warblers.

THE IMPORTANCE OF MAST

Mast is a term used to describe the fruit of a woody plant. The fruit is the part of the tree that contain the seeds and protects them until they can sprout in the ground. These fruits are categorized as either hard mast or soft mast.

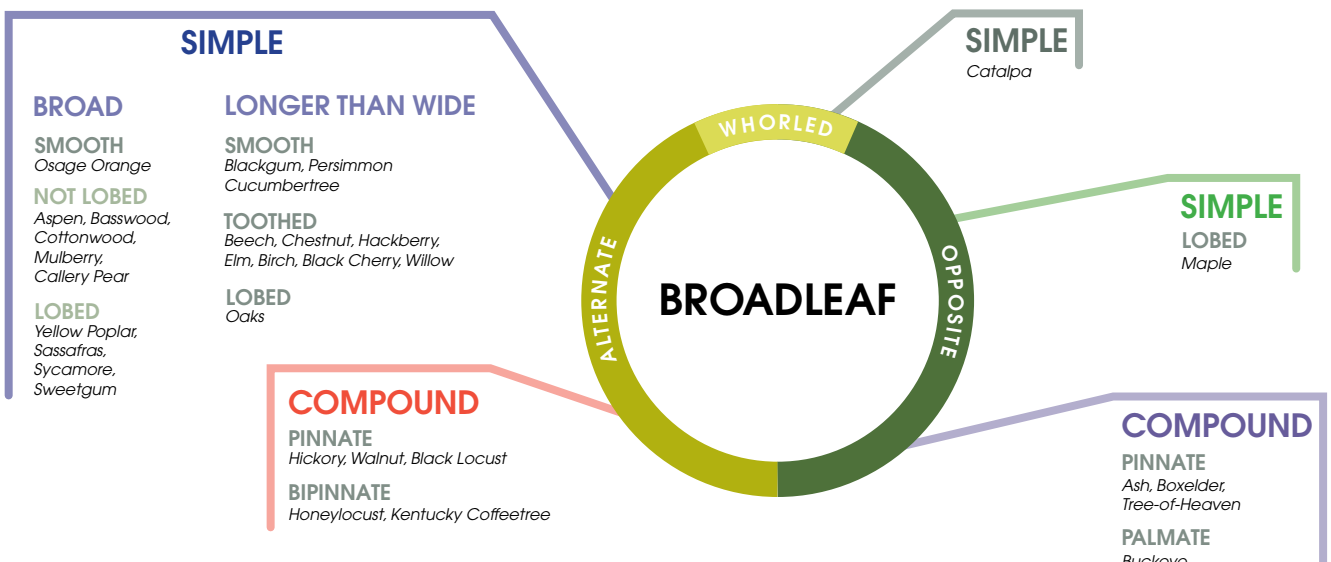
Hard mast are seeds with a hard outer covering, such as acorns, hickory nuts, and walnuts. Hard mast is an important food source for wildlife because it does not decay quickly, thus providing animals with nutrition throughout the winter. It is a good source of protein and fat which are important nutritional components. Trees require a large amount of energy to create hard mast, so they generally only produce a substantial crop every few years. Many wildlife species consume acorns, including some you might not think of, such as foxes and ducks. Oak-hickory forest is the most widespread forest type in Ohio and is an important habitat in the eastern U.S. However, poor oak regeneration in recent years is a cause for concern.

Tree species such as maple, poplar, and beech are increasing in abundance. These species grow faster than oaks and do not require as much sunlight, shading out smaller trees. Maples and poplars produce a fruit that is classified as soft mast, meaning it has a soft outer covering and decays quickly. It is usually high in sugar and carbohydrates which are not as important nutritionally. This makes it an unreliable food source during the winter, but it does serve as a good short-term energy source for migrating wildlife that pass through Ohio. Trees don't use as much energy to produce soft mast, so it is more readily abundant every year.

SQUIRRAL
BY NINA HARFMANN

BROADLEAF TYPES

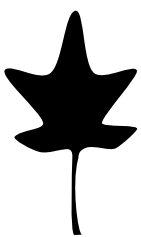
One of the most important tree identification concepts is leaf and branch arrangement. All of Ohio's trees can be placed into one of three categories: alternate, opposite, or whorled. In an alternate leaf and branch arrangement, there is one leaf or branch per plant node, and they alternate sides. In an opposite leaf and branch arrangement, two leaves or branches arise from the same node on opposite sides of the stem. Most Ohio tree species have alternate arrangement. To remember the few tree species that have opposite arrangement, use the mnemonic of MAD BUCK (maple, ash, dogwood, and buckeye). Another important concept is differentiating between simple and compound leaves. Simple leaves have a single leaf blade, while compound leaves consist of multiple leaflets. Once you have determined if a tree has alternate, opposite, or whorled leaf and branch arrangement, you can use the broadleaf diagram on the following page to further identify leaves.



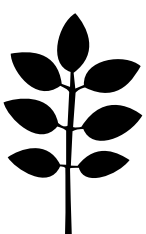
LEAVES & LIMBS

SHAPES

Lobed
deeply indented margins



Palmate
resembles a hand



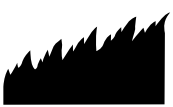
Odd Pinnate
leaflets in rows, one at tip

Bipinnate
leaflets also pinnate

MARGINS

Entire
even, smooth throughout

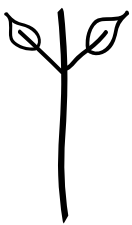
Spiny
teeth sharp
stiff points



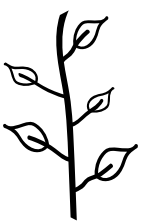
Doubly Serrate
serrate with sub-teeth

Serrate
teeth forward-pointing

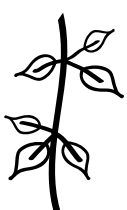
ARRANGEMENT



Opposite



Alternate



Whorled

GLOSSARY

alternate—only one bud or leaf found at each node

asymmetrical—uneven or unequal

blade—the broad or expanded part of the leaf

branching—*opposite:* occurs directly across from each other on both sides
alternate: occurs in a zigzag pattern along the branch but never directly across

broadleaf—usually deciduous hardwood tree, as opposed to conifer

bristle tip—a small hair on the pointed tips of leaves (such as red oaks)

bud—a structure containing dormant, beginning leaf or flower tissue

bud scales—protective, often overlapping structures, which cover dormant plant tissue

bundle scars—small mark inside the leaf scar indicating where the leaf vein connected to the stem

catkins—elongated, cylindrical flower cluster that usually lacks petals and is drooping, usually indicates unisex flowers

chambered—containing hollow opening

compound—having multiple leaflets on a common stalk

conifer—evergreen, cone-bearing trees

crenate—leaf shape having a round-toothed shape

drupe—fleshy fruit with a thin skin that develops around a central seed (such as cherries, plums, olives)

diaphragmed—partitioned by membranous structures

fascicle—bundle of conducting vessels

fruit—the seed-bearing organ of a plant, such as a nut, berry, and pome

globular—spherical in shape

husk—dry outer covering of fruits or seeds (such as walnuts and hickories)

lance shaped—narrow and tapering toward the tip

leaf-scar—mark left on twig where leaf was attached

leaflet—one of the blades or divisions of a compound leaf

lobed—divided rather deeply

margin—leaf edge

midrib—central or middle vein on a leaf

needle—a needle-shaped leaf such as a pine needle

node—place on twig that bears one or more leaves

opposite—two leaves found at each node

ovate—leaf or leaflet is widest below the middle (that is, closer to the top of the petiole)

palmate—with multiple leaflets, arranged in a pattern that resembles fingers radiating from a hand

parallel—veins that extend in the same direction and do not cross

petiole—stem supporting a leaf with a single blade

pinnate—with multiple leaflets, arranged in a pattern that resembles a feather, leaflets are attached to a central axis or rachis

pith—center of stem or twig; often soft or spongy

pubescent—covered with short soft hairs

rachis—the central stem of a compound leaf to which leaflets are attached

serrate—toothed or notched on the leaf edge

simple—having one leaf blade

sinus—rounded depression between lobes

spur—a short stout branchlet

stipules—leaflike structure found at the base of a leaf petiole

symmetrical—even or equal on opposite side

thorn—a sharp pointed outgrowth on a plant

twig—a small outgrowth on a stem

valvate—petals or leaves that have adjacent edges but do not overlap

veins—tissue that forms the framework of a leaf

whorled—three or more leaves or buds present at each node

What is a leaf?

To a plant, leaves are food producing organs. Leaves "absorb" some of the energy in the sunlight that strikes their surfaces and also take in carbon dioxide from the surrounding air in order to run the metabolic process of photosynthesis. The green color of leaves, in fact, is caused by an abundance of the pigment "chlorophyl" which is the specific chemical agent that acts to capture the sunlight energy needed for photosynthesis. The products of photosynthesis are sugars and polysaccharides. An important "waste product" of photosynthesis is oxygen. To an animal, a leaf may be a food source or a place to live on or under (i.e. a "habitat").

What kinds of leaves do we see on the trees found on the Nature Trail?

The leaves found on the trees of the Nature Trail are either broad and flat (like oak leaves) or needle-shaped (like red pine needles). Both kinds of leaves are photosynthetic organs and both kinds of leaves can serve as food or as habitat for a great variety of other organisms.

Why do tree leaves have different shapes?

The shape of a tree's leaves are a response to the tree species' long term ecological and evolutionary histories. An ecosystem's limiting factors may also modify the finished form and shape of a tree's leaves. Understanding of the "logic" behind the varied forms of leaves is facilitated by a firm grasp of the precise functions a leaf must accomplish.
1. A leaf must "capture" sunlight for photosynthesis (and as it does this it may also absorb a great deal of heat!)
2. A leaf must take in carbon dioxide from the surrounding air via pores (called "stomatae"). This carbon dioxide is also needed for photosynthesis. When these leaf stomatae are open to allow the uptake of carbon dioxide, water from inside the leaf is lost to the atmosphere.
The leaf, then, is affected by these balancing acts: enough sunlight and carbon dioxide to run photosynthesis, but not too much associated heat absorption or water loss.

How does this "balancing act" influence the ultimate expression of a leaf's shape?

Leaves high in the tree canopy receive a great deal of sunlight. These leaves tend to be smaller in size (and, therefore, have reduced light absorptive surface area) and tend also to have complex edges and lobes (which enables them to disperse absorbed heat very rapidly). Leaves in the lower tree canopy are more shaded. These lower canopy leaves tend to be larger (more light absorptive surface area) and tend to have reduced expressions of lobes and edges. These trends may be observed in comparing the leaves of high canopy trees (like oaks) to the leaves of low canopy trees (like dogwoods), or they can also be observed in an individual tree that has leaves in both the upper and lower canopies (the white oak, for example). In the white oak the smaller upper canopy leaves are also noted to allow significant amounts of light to pass through the upper canopy in order to keep the lower leaves supplied with sufficient light to allow their continued photosynthesis.

Needle-shaped leaves have a very low light absorptive surface area. Each needle, then, is not able to capture very much sunlight energy for photosynthesis. Needles also have a very thick, outer cuticle coating and special "pit-like" stomatae designed to prevent excessive water loss. Trees with needle-shaped leaves are especially well suited to site's that have drier soils and to climates in which the careful conservation of water is an important survival

strategy. Needle-shaped leaves also differ from broad leaves (in our climate zone anyway) in that needles last for three or four years while broad leaves only "live" for a single growing season. These 'evergreen" needled trees, then, have a great advantage over the "deciduous" broad leafed trees in that the metabolic cost of the leaf's synthesis can be recovered via photosynthesis over several growing seasons. Also, the continuous presence of the needles means that whenever environmental conditions are sufficiently moderate (even in the middle of winter!) the needles can photosynthesize and thus gather energy for the tree! A study in Germany compared energy production in beech trees (which have broad, flat leaves) and Norway spruce trees (which have needles). It was found that the beech trees photosynthesize for 176 days in a year while the Norway spruce photosynthesize 260 days in a year! The bottom energy line was that with this increased time base for photosynthesis, the smaller leafed surface area of the Norway spruce was actually 58% more productive than the beech!

Are the arrangements of leaves on a tree always the same?

There are two basic arrangement patterns of leaves on a tree: "mono-layer" and "multi-layer". In a mono-layer arrangement the leaves are arrayed so that no leaf is above and, therefore, shading any other leaves of the tree. This is the leaf pattern seen in the shade dwelling under story trees like the dogwood. In a multi-layer arrangement there are leaves above and below other leaves on the tree. This is the pattern seen in trees which extend u into the upper stories of a forest canopy. The light-rich upper leaves (as previously mentioned) tend to be smaller and more lobed than the lower. This leaf shape facilitates heat loss and prevents extreme self-shading.

This page was last updated on July 12, 2009

Thank you for visiting Penn State New Kensington.
Web Coordinator

2022 NCF-Envirothon Ohio

Forestry Study Resources

Key Topic 3: Forest Pests and Invasive Species

7. Identify common Ohio forest pests and describe their impact to forest health and local ecosystems.
8. Explain prevention and treatment strategies for common Ohio forest pests.
9. Identify common invasive species, describe their life cycle, and explain how they impact forest ecosystems.
10. Apply management strategies for prevention and eradication of invasive species to field scenarios.

Study Resources

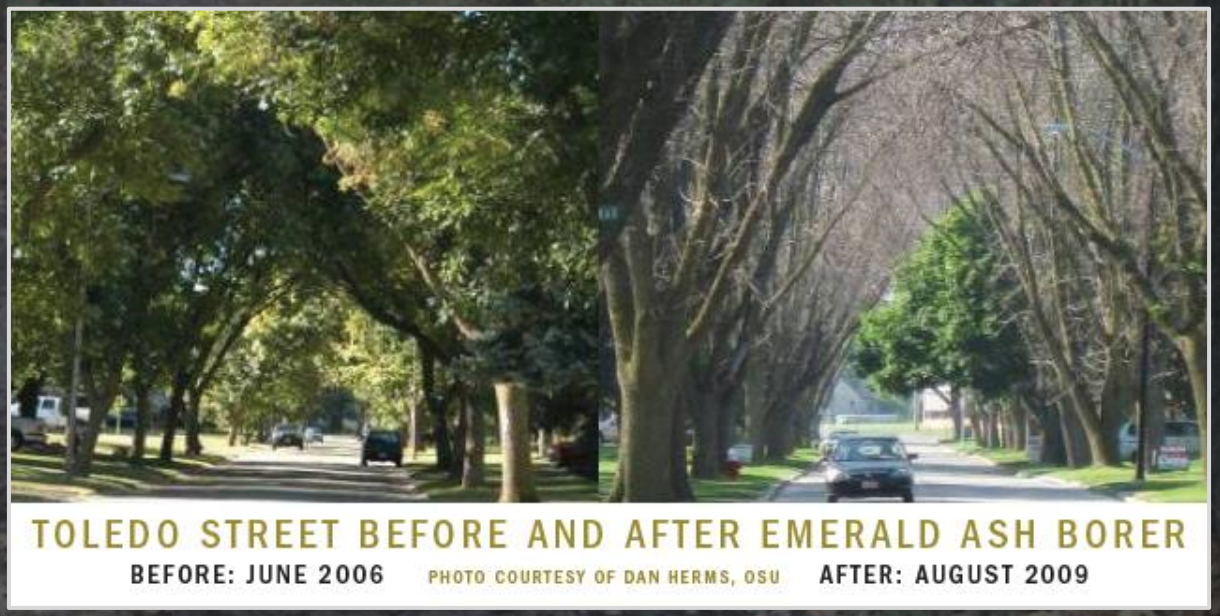
Resource Title	Source	Located on
Tree Pest and Diseases in Ohio	*Tom Macy, 2017*	Pages 34-42
Controlling Non-Native Invasive Plants in Ohio Forests: Bush Honeysuckle	*Smith, Kathy and Smith Annemarie, 2010*	Pages 43-48
Controlling Non-Native Invasive Plants in Ohio Forests: Ailanthus	*Smith, Kathy and Smith Annemarie, 2009*	Pages 49-54

Study Resources begin on the next page! ➡

Emerald ash borer (EAB)

History:

- Native to NE China, Korean peninsula, and E Russia
- Discovered in 2002 near Detroit, MI
- Probably imported to NA via shipping crates or pallets
- Dendrochronological analyses show EAB was established in SE MI by at least the early 1990s and trees were killed by 1998
- Has killed hundreds of millions of ash trees in NA



Emerald ash borer

Photo: Joe Boggs

Emerald ash borer

- Chemical treatment
- “Lingering ash”
- Biological controls

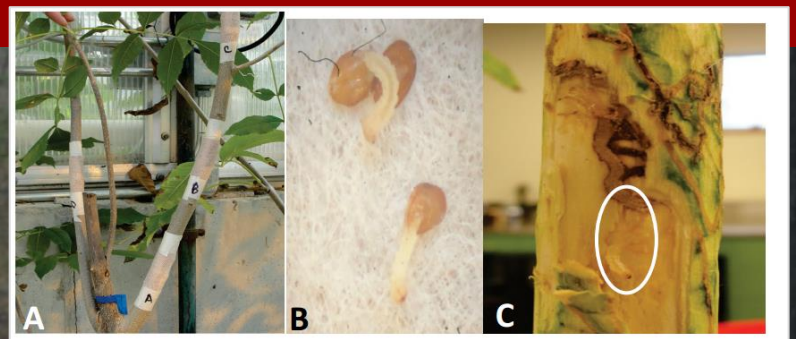


Figure 1—Development of emerald ash borer (EAB)-resistance screen. A. Coffee filters with EAB eggs are placed against the tree and covered with cheesecloth. B. Neonate larvae emerging from their eggs on the coffee filter. C. 3rd instar larva and gallery 6 weeks after egg hatch.

From: Koch et al. 2012

Photo: Houping Liu

Photo: Jian Duan

emeraldashborer.info

Hemlock woolly adelgid

- Tiny, aphid-like insect native to Japan (VA 1950s)
- Attaches to undersides of hemlock needles
- Woolly covering (<1/8” dia) October – June
- 2 generations/yr (100+ eggs laid per adelgid)

Hemlock woolly adelgid

- Killed millions hemlocks in Appalachians and New England
- Kills trees in 4-15+ years
- Spread by wind, wildlife (birds), people


Photo: Dave Apsley

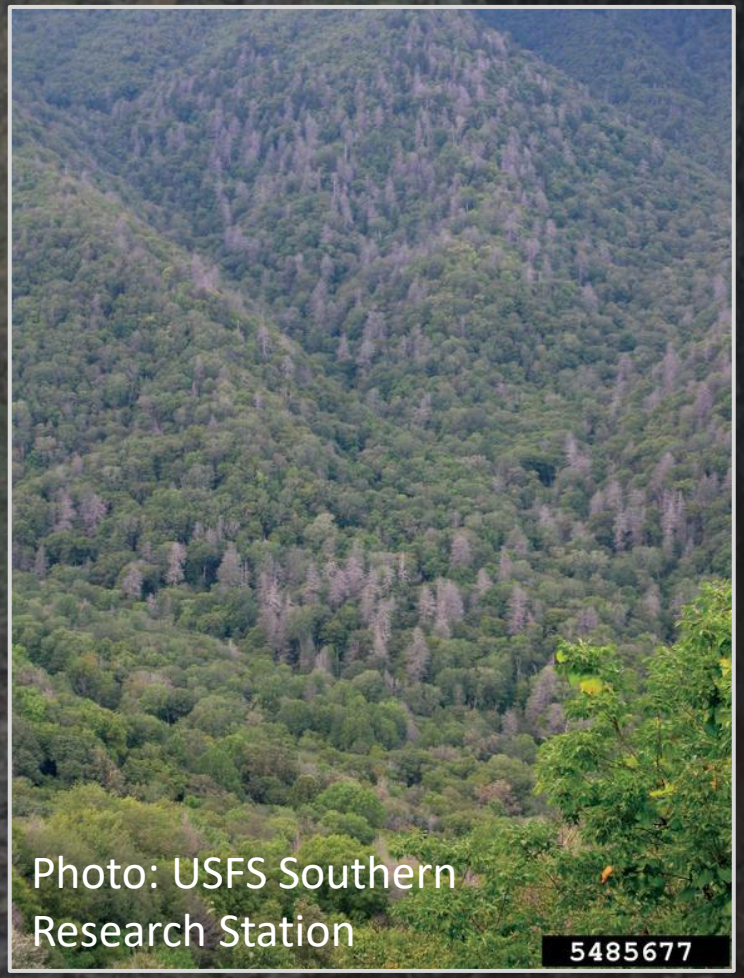
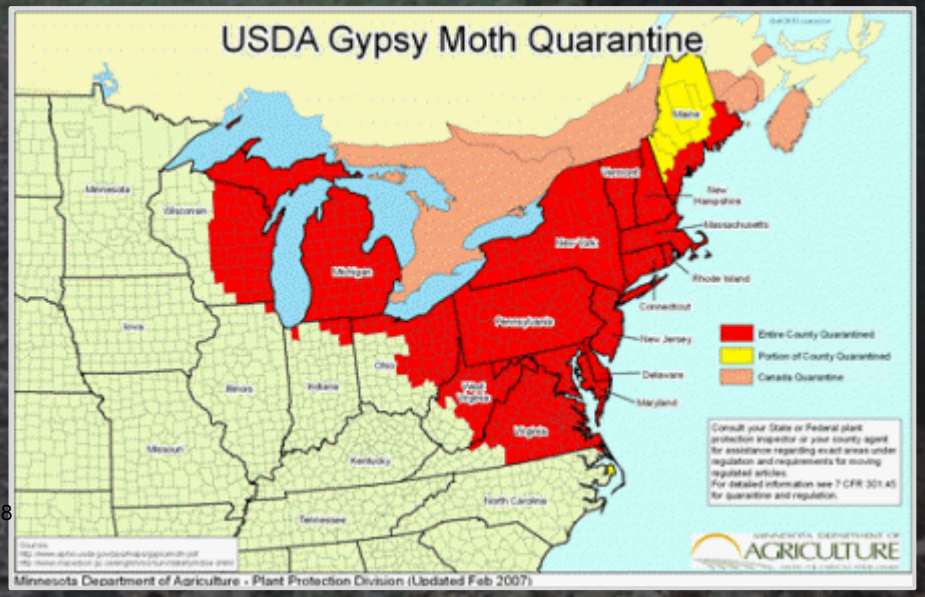


Photo: USFS Southern Research Station

Spongy moth

- Native to Europe
- Introduced to MA in 1860s
- Defoliates a of wide range of plants (>300 spp)
- Oaks are preferred host
- Slow the Spread Program



Asian longhorned beetle

- Native to Asia (China, Korea, Taiwan)
- First discovery – 1996, NYC
- 5 other sites since – all unique introductions
- Goal = 100% eradication
- Feeds on 12 genera:
  - **Maple**, buckeye, willow, elm, birch, ash, golden raintree, poplar, planetree, horsechestnut, mimosa, mountain-ash, katsura

Photo: Joe Boggs

Asian longhorned beetle

Photo: Joe Boggs


Photo: Ontario Ministry of Natural Resources and Forestry

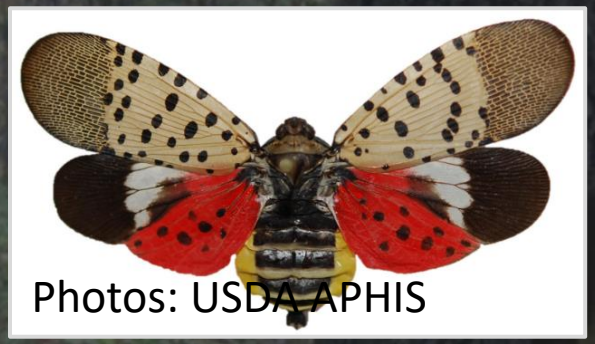
Photo: Steven Katovich


Photo: Rutgers University


Photo: Joe Boggs

Spotted lanternfly

- Discovered in SE PA in 2014
  - Ohio 2020
- Planthopper native to Asia
- Egg masses likely imported on stone
- Fairly large (1”) and colorful
- Many known host plants (including *Ailanthus altissima*, grape, and various fruit trees)
- Serious pest for grape orchards



Photos: USDA APHIS

Photos: Itchydogimages

FACT SHEET
Agriculture and Natural Resources

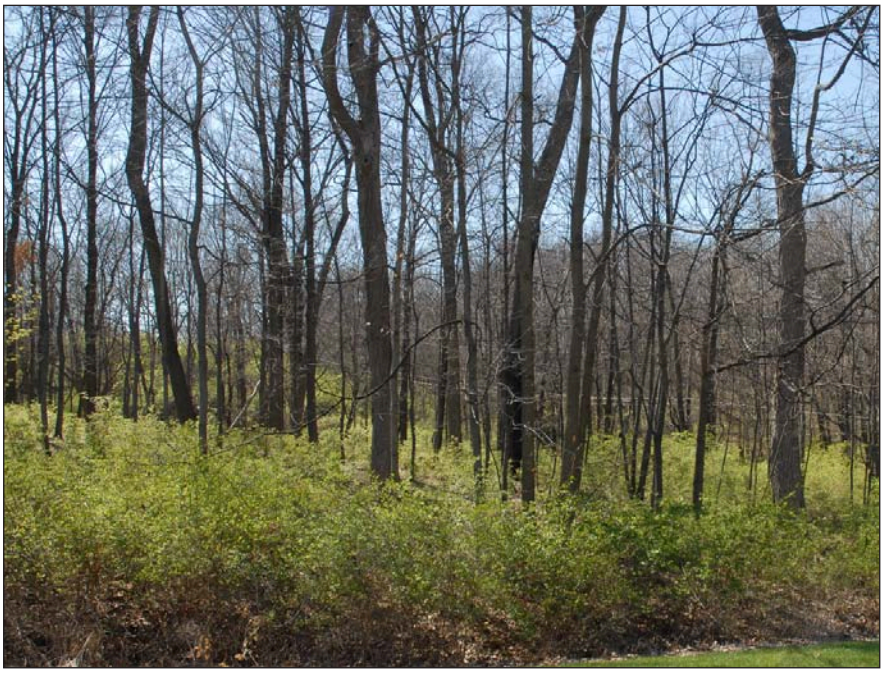
F-68-10

Controlling Non-Native Invasive Plants in Ohio Forests: Bush Honeysuckle

Kathy Smith, Extension Program Director–Forestry
School of Environment and Natural Resources

Annemarie Smith, Invasive Species Forester
Ohio Department of Natural Resources
Division of Forestry

Amur, Morrow, and Tartarian honeysuckle (*Lonicera* spp.)



Bush honeysuckles are one of the first plants to green up in the spring and easily dominate this woodland understory. *Photo by Kathy Smith, OSU Extension, School of Environment and Natural Resources.*

The species known as "bush honeysuckle" are upright deciduous shrubs with long arching branches, are commonly 6 to 20 feet tall, and have shallow root systems. They were first introduced into the United States in the mid to late 1800s from Europe and Asia for use as ornamentals, wildlife food and cover, and erosion control. These non-native plants thrive in full sunlight, but can tolerate moderate shade, and are therefore aggressive invaders of a variety of sites including abandoned fields, roadsides, right-of-ways, woodland edges, and the interiors of open woodlands. Honeysuckle out competes and shades out desirable

native woodland species, and can form pure, dense thickets totally void of other vegetation. Reproduction and spread is by both sprouting and seeds, which are disseminated primarily by birds. While honeysuckle fruit is abundant and rich in carbohydrates it lacks the high-fat and nutrient-rich content that most of our native plants provide migrating birds. Wherever invasive honeysuckle shrubs displace our native forest species there is a huge potential impact on these migrating bird populations due to the reduction in availability of native food sources.

The three most common bush honeysuckle species found in Ohio, Tartarian (*L. tatarica*), Amur (*L. maackii*), and Morrow *(L. morrowii*), can be distinguished from each other by characteristics of their leaves and flowers. Tartarian honeysuckle can hybridize with Morrow resulting in another invasive bush honeysuckle called Bella (*L.* x *bella*) or showy fly honeysuckle. This hybrid has characteristics of both parent plants making positive field identification difficult. However, for purposes of control, the non-native bush honeysuckle species can be considered as a group.

Identification

The bush honeysuckles leaf out earlier in the spring and retain their leaves later into the fall than most native trees and shrubs. To identify non-native bush honeysuckle look for a shrub with long arching branches and the following characteristics:

- **Leaves**—1 to 3.5 inches long without teeth, short stalked, arranged oppositely along the stem; dark green with abruptly long-pointed tip (Amur); or oval to egg-shaped, consistently hairy on the underside (Morrow), or lacking hair on the underside (Tartarian).
- **Stems**—grayish-brown, with short hairs on young stems; older, larger stems have broad ridges and grooves and appear striped; older stems are hollow (native honeysuckle has a solid stem).
- **Flowers**—fragrant tubular flowers (less than 1 inch long) appear along the stem in pairs from early to late spring; Amur and Morrow typically have white flowers that turn yellow as they age; Tartarian has pale pink to crimson flowers.
- **Fruits**—small (1/4 inch) round berries in clusters of 2 to 15; commonly red, occasionally orange to yellow. Fruit is produced from mid-summer through early fall.

Amur honeysuckle. *Photo by Annemarie Smith, ODNR Forestry.*

Honeysuckle fruit. *Photo by Kathy Smith, OSU Extension, School of Environment and Natural Resources.*

Tartarian honeysuckle. *Photo by Kathy Smith, OSU Extension, School of Environment and Natural Resources.*

Control Methods

When trying to control non-native invasive bush honeysuckle, there are several methods that may be considered. Which method is applied depends on the size of the plants, the size of the infestation, and a landowner's comfort level with the control method. The bush honeysuckles as a group are shallow rooted plants that leaf out before many of our native plants and lose their leaves after many of our native plants. Both of these characteristics give landowners some flexibility in their choice of control options. For a more detailed description of the methods covered below see OSU Extension's *Controlling Undesirable Trees, Shrubs, and Vines* Forestry Fact Sheet F-45 and *Herbicides Commonly Used for Controlling Undesirable Trees, Shrubs, and Vines in Your Woodland* Forestry Fact Sheet F-45 Supplement-06.

Environmental note: Many of the following herbicides are labeled to be mixed with a penetrating basal oil, diesel fuel, or kerosene as their carrier agent. The choice to utilize a methylated seed oil based basal oil instead of diesel fuel or kerosene will result in a more environmentally friendly practice. However, read the label to ensure using a basal oil is appropriate for the herbicide you have chosen.

Mechanical Control

If only a few small plants are present, they can be pulled, dug, cut, or mowed fairly easily. Pulling or digging of small plants is most effective if done following a rain and fairly easy since the plants are shallow rooted. Cutting and mowing is most effective when initiated in early summer when food reserves are at their lowest. In order to achieve control, pulling or digging must be done so that essentially every root is removed. While this is perhaps impossible, if it is repeated frequently, small honeysuckle shrubs can ultimately be eliminated once food reserves are exhausted. The key to this type of control method is to be vigilant.

Mechanical control alone is usually not a completely effective method of controlling medium to large bush honeysuckle shrubs. Simply cutting the shrub off at the base will cause prolific sprouting and increase the number of stems. An effective strategy for controlling mature bush honeysuckle will deaden both the above ground portion and the root system, which eliminates the potential for sprouting. This can be achieved most effectively through the use of herbicides.

When honeysuckle infestations are so dense that access to the area is limited, landowners may elect to use some mechanical means of

removing large plants and a large number of plants. Whether using a skid steer, tractor, or some other piece of equipment to pull the plant out of the ground, realize that some follow-up treatments will be needed. Care needs to be taken that any damage to the residual forest stand is minimal, and a follow-up application of a foliar herbicide should be applied when the remaining honeysuckle roots begin to sprout (see Table 1 for foliar herbicide options). Also, be cautious of the timing of removal. These types of removals may best be done when the ground is frozen or at a minimum when the ground is not wet. Removing vast amounts of plants may result in large areas of disturbed soil and care should be taken to minimize any erosion and compaction potential created when the plants are removed.

Foliar Spraying

Foliar spraying is a method of control in which diluted herbicide is sprayed directly on the leaves of the targeted plants. This can be a very effective method of controlling honeysuckle but should only be used when the target plants are within easy reach of the sprayer. Spraying directed at less accessible plants can damage or kill valuable non-target plants through herbicide drift or overspray. In addition, care needs to be taken to ensure that herbicides are sprayed to wet the foliage but not to the point of runoff.

Honeysuckle sprouts as a result of cutting off the shrub at the ground. A follow-up foliar herbicide application can now be applied. *Photo by Kathy Smith, OSU Extension, School of Environment and Natural Resources.*

Bush honeysuckle leaves remain green and active late into fall (mid to late October) when most native plant species have gone dormant. Foliar applications of some herbicides can be used at this time with little or no impact to non-target species especially after the first hard frost in the fall. Herbicides recommended for foliar spraying of bush honeysuckle are listed in Table 1.

Table 1: Herbicides recommended for foliar treatment of bush honeysuckle.

Herbicide	Example Brand Names	Comments[1]
glyphosate	Roundup, Accord, and other herbicides containing at least 41% glyphosate	Apply solution of 2% herbicide in water (vol/vol) when leaves are green; add a surfactant if not in herbicide.
2,4-D + triclopyr	Crossbow	Wet foliage and stems with 1–1.5 gallons Crossbow in 100 gallons water; spot spray with 0.25 pt (1/2 cup) Crossbow in 3 gallons water.
triclopyr	Garlon 3A, Tahoe 3A	Apply solution 3–5% (vol/vol) of herbicide in water when leaves are green.*
*A surfactant at .25% vol/vol rate may be added to the various triclopyr formulations when foliar spraying.		

[1]These comments are not intended to be a substitute for the herbicide labels. To ensure the safe and effective use of the herbicides recommended in this publication read the label and MSDS (Material Safety and Data Sheet).

Cut Stump Herbicide Treatment

Cut stump treatments are a very effective method for controlling many undesirable woody shrubs and work well on bush honeysuckle. This method involves cutting the shrub off close to the ground and applying an herbicide to the cut surfaces (and sometimes the bark) with a spray bottle, paintbrush, roller, or wicking device.

Whether to use an oil or water soluble herbicide depends on the timing of the herbicide application after the cut. Herbicides carried in water should be applied to the outer 1/3 of the top of the stump ***within minutes*** of making the cut.

Utilize an oil soluble herbicide when planning to cut and later return to treat the stumps. Apply the oil soluble herbicide to the entire top and sides of the cut stump but not to the point of excessive runoff. Apply anytime as long as the stumps are dry and not frozen.

Herbicides (both water- and oil-soluble) recommended for cut stump treatments of bush honeysuckle are listed in Table 2. Late summer, early fall, or dormant season applications have all proven to be effective. Avoid applications during sap-flow (spring) as this lessens the effectiveness of the herbicide application.

A basal application of herbicide needs to be made to the lower 12–18 inches of the honeysuckles' stems. *Photo by Kathy Smith, OSU Extension, School of Environment and Natural Resources.*

Basal Spraying

A basal application for bush honeysuckle refers to the spraying of a labeled herbicide mixed with an oil based carrier on the lower 12–18 inches of the stem. The herbicide is sprayed, ensuring that the stems are wet but not to the point of run-off. Basal treatments should only be applied when the areas to be treated are dry and not frozen. The basal treatments recommended in Table 3 should be applied during the dormant season

Table 2: Herbicides recommended for cut stump treatment of bush honeysuckle.

Herbicide	Example Brand Names	Comments[1]
glyphosate	Roundup, Accord, and others	Apply 20% active ingredient to outer third of cut stem/stump surface immediately after cutting.
2,4-D + picloram	Pathway, Tordon RTU	Apply undiluted to surface of cut stem immediately after cutting.
	Tordon 101	Apply undiluted or diluted 1:1 with water.
2,4-D + triclopyr	Crossbow	Apply solution of 4% Crossbow in diesel fuel, fuel oil, or kerosene.
triclopyr	Garlon 4, Garlon 4 Ultra, Tahoe 4E, Remedy, and others	Apply 20% Garlon 4 + 10% penetrate (e.g. Cide-Kick II) in diesel, fuel oil, kerosene, or basal oil (penetrate not needed with basal oil).

[1]These comments are not intended to be a substitute for the herbicide labels. To ensure the safe and effective use of the herbicides recommended in this publication read the label and MSDS (Material Safety and Data Sheet).

(winter or spring). Due to the arching nature of bush honeysuckle shrubs, access to the lower portion of the shrubs trunk is not always easy to achieve. Care should be taken to ensure that the chemical being applied is reaching the lower portion of the shrub's trunk and not merely being applied in its general vicinity.

Summary and Disclaimer

Label recommendations must be followed to maximize the potential for successful control. Just as important as the initial work is the follow up. Several of the treatments detailed in this fact sheet take time to completely deaden bush honeysuckle. Monitor treated plants for at least one year to determine if complete control is achieved. Any plants that re-sprout or are not completely killed by the first treatment will warrant a follow up treatment.

Herbicides, like all pesticides, are registered and approved (labeled) for specific uses by the Environmental Protection Agency. Approved uses and application methods are listed and described on the pesticide's label. The herbicides listed in this fact sheet were appropriately labeled at the time of publication. Because pesticide labeling may change at any time, you should verify that a particular herbicide is still labeled for your intended use. At the time of publication, copies of most herbicide labels and MSDS could be obtained online at the Crop Data Management System web site (**http:// www.cdms.net/manuf/manuf.asp**). Others are available through the individual manufacturer's web site.

Table 3: Herbicides recommended for basal spraying of bush honeysuckle.

Herbicide	Example Brand Names	Comments[1]
triclopyr + imazapyr	Garlon 4 and Stalker	Apply a solution of 15% Garlon 4 + 3% Stalker + 82% Ax-It basal oil mixed by volume.
triclopyr	Garlon 4, Garlon 4 Ultra	Apply a solution of 20% Garlon 4 in basal oil (Ax-It or Arborchem). Diesel fuel may also be used as a carrier but this requires that a 10% penetrant (such as Cide-Kick II) must also be added.
2,4-D + triclopyr	Crossbow	Apply a 4% solution of Crossbow in diesel oil, fuel oil, or kerosene.

[1]These comments are not intended to be a substitute for the herbicide labels. To ensure the safe and effective use of the herbicides recommended in this publication read the label and MSDS (Material Safety and Data Sheet).

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

extension.osu.edu
senr.osu.edu

Controlling Non-Native Invasive Plants in Ohio Forests: Ailanthus

F-65
Agriculture and Natural Resources
Date: 11/21/2013

Kathy Smith, Extension Program Director–Forestry, School of Environment and Natural Resources, The Ohio State University

Annemarie Smith, Invasive Species Forester, Ohio Department of Natural Resources, Division of Forestry

Ailanthus (*Ailanthus altissima*), also known as tree-of-heaven, is a moderate sized (60 to 80 feet in height), deciduous tree first introduced into the United States from Asia in the late 1700s for use as an urban landscape tree and in strip mine reclamation in the Eastern United States. In many ways ailanthus is an ideal invasive—it grows rapidly (sprouts can attain a height of 6 to 12 feet the first year and grow 3 feet or more per year), is a prolific seeder, a persistent stump and root sprouter, and an aggressive competitor that thrives in full sunlight. It also produces an allelopathic compound that suppresses the growth of many native woody and herbaceous species. It will grow in relatively infertile, shallow soils of varying pH, and is highly tolerant of poor air quality.

Identification

Ailanthus trees may be commonly mistaken for black walnut, sumac, or butternut. To correctly identify a tree as ailanthus look for a tree with:

- **Leaves**—pinnately compound, 12 to 36+ inches long, with 11 to 27 leaflets that are green on upper side and grayish green on lower side; leaflets long and tapered with lobed bases and smooth edges. Each leaflet has one to several glandular teeth near the base (Figure 1).
- **Twigs**—stout, light chestnut brown, smooth to velvety with large tan bumps (lenticels) and a spongy pith, heart-shaped leaf scars; easily broken.
- **Bark**—pale gray and smooth with vertical streaking that develops into light tan fissures with age.
- **Flowers**—in large terminal clusters (up to 20 inches) of small yellowish green flowers, appearing from April to June. Male and female flowers commonly on separate trees.
- **Fruit**—winged fruit (samara), color ranges from yellow green to reddish brown, containing single seed, born in clusters (panicles) visible from mid to late summer and often persistent until following late winter or spring (Figure 2).

Note: All parts of ailanthus have a strong offensive odor (particularly the male flowers), often described as smelling like rotting peanuts or cat urine.

Control Methods

Methods effective in controlling ailanthus depend on plant size, the size of the infestation, potential non-target impacts, and a landowner's comfort level with those methods. While not always easy to control, ailanthus less than 8 inches in diameter have proven considerably easier to control than larger trees. Small ailanthus trees, perhaps up to ½ inch to 1 inch in diameter, can be controlled by physical means or with foliar herbicides. Larger trees, up to about 8 inches in diameter, can be effectively controlled using basal herbicide application, with the need for occasional follow-up to control sprouting. Trees larger than 8 inches are commonly more difficult to control whether by basal spraying, cut stump herbicide application, or herbicide injections as all of these methods may result in a need for follow-up treatments to control sprouting. Frilling or girdling is not commonly recommended for killing ailanthus, as it almost always results in prolific sprouting. **Whatever method is used, it will be important to monitor treated areas to make sure that 100% control is achieved.** Any trees that survive the initial treatment should be re-treated along with any new sprouts or seedlings that appear. For a more detailed description of the methods covered below see OSU Extension fact sheet *Controlling Undesirable Trees, Shrubs, and Vines*, OSU Extension Forestry Fact Sheet F-45, and *Herbicides Commonly Used for Controlling Undesirable Trees, Shrubs, and Vines in Your Woodland*, F-45 Supplement-06.

Environmental note: Many of the following herbicides are labeled to be mixed with a penetrating basal oil, diesel fuel, or kerosene as their carrier agent. The choice to utilize basal oil (particularly a methylated seed oil) instead of diesel fuel or kerosene will result in a more environmentally-friendly practice.

Figure 1. Ailanthus bark, twig, leaf, and glandular teeth.

MECHANICAL CONTROL

Small infestations of small plants can be pulled, dug, cut, or mowed. Because none of these methods remove the entire tree (including roots) they must be repeated until food reserves are exhausted and the tree dies. Pulling or digging of small plants is most effective if done when the ground is moist. Cutting and mowing is most effective when initiated in early summer when food reserves are at their lowest. Again, the key to any mechanical control is to repeat frequently until the food reserves are exhausted.

Mechanical control is generally not the best choice when dealing with larger trees. Cutting large stems often stimulates the production of hundreds of sprouts. Control methods that follow are more effective in controlling larger plants or larger populations of smaller plants.

FOLIAR HERBICIDE

Foliar spraying is a method of control in which a dilute herbicide is sprayed directly on the leaves. Herbicides need to be applied sometime after the plant is in full leaf and before the onset of fall color in order to maximize effectiveness. Generally herbicides are applied to wet the leaves but not to the point of runoff.

Exercise caution when applying foliar herbicide. This method should only be used when the target plants are within easy reach of the sprayer. Spraying directed at taller or otherwise less accessible plants can damage or kill valuable non-target plants through herbicide drift or overspray. Herbicides recommended for foliar spraying of ailanthus in a forest setting are listed in Table 1.

BASAL BARK APPLICATION OF HERBICIDE

Basal bark applications are commonly used to control small to medium sized ailanthus by spraying the circumference of the lower 12–18 inches of the trunk with an herbicide in an oil carrier. This method is very effective in controlling trees up to 8 inches in diameter; larger trees can be controlled but research and experience is limited in regards to the success rate; therefore, follow-up treatments will be necessary if sprouting occurs.

Current research and experience suggests that basal bark treatments can be applied effectively May through October, and may be most effective in the later part of that window. Herbicides recommended for basal spraying are listed in Table 2. To avoid the unintentional killing of desirable plants when basal spraying, special care should be taken to avoid over-spraying (spraying that does not strike the targeted trunk) or excessive spraying to runoff. Basal bark treatments should only be applied when the trunk is dry.

Table 1. Herbicides recommended for foliar spraying of ailanthus.		
Herbicide	**Example Brand Names**	

		Comments[1]
glyphosate	Roundup herbicides, Accord herbicides, and other herbicides containing at least 41% glyphosate	Apply solution of 2% herbicide in water (vol/vol) when leaves are green; add a surfactant if not in herbicide.
	Groundwork Ready to Spray Foam Weed and Grass Killer and others	Ready to use formulations should be at least 1% glyphosate. Follow directions on label.
triclopyr	Garlon 3A, Tahoe 3A	Apply 2% solution (vol/vol) of herbicide in water when leaves are green.*
	Garlon 4, Garlon 4 Ultra, Tahoe 4E, Remedy	Apply 1.5% solution (vol/vol) of herbicide in water.*

*A surfactant at .25% vol/vol rate may be added to the various triclopyr formulations when foliar spraying.

[1]These comments are not intended to be a substitute for the herbicide labels. To ensure the safe and effective use of the herbicides recommended in this publication read the label and SDS (Safety Data Sheet).

Table 2. Herbicides recommended for basal treatment of ailanthus.

Herbicide	Example Brand Names	Comments[1]
triclopyr	Pathfinder II RTU	Ready to use formulation; do not dilute.
	Garlon 4, Garlon 4 Ultra, Tahoe 4E, Remedy	Apply solution of 20% herbicide in a basal or penetrating oil, diesel, or kerosene.
imazapyr	Stalker, Chopper	Mix 8 to 12 ounces in enough basal oil or diesel fuel to make 1 gallon.
triclopyr + imazapyr	Garlon 4, + Stalker or equivalent	Mix 15 to 20% Garlon 4 + 3 to 5% Stalker in a basal or penetrating oil, diesel fuel, or kerosene.

CUT STUMP HERBICIDE TREATMENT

Traditionally cut stump treatments have been an effective method for controlling larger ailanthus, though sprouting may occur and require one or more follow-up treatments.

Herbicides carried in water should be applied to the outer 1/3 of the top of the stump

within minutes of making the cut. These herbicides have proven to be most effective on ailanthus when applied late May through September.

Oil soluble herbicides should generally be applied to the entire cut surface and sides of the stump. When using an herbicide carried in oil, immediate application is not as crucial as when using an herbicide carried in water. These herbicides have proven to be most effective on ailanthus when applied from late May through November.

HACK & SQUIRT (HERBICIDE INJECTION)

Hack & squirt (or herbicide injection) involves introducing an herbicide into an ailanthus tree through spaced cuts made around the trunk of the tree with an ax, hatchet, or tree injector. When using an ax or hatchet, small amounts of herbicide are applied to each cut using a pint or quart spray bottle (such as those available at garden stores). When using an injector, the herbicide is automatically applied to the cut when the cut is made. Several types of injector systems are available including one that utilizes an herbicide shell. The choices between using an ax or hatchet versus an injector, and the type of injector, depend on individual preference, the herbicide to be used, and the size of the job. Because the herbicide is applied to only a small area, this method minimizes the potential for non-target effects through overspray, drift, or runoff. However, non-target species can still be impacted if they are connected to the targeted plant through root grafts. This method can result in extensive sprouting and requires follow-up treatments.

Figure 2. Immature winged fruit.

Figure 3. Basal bark application.

Figure 4. Cut stump application.

Figure 5. Hatchet used for spaced cuts (hack) with herbicide applied in cut (squirt).

Summary

Label recommendations should be followed to maximize the potential for successful control. **At a minimum, monitor treated ailanthus trees for two years to determine if complete control is achieved**. Trees that resprout or are not completely killed by the first treatment will require a follow-up treatment.

Herbicides, like all pesticides, are approved (labeled) for specific uses by the Environmental Protection Agency. Approved uses and application methods are listed and described on the pesticide's label. The herbicides listed in this fact sheet were appropriately labeled at the time of publication. Because pesticide labeling may change at any time, you should verify that a particular herbicide is still labeled for your intended use. At the time of this writing, copies of most herbicide labels and SDS could be obtained online at the Crop Data Management System website cdms.net. Others are available through the individual manufacturer's website.

Ohio State University Extension and the Ohio Division of Forestry do not endorse any of the products mentioned in this fact sheet and assume no liability resulting from the implementation of these recommendations.

2022 NCF-Envirothon Ohio

Forestry Study Resources

Key Topic 4: Conservation and Management of Forests and Urban Trees

11. Describe common forest management and harvest techniques and apply them to field scenarios.
12. Apply forest management techniques for different management goals, such as wildlife habitat, timber harvest, et cetera.
13. Compare and contrast conservation plans on private woodlots with forestry plans for state parks and state forests.
14. Apply the fundamentals of tree measurement to field scenarios.
15. Determine the volume of a tree using common forestry tools and tables.

Study Resources

Resource Title	Source	Located on
Incorporating Wildlife Needs into Forest Management Plans	*Amanda D. Rodewald and Margaret C. Brittingham, 2001*	Pages 56-59
Forest Management: Developing a Plan to Care for Your Forest	*Randall B. Heiligmann, 2002*	Pages 60-61
Crop Tree Management: A New Tool to Help You Achieve Your Woodland Goals	*Apsley, David and Heiligmann, Randall, 2002*	Pages 62-65
Using the Tree Measuring Stick	*Smith, Kathy and Apsley, David, 2006*	Pages 66-70
Basal Area: A Measure Made for Management	*Jim Elledge and Becky Barlow, 2012*	Pages 71-76
Measuring Standing Trees Determining Diameter, Merchantable Height, and Volume	*Heiligmann,Randall and Bratkovict, Stephen., 2002*	Pages 77-78
Ecological Effects of Prescribed Fire Season: A Literature Review and Synthesis for Managers –	*Knapp, Eric, Estes, Becky and Carl Skinner, 2009*	Pages 79-87
Using Midstory Removal to Enhance Oak Development	*Parrott, David; Lhotka, John, Stringer, Jeff, 2012*	Pages 88-89
Returning Controlled Fire to the Landscape	*The Nature Conservancy, 2021*	Pages 90-91

Study Resources begin on the next page! ➡

W-1-2001

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

School of Natural Resources, 2021 Coffey Road, Columbus, Ohio 43210

Incorporating Wildlife Needs into Forest Management Plans

Amanda D. Rodewald, Assistant Professor of Wildlife Ecology and Extension Wildlife Specialist, School of Natural Resources, The Ohio State University

Margaret C. Brittingham, Associate Professor of Wildlife Resources and Extension Wildlife Specialist, School of Forest Resources, The Pennsylvania State University

Nearly one-third of Ohio is forested, and private individuals own over 90 percent of these forests. Forests are important not only to landowners, recreationists, and natural resource professionals but to many wildlife species as well. Forests provide these species with major habitat requirements: food, cover, water, and space. As a landowner, you have the opportunity to manage all or part of your land in a way that is sensitive to wildlife needs. If you have made the decision to harvest timber from your property, you can decide to protect important habitat components for wildlife while harvesting timber. This fact sheet describes several ways that you can incorporate wildlife needs into your forest management plan. Even adopting one or two suggestions can make your managed land more attractive to wildlife.

Benefits of Wildlife

As you probably have already experienced on your own land, wildlife can provide many aesthetic and recreational benefits to landowners. Watching a fox hunt for mice, listening to a wood thrush sing, or finding a red-backed salamander hiding under a log can add beauty and enjoyment to your day. Some landowners also enjoy hunting for wildlife on their own land.

Fewer people recognize the ecological services provided by wildlife. Each species performs a specific function in the ecosystem that directly or indirectly benefits the environment and other organisms, including humans. For example, many birds, such as blue jays, disperse acorns and other seeds throughout the landscape. Bats may reduce the numbers of mosquitoes around your home by feeding on them. Similarly, insectivorous birds can benefit trees by consuming insects living on bark, leaves, or branches. Earthworms, beetles, and some rodents turn over the soil and recycle nutrients. Ecologists are continually learning about new complex relationships among organisms and their environment. By providing habitat for wildlife, you ensure that some of these ecological, recreational, and aesthetic benefits will be maintained on your land.

Forests and Wildlife

Forests provide many wildlife species with major habitat requirements—food, cover, water, and space. When you harvest timber, the quantity, quality, and distribution of these habitat features change. As a result, certain wildlife will be favored in forests at different stages of succession. In forest succession, a grassy field or harvested stand will eventually become a mature forest.

Wildlife may be associated with forests at a particular successional stage because of the types and amounts of habitat that are provided by that stage. See Figure 1 on page 2. For example, early-successional forests have more fruit, seeds, and woody browse but less nuts, acorns, and cavity trees. Older forests have more nuts, acorns, and cavities but fewer fruits, seeds, and woody browse.

Soon after clearcutting or farm abandonment, the land may have areas of bare soil and herbaceous vegetation, such as grass. Grassy areas will provide wildlife with insects, seeds, and herbaceous food and cover. Wildlife such as cottontail rabbits, voles, and field sparrows are attracted to these areas. As succession continues, woody shrubs, seedlings, and saplings invade the area. These provide woody browse and cover as well as berries and seeds for white-tailed deer, rabbits, ruffed grouse, and songbirds (catbirds, towhees, and warblers). As the saplings grow, they usually will develop into dense stands of small trees that provide too much shade to support the shrubs of early-successional forests. These young, pole-sized forests are generally considered the least productive for wildlife, because they lack the woody browse of early-successional areas but do not yet have many features associated with mature forests, such as acorns or tree cavities. Eventually, the forest matures and has large trees that produce acorns, decaying trees with cavities, downed logs, and deep leaf litter. All of these features allow wildlife like salamanders, black bear, flying squirrels, and pileated woodpeckers to thrive.

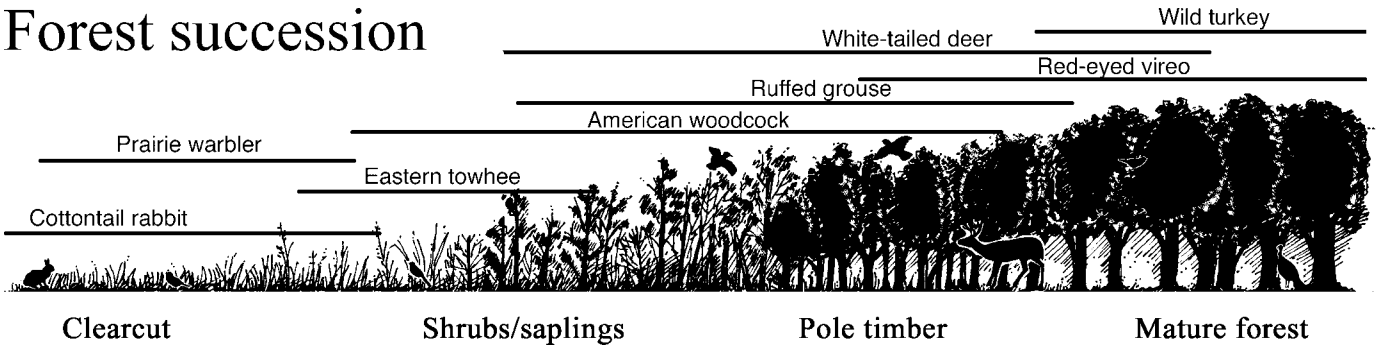


Figure 1: The above figure shows forest succession and examples of associated wildlife.

Depending on the type of harvesting you use, you will be creating or maintaining different successional stages of forest and, as a result, favoring different groups of wildlife. For example, clearcut stands will attract animals, such as eastern cottontail and chestnut-sided warbler, that use shrubs and saplings but will not be regularly used by species that require mature forests. Harvesting methods that retain large numbers of overstory trees can usually still provide suitable habitat to many forest animals, such as ovenbird, wood thrush, and scarlet tanager. Some wildlife species, like the pileated woodpecker, are called habitat specialists and will only be found in forests of one successional stage. Other wildlife are habitat generalists, such as deer, and they may occur in forests of any age.

In addition to requiring particular successional stages, wildlife also differ in the amount or location of the habitat they require. Some area-sensitive species require large amounts of land, whereas other species can live on small parcels of habitat. Many forest songbirds, such as wood thrush and scarlet tanager, are known to be area-sensitive. Location of habitat can also influence wildlife. Even if suitable habitat is available, some species will avoid using areas near a habitat edge (junction between two habitat types). These species are often referred to as interior species and include animals like salamanders and many warblers. Other wildlife, such as turkey, grouse, and deer, prefer using edges of habitat because of the abundant browse and vegetation usually present.

What Can You Do?

As a landowner, you have the opportunity to manage all or part of your land in a way that is sensitive to wildlife needs. The first step is to define your objectives in terms of income, timber, firewood, wildlife, watershed protection, and aesthetics. In addition to defining your overall goals, you also need to decide on your objectives in terms of wildlife management. For example, do you want to manage only for specific game species, or do you want to manage for species that use mature forests? The next step is to contact a professional forester or a wildlife biologist. Be sure to specify your objectives to that person. Make it clear that you want to incorporate wildlife needs into the timber-harvest plan.

Forest Management Approaches

There are two very different approaches to forest management: even-aged and uneven-aged management. Even-aged forest management removes most overstory trees from a stand. Examples are clearcuts (all trees removed), seed-tree cuts (a few trees are left standing to be sources of seeds for regeneration), and shelterwood cuts (more trees are left to provide shelter to regenerating trees). These methods work best when you are trying to regenerate trees that are not tolerant of shade, such as oak. Because the trees will regenerate at the same time, even-aged methods create stands dominated by one age class. Uneven-aged management creates stands with at least three tree age classes by cutting scattered individual trees (single-tree selection) or small groups of trees (group selection). Because stands treated with uneven-aged techniques retain many overstory trees, shade-tolerant tree species, like maple and beech, regenerate best in these stands. Uneven-aged management also may be a good strategy on small parcels of forest if landowners want to realize both timber and wildlife benefits. Based on your goals, the type of forest you have, and other site characteristics, a professional forester can suggest which method is appropriate for your land.

Even-aged and uneven-aged management approaches differ greatly in which wildlife are favored by creating either early- or late-successional stands. From a wildlife perspective, the "best" approach depends on the availability of nearby habitat and the sensitive wildlife species in your area. For example, if you have one of the only large tracts of forest within several miles, then forest wildlife may rely heavily on your land for habitat requirements, and an uneven-aged approach may be best. However, if your land is within a highly forested area, then an open or shrubby harvested stand produced by even-aged techniques might provide important habitat for wildlife associated with early-successional forest.

How to Incorporate Wildlife Needs into Your Forest Management Plan

Protect unique or important habitat features, such as vernal pools and spring seeps. Vernal pools are temporarily filled with water during rainy seasons, and they are critical breeding and hibernating grounds for amphibians because they do not contain fish and other predators. Spring seeps are small streams or ponds with year-round water from belowground sources. Seeps are particularly important in the winter, because they are less likely to freeze and be covered by snow. In addition, important food resources, such as herbaceous vegetation and insects, are often abundant near seeps. Harvesting near pools and seeps can destroy the habitat they provide by affecting

water temperature and quality as well as adjacent food and cover. If possible, do not harvest within at least 100 feet of these important habitat features.

Retain buffers along streams. Riparian habitats perform critical ecological functions as well as provide habitat for a rich diversity of flora and fauna. Harvesting near streams not only destroys riparian habitat for terrestrial wildlife but also harms aquatic habitat by increasing water temperature and sedimentation. To reduce the negative impacts, leave buffer strips of unharvested trees (at least 50–100 feet wide) along both sides of streams. Remember to keep roads and skid trails at least 50 feet away from water and minimize the number of stream crossings for roads. If you are logging on a slope, these buffers should be wider.

Do not harvest all trees. Retain some live overstory trees in a variety of species and size classes. More wildlife will use harvested stands that contain residual trees because of the perching, nesting, and foraging opportunities they provide. In addition, by retaining at least one individual tree of every species on your land, you increase the probability of some seed production every year. Sometimes retaining a single mature tree of a species uncommon to your woodlot can preserve wildlife values not provided by a common tree species. Aside from providing food and cover to wildlife, the retention of overstory trees and snags can accelerate regeneration of clearcut stands because birds that perch on trees may excrete seeds.

Enhance the vertical structure within the stand. Some animals forage or nest only in small saplings or shrubs, whereas others spend most of their time in the forest canopy. By retaining trees, saplings, and shrubs in a variety of size classes, you can provide more vertical layers of forest to wildlife.

Retain decaying and dead trees (snags). Woodland owners are often encouraged to remove dead or decaying trees since they have little market value, but these trees are important to wildlife, especially because decay is a slow process. For wildlife use, snags should be greater than 8 inches diameter breast height (dbh). Leaving all standing dead trees is best for wildlife, but at least one large (greater than 18 inches dbh) cavity tree per few acres is needed for larger species that use cavities, such as wood duck, pileated woodpecker, and mergansers. Beech, basswood, and aspen are generally good cavity-producing trees. A professional forester can evaluate any safety threats posed by a particular snag and then recommend actions that you can take to minimize the risk.

Retain dead and down wood. Many animals, especially salamanders and small mammals, use logs, slash, and other woody debris for cover, dens, nests, foraging sites, and even as places for courtship displays. If possible leave large logs that will last longer than small logs. Also, try to leave some woody debris in piles to prevent quick decay, especially in wet sites. Brush piles can be placed anywhere but are most useful near edges, food sources, water, or areas with little cover.

Create irregular rather than straight or abrupt edges to the cut, and reduce the contrast between habitats at edges. Some wildlife, such as salamanders and certain forest birds, avoid using abrupt edges, and those that use them may experience high rates of predation. Edges are often associated with higher amounts of nest predation, fewer food resources for some species, warmer air and soil temperatures, drier conditions, and more wind than interior forest. Edges between very different habitats, like between a mature forest and agricultural land, are abrupt and high-contrast. These edges generally have more negative "edge effects" than gradual or low-contrast edges. In addition, edge-adapted species, such as deer, may prefer gradual edges that provide both cover and foraging opportunities. Low-contrast, gradual edges can be made by allowing shrubs, saplings, and some overstory trees to remain along the harvest boundary. Edges can be feathered by retaining more trees closer to the forest interior and gradually fewer trees closer to the harvest area. See Figure 2 on page 4.

Leave large patches of forest close to other forest patches. If you are trying to manage for forest-associated species, then you need to consider patch size (how large a piece of habitat is) and the amount of isolation (how far that patch is from other

Which live trees should you retain?

- Try to retain some of each tree species on your land. If possible, retain several individuals of each species within the stand.
- Retain trees that produce mast, such as beech, oak, cherry, and dogwood. Mast refers to fruits and seeds of trees and shrubs; it's an important food source for many wildlife. Hard mast (e.g., acorns and beechnuts) is especially important in the fall and winter diets of many wildlife such as white-tailed deer, black bear, wild turkey, woodpeckers, and squirrels. To select trees that have steady seed production potential, choose trees of large size and moderate age with full, rounded crowns. Soft mast (e.g., cherries and grapes) is produced by fruiting trees, shrubs, and vines. Fruiting trees along woodland edges are especially valuable because sunlight stimulates heavy fruiting.
- Retain small groups of conifers (such as pine and hemlock). Because they keep their needles year-round, conifers provide important winter cover for wildlife, especially in snowy areas. Their seed-bearing cones also are a food source for many animals.
- Leave some long-lived trees, such as white oak, sugar maple, yellow birch, American beech, white ash, and red oak.
- Leave small groups of trees. This will provide small islands of habitat for wildlife as well as make trees more stable and resistant to wind.
- Leave trees with loose, rough, or deeply furrowed bark to provide foraging sites for birds that glean insects from bark. Loose bark may also provide roost sites for bats and nest sites for brown creepers.
- Retain living trees with cavities. Tree cavities provide shelter, dens, nests, and foraging sites for many wildlife species. In Ohio, over 50 species of birds and mammals use tree cavities. Some damaged young trees also can be reserved to provide future cavity trees. Trees with fungal conks, dead branches, old scars, and soft or decaying wood (especially heartrot) are good indicators of cavity potential.

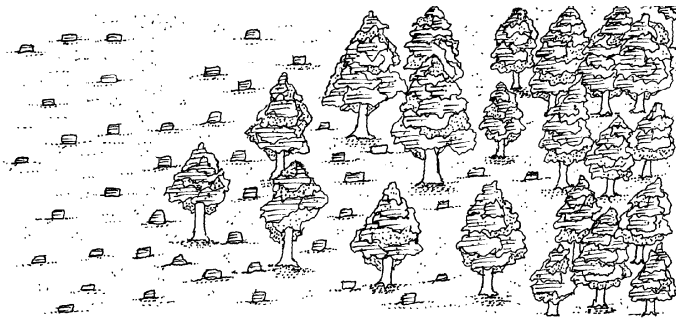


Figure 2 shows a feathered cut to the forest.

patches). Both of these can strongly influence populations of certain forest wildlife. For example, small woodlots, which have a lot of edge relative to forest interior, generally have less diverse and abundant bird communities than in larger forest areas. In addition, dispersal of animals may be impaired when woodlots become isolated, especially for salamanders and mammals. As a result, landowners trying to manage for forest wildlife should try to harvest in a way to leave the largest patch size possible and, if possible, leave patches closer to, rather than farther from, other patches.

Try to maximize the interior forest of your unharvested stands. Forest interior is unbroken forest at least 200–300 feet from habitat edges and usually is positively related to the size of a patch of forest (i.e., the larger the patch size, the more forest interior there is). To maximize the amount of interior forest, you can cut around the borders of a forest stand rather than fragment the stand into smaller ones. Also, circular and square-shaped forest patches retain more forest-interior than oblong, rectangular, or irregularly shaped patches.

Consider leaving a portion of your land unharvested or using longer cutting cycles. The machines, noise, people, and alteration of habitat associated with harvesting operations are disturbing to most wildlife. Not harvesting in some areas will provide forest wildlife with some habitat that is free of disturbance and intensive human activity.

Limit the size of your clearcut. Harvested stands that are very large can inhibit wildlife from using them or even crossing them. In addition, large harvests without residual trees may take longer to regenerate because seed sources are more distant. If you are trying to manage for wildlife that use edges, small clearcuts (e.g., between 5-40 acres in size) may be best.
On the other hand, multiple small cuts in forested areas will be detrimental to many animals associated with the forest-interior. Another consideration is that small cuts in areas with high deer density can have difficulty regenerating. Ultimately, the desirable size will depend on your goals, the wildlife species that you want to attract, and characteristics of your woodlands. Again, you should check with a professional forester about appropriate harvest sizes for your land.

Seed log landings and roads. As soon as the logging is completed, haul roads and skid trails should be graded to eliminate ruts and then re-vegetated with grasses. Lime, fertilizer, and mulch may be needed in order to establish good grass cover. Water bars should be installed at intervals of 35–250 feet depending on the length and slope of the road or trail. Unless you intend to do this work yourself, you should put these requirements in the timber sale contract that you have with your logger. If the roads and trails are likely to get heavy use from off-road vehicles, you may want to install to protect these newly-seeded areas.

Specify all wildlife management prescriptions that you want performed on your land in your timber sales contract. Do not assume that the forester or logger will automatically know how you want to be sensitive to the needs of wildlife. Ultimately, incorporating wildlife needs into your forest management plan is your responsibility.

Best Management Practices for Erosion Control on Logging Jobs in Ohio

Grass Seed Mixtures for Disturbed Sites:

Skid Trails and Road Cuts	
Perennial Rye Grass	50%
KY31 Tall Fescue	20%
Potomac Orchard Grass	20%
Red Clover	10%
Landings and Flat Cuts	
Perennial Rye Grass	50%
Red Top Clover	20%
Potomac Orchard Grass	20%
Ledina Clover	10%

Glossary

Area-sensitive species: A species whose occurrence or reproductive success is reduced in small habitat patches.

Ecosystem: All living (e.g., plants and animals) and non-living (e.g., water and nutrients) components of the immediate environment and the interactions between them.

Edge species: A species that prefers to use habitat edges, such as the interface between a clearcut and a mature forest.

Forest-interior species: A species that requires large tracts of forest away from habitat edges.

Habitat: The place where a microorganism, plant, or animal lives.

Habitat generalist: An organism that can live in a variety of habitats.

Habitat specialist: An organism that requires a specific type of habitat, such as an old growth forest.

Mast: The fruits, seeds, or nuts of trees and shrubs.

Snag: A standing dead tree.

Succession: The gradual replacement of one community of plants by another (e.g., an abandoned field ultimately becomes a forest again).

Vertical structure: The layers of foliage within a habitat (e.g., ground, understory, subcanopy, and canopy).

4/2001-jah

F-34-02

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

School of Natural Resources, 2021 Coffey Road, Columbus, Ohio 43210

Forest Management

Developing a Plan to Care for Your Forest

Randall B. Heiligmann
Extension Specialist, Forestry

What Is Forest Management?

If you were to ask a forester to define forest management, he/she would probably tell you something like: "Forest management is the application of appropriate technical forestry principles, practices, and business techniques (e.g., accounting, cost/benefit analysis, etc.) to the management of a forest to achieve the owner's objectives." Stated more simply, forest management is providing a forest the proper care so that it remains healthy and vigorous and provides the products and the amenities the landowner desires. Forest management is not so much a subject or a science as it is a process. Think of it as the development and execution of a plan integrating all of the principles, practices, and techniques necessary to care properly for the forest.

The Planning Process

This planning process includes careful identification of landowner objectives, inventory of resources, development and implementation of the management strategy to be used, and periodic re-evaluation of the implemented strategy.

Identify Landowner Objectives

The first step in developing a management plan is to identify landowner objectives — what products and amenities does the landowner wish to obtain from the land. It is imperative that these objectives be identified at the beginning because they determine what resources should be inventoried and define the goal of the management plan. Table 1 lists some examples of forest landowner objectives.

Some landowners may be interested in emphasizing only one management objective. They might, for example, be interested in maximizing the net financial return on investment through timber yield, or they might wish to develop the forest primarily as wildlife habitat. Management such as this, which emphasizes a single resource objective, is called dominant-use management. The forest can and will provide other products and amenities as it is managed (e.g., cuttings to enhance wildlife habitat will yield timber and/or income), but the management plan is developed to enhance or improve one (dominant) resource.

Most forest landowners, however, are interested in obtaining more than one product or amenity from their forests. They might, for example, desire income from timber harvest, wildlife habitat enhancement, and the maintenance of aesthetic quality. Forest management designed to enhance or produce more than one product or amenity is called multiple-use management. It is important to note that multiple-use management does not require that every acre of the forest be managed for every desired product or amenity, but rather that the forest as a whole be managed in such a way that it yields the desired mix. In the example given previously, some areas might be managed primarily for timber with aesthetic considerations, while on other acres specific practices are undertaken to enhance wildlife habitat.

Resource Inventory

Once ownership objectives have been defined, resources can be inventoried. Obviously, the tree/forest resources will be inventoried and such forest characteristics as tree species, con-

Table 1. Examples of Forest Landowner Objectives

- Source of Income
- Tax Shelter
- Product Yield
- Soil Stabilization
- Aesthetics
- Preservation
- Pride & Self-Satisfaction
- Speculation
- Inheritance
- Security
- Wildlife Habitat
- Recreation
- Increase Species Diversity
- Exercise/Hobby

dition, numbers, age, volume, value, growth, and basal area will be measured. Soil/site quality will be evaluated to determine what the site can produce. Depending on ownership objectives, other resources may be inventoried such as boundaries, wildlife, wildlife habitat, streams, trails, roads, campsites, vistas, and easements. Inventory data are analyzed to determine what is present and what the forest site is capable of producing.

Develop and Implement the Management Strategy

Based on the inventory analysis, one or more management plans are then developed to achieve the ownership objectives. These forest management plans are based on and limited by what is biologically/ecologically possible on the area, what is economically and organizationally feasible, and what is socially and politically desirable.

The biological/ecological characteristics of the forest (e.g., tree species, soil type, topography, etc.) determine what is possible on the area, including such things as which tree species will grow, how fast they will grow, what wildlife will live on the area, etc. Based on the biological/ecological characteristics of the site, silvicultural practices can be prescribed to achieve ownership objectives. Silvicultural prescriptions are treatments designed to manipulate forested land such as various kinds of timber cuttings, tree plantings, prescribed burning, and the use of specific chemicals such as herbicides and fertilizers.

Economic/financial considerations may determine which activities are feasible. If economic/financial objectives are important to the landowner, then silvicultural activities undertaken must not only be biologically/ecologically possible, but also must contribute positively in the appropriate economic/financial analysis.

As an example, fertilization of most hardwood woodlands in Ohio would result in an increase in total growth — it is ecologically possible and produces positive results. However, if the cost of the fertilizer was invested in a certificate of deposit, it would increase in value more than the forest will as a result of the fertilization. Therefore, if economic/financial return is an important ownership objective, fertilization is not an attractive silvicultural alternative.

On the other hand, there may be activities in which the landowner is willing to invest with little or no expected financial return because of the expected non-financial returns. These might include such things as the development of hiking trails, vistas, or wildlife habitat.

Similarly, limited financial or organizational resources may restrict management activities in a woodland. Obviously, if a landowner does not have the financial resources or labor to accomplish desired activities, they won't be done.

Finally, management activities are constrained by what is socially and politically desirable. Activities that violate the law are obviously unacceptable, and activities that upset neighbors are generally not prudent.

The careful development of a forest management plan in consultation with a professional forester is essential if landowners are to achieve their desired ownership objectives. The forest management plan is the blueprint of activities for caring for the forest. It is important to remember, too, that the management plan is not "cast in stone," but is an evolving plan that should be periodically reviewed and updated.

Review the Management Plan

Changes in ownership objectives, forest inventory, technology, and/or the business climate can all result in the need for modification of a forest management plan. In Ohio, intervals between periodic reviews and updates should probably be no more than five to 10 years and more often if recommended by a forester.

2/2002-jaf

F-50-02

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

School of Natural Resources, 2021 Coffey Road, Columbus, Ohio 43210

Crop Tree Management: A New Tool to Help You Achieve Your Woodland Goals

David K. Apsley
District Extension Specialist, Natural Resources

Randall Heiligmann
State Extension Specialist, Forestry

Ohio woodland owners have many different reasons for owning and managing their woodlands. Some desire woodlands that provide habitat for a variety of wildlife. Others want a woodland that supports particular types of recreation such as hiking, hunting, and bird watching. Still others want to harvest timber and non-timber products from their woods for home and farm use or to provide periodic income. Most aspire to maintain or improve the health, vigor, and attractiveness of their forest. For many private woodland owners, the ability of their woodlands to provide these and many other values can be enhanced through crop tree management.

Crop trees are trees that produce or have the potential to produce the desired landowner benefits. If, for example, improved squirrel habitat is desired, a large-crowned white oak that produces abundant acorns would be a valuable crop tree. If increased economic value is an important ownership objective, a 14-inch-diameter black walnut tree with a straight and relatively defect-free trunk and a fairly small crown would be a valuable crop tree. On the other hand, if fall color was important, a group of black gum trees, which turn brilliant red in the fall, might all be potential crop trees.

In an unmanaged woodland, competition among trees for light, water, and nutrients is often severe and can result in slow growth or even the death of the more desirable trees. In a woodland under crop-tree management, these crop trees are freed from excessive competition by reducing or eliminating some of the less desirable competing trees. The released[1] crop trees are healthier and more vigorous, more insect and disease resistant, grow faster, and produce additional landowner benefits.

Figure 1. Crop tree after release.

[1] Released trees are those that have had crown touching competitors removed.

In application, crop tree management is simple. Once ownership goals and objectives have been clearly identified, criteria are developed for selecting crop trees based on those goals and objectives. Next, trees meeting those criteria are located in the woodland, and then some or all of those trees are released from competing trees (Figure 1). An important tangible advantage of crop-tree management for the private nonindustrial forest landowner is that it focuses management activities on improving the health, vigor, and growth rate of trees that directly satisfy ownership objectives.

This fact sheet is intended to introduce the crop-tree management process and to provide some guidance in its application. Landowners and others seeking a more in-depth written reference to crop-tree management are encouraged to obtain a copy of *Crop Tree Management in Eastern Hardwoods.*[2] Although written for professionals, its content is well within the grasp of knowledgeable forest landowners.

Identifying Goals and Objectives

The first and most important step in managing any resource is identifying ownership goals. In this case, why do you own your woodlot? Do you like to hike and bird watch? Are you a hunter? Do you hope to produce income from timber now or in the future? Is it the fall foliage and spring wild flowers that grab your attention? Ever thought about how your forest can improve the quality of water flowing through your property?

Clearly, identifying goals for your woodland is critical. They provide the basis for determining what should and should not be done in your woods to improve its ability to satisfy your needs and desires. Said another way, ownership goals define the target for management activities such as crop-tree management.

The next step is to translate the more general ownership goals into stand-specific[3] objectives. For example, if enhancing the quality of wildlife habitat is an ownership goal, shortening the time to mast[4] production and increasing the amount of mast produced using crop-tree release might be an objective for a young oak-hickory stand. Or, if future income was a goal in a mixed species stand, increasing the growth rate of the economically more valuable trees through crop-tree release might be an objective.

And just as we can have more than one goal for our woodland, we can and most likely will have more than one objective for individual stands. We could, for example, be looking at a 30-year-old mixed oak-hickory stand with overall goals of improving timber production and wildlife habitat. In such a stand, crop-tree management could be used to selectively release some trees that satisfied the timber production goal (high-value species, good quality, fast growing), some that satisfied the wildlife habitat goal (mast-producing species, variety of species, large crowns, etc.), and some that might satisfy both goals.

[2] Perkey, Arlyn W. and Brenda L. Wilkins. *Crop Tree Management in Eastern Hardwoods.* U.S.D.A. Forest Service Technical Publication NA-TP-19-93.

[3] A stand is a group of trees with similar characteristics such as age, species, health, and quality.

[4] Mast is the seed and fruit of trees utilized as food by wildlife.

Table 1. Examples of Crop Tree Selection Criteria for Woodland Owners With Wildlife, Timber, Aesthetics, and Water Quality as Primary Objectives.

WILDLIFE

- Crown is large, healthy, and in or above the main canopy.
- Mast-producing species (prefer hard over soft).
- Trees with dead branches and open cavities are desirable.
- Species variety is highly desirable.
- Expected longevity of 20+ years.

TIMBER

- Crown is large, healthy, and in or above the main canopy.
- High-value commercial species.
- High-quality tree with:
  - ✓ Butt log with high-grade potential.
  - ✓ No sprouts on butt log.
  - ✓ No lean, low forks, etc.
- Species well adapted to the site.
- Expected longevity of 20+ years.

AESTHETICS

- Select trees and species that are unique in appearance or character, produce attractive flowers and colorful foliage, and have attractive or unique bark.
- Visible from travel lanes, vantage points, etc.
- Expected longevity of 20+ years.

WATER QUALITY

- Crown is large, healthy, and in or above the main canopy.
- Species that are good nutrient accumulators (young, deciduous).
- Species tolerant to flooding.

Developing Crop Tree Selection Criteria

Once specific goals and objectives have been established, criteria can be developed for selecting crop trees. These criteria are simply characteristics looked for when selecting crop trees. Table 1 shows examples of selection criteria for landowners with wildlife, timber, aesthetics, or water quality as their primary objective. Remember, these are only examples. You can — and should — develop criteria to suit your specific goals. And, as we noted earlier with our timber and wildlife example, several criteria aimed at achieving more than one objective can be used in a single stand.

Inventory — Identifying Crop Trees

Now it's time to inventory your property, utilizing your selection criteria, to see how many potential crop trees are present. How extensive and sophisticated this inventory needs to be depends on the size and character of the woodland and the

intensity of crop-tree management planned. A woodland owner with 10 acres who intends only to release three or four hard mast-producing trees per acre to improve wildlife habitat may need to do little more than walk over the property and select the trees based on the selection criteria and their spacing throughout the woodland.

On the other hand, a woodland owner with 50 acres who intends on releasing 20 to 30 crop trees per acre to favor timber production and wildlife habitat may need a fairly detailed inventory to determine the number of suitable crop trees, identify their location, evaluate their potential to respond to release, and indicate how many trees need to be removed to release the crop trees. Also, if the trees to be removed are merchantable and the removal is to be a commercial sale, some form of formal inventory will be desirable for marketing purposes.

The methodology to perform a formal inventory is beyond the scope of this fact sheet. However, when a complete or sample inventory is performed for crop tree management, it should include the species, diameter, height, and free-to-grow rating (described in the next paragraph) of the potential crop trees, along with a record of the trees competing with the crop trees that would be removed if the crop trees were released.

The *free-to-grow* rating is an index of competition which rates the available growing space for the crop tree by determining on how many sides of the crown there is room for growth. The rating is accomplished by visually dividing the crown of the tree into four sections and then determining how many of the sections have room to grow (Figure 2). Ratings range from 0 for trees with no room to grow to 4 for trees with room to grow in all four directions.

Application

The application of crop-tree release involves removing or deadening all of the trees that directly compete with the designated crop trees. Essentially, this involves removing or deadening all of the trees whose crowns touch the sides of or overtop the crowns of the crop trees. Trees whose crowns are below those of the crop trees' crowns do not provide significant competition and are usually not removed or deadened.

The number of crop trees released and the number of competing trees is dependent on several factors including number of potential crop trees occupying the site, age and size of the forest stand, and landowner preference. Ideally, a released crop tree should have a *free-to-grow* rating of 4, meaning it has been released from competing crowns on all four sides of its crown. Occasionally, two crop trees will be so close that both cannot be released on four sides. If the decision is made to keep both trees, each can be released on three sides and their crowns allowed to touch. In general, younger stands will require more crop trees to be released since not all crop trees will survive until the stand matures.

Once the crop trees and trees to be removed have been identified, it is usually a good idea to mark them with different colored flagging and evaluate the planned release. While a crop-tree release that releases only a few crop trees per acre will have little effect on the woodland's appearance, a moderate to heavy crop-tree release may substantially alter its appearance. Evaluating the visual impact before cutting will allow modifications if the anticipated results are not as desired.

If releasing all of your crop trees will result in an unacceptable visual effect, release fewer crop trees. It is far more desirable to completely release fewer crop trees than to partially release more. Partially released trees, with lower free-to-grow ratings, grow at a much slower rate than completely released trees. For example, using the data from Figure 3, a 10-inch-diameter tree with a free-to-grow rating of 4 would increase to more than 14 inches in 10 years while the same-sized tree with a 0 free-to-grow rating would only increase to less than 12 inches. Based on a conservative estimate, the tree with a free-to-grow rating of 4 would have approximately 80% more board

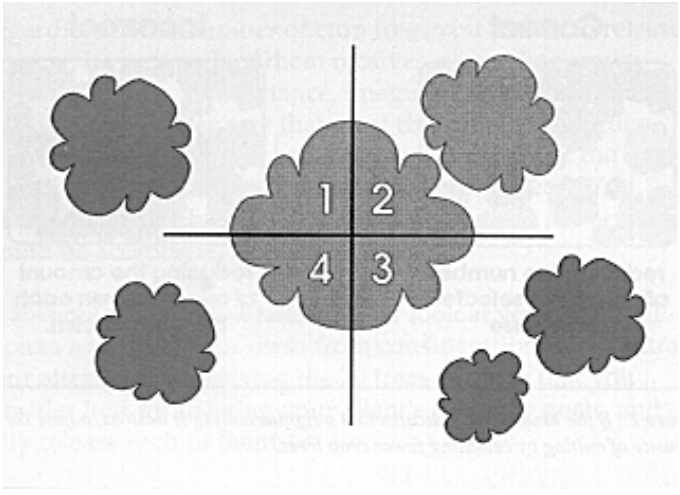


Figure 2. The center "crop tree" has a free-to-grow rating of 3. It has space to grow on three of its four sides. (From: *Crop Tree Management in Eastern Hardwoods.* USDA-FS. Used with permission.)

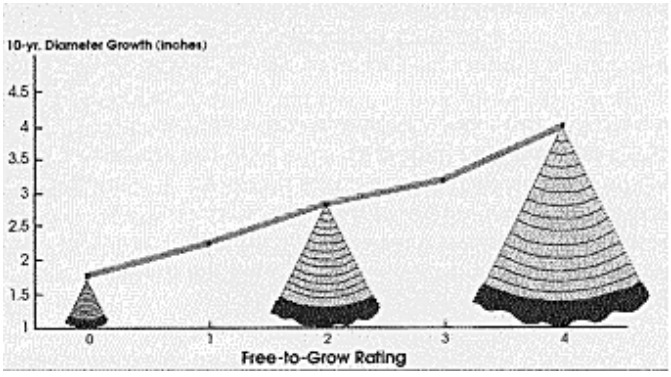


Figure 3. This graph shows how an increase in free-to-grow rating from a crown-touching release can dramatically increase crop-tree growth. (From: *Crop Tree Management in Eastern Hardwoods.* USDA-FS.)

foot volume after 10 years than the tree with a free-to-grow rating of 0. Larger trees not only produce more timber volume but also produce substantially more wildlife food and other benefits. Consequently, crop trees that are free-to-grow are much more likely to contribute toward reaching woodland ownership goals.

Trees to be removed may be cut or deadened. In some instances, enough trees of suitable size may be cut to warrant a commercial timber sale. More commonly, the trees being removed will be too few or too small to be marketable. In such instances, the trees can be cut for landowner use (firewood, fence posts, etc.) or deadened in place by girdling or other appropriate technique. Girdling can be accomplished by using a chain saw to cut through the bark and about one inch into the wood of the tree around its entire perimeter. Double girdling, with a second girdle about three inches above the first girdle, is even more effective. Properly girdled trees will die standing and will slowly decay, providing habitat for wildlife in the process. For more information on girdling and other techniques to free your crop trees from competition, refer to OSU Fact Sheet F-45, *Controlling Undesirable Trees, Shrubs, and Vines in Your Woodland*.

2/2002-jaf

F-62-06

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

School of Environment and Natural Resources, 2021 Coffey Road, Columbus, Ohio 43210

Using the Tree Measuring Stick

Kathy L. Smith, Extension Associate–Forestry
and **David K. Apsley**, Natural Resources Specialist

The tree measuring stick is a useful tool for measuring trees and logs. Although not as precise as more specialized tools, it is inexpensive, easy to carry, and accurate enough for most of your tree and log measurement needs. This stick incorporates several tools that are commonly used by foresters and the forest industry, and can help woodland owners better understand and manage their forest resource.

What can you measure with this stick? The stick is primarily used to measure the diameter of standing trees in inches, their height in 16 foot logs, and the volume they contain in board feet or cords. It can also be used to measure diameters of logs and estimate their volume. Additionally, the stick has an angle gauge that can be used to determine basal area—a measurement of tree density or crowding.

Even though the stick is a useful tool, it will not eliminate the woodland owner's need for the assistance of a professional forester. A woodland owner should utilize a professional forester to develop a management plan and to assist with forest management activities such as timber harvests and tree planting.

Measuring Tree Diameter

There are two important factors to keep in mind when measuring tree diameter: 1) the diameter of a tree should be measured at a point on the tree 4½ feet off of the ground (this is known as Diameter at Breast Height or d.b.h.) on the uphill side of the tree, and 2) trees are often not perfectly round; therefore, it is a good idea to take two measurements perpendicular to each other and average them.

When measuring tree diameter be sure to utilize the side of the stick labeled "Tree Scale Stick" (Figure 1) and follow the steps outlined below:

1. Hold the stick 25 inches from your eye and against the tree with the "Tree Scale Stick" side facing you.
   a. Remember, diameter should be measured at 4½ feet from the ground (d.b.h.) on the uphill side of the tree (Figure 2a). It is useful to measure 4½ feet from the ground and note the point on your body where this occurs or carry a walking stick that is 4½ feet tall to determine where to measure diameter.

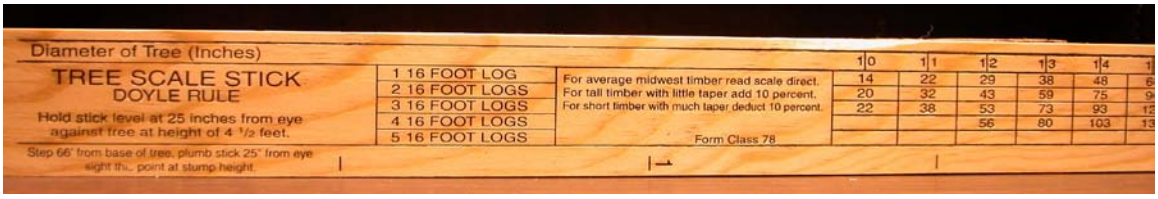


Figure 1. A tree measuring stick showing the "Tree Scale Stick" side.

b. Check the distance between your eye and stick to be sure it is 25 inches (Figure 2b). The "Diameter of Log" scale on the top of the opposite side of the stick is a ruler that can be used to check this distance. Make a mental note of the bend in your arm when the stick is 25 inches from your eye. For accurate diameter measurements it is critical that the stick is 25 inches from your eye. Check this distance frequently until you can consistently hold the stick at 25 inches.

2. Using the "Diameter of Tree (inches)" scale on the top of the tree scale stick, adjust the stick so that the left side ("0" end) of the stick is in line with the left edge of the tree (Figure 2b).

3. **Without moving your head**, shift your line of sight to the right-most visible portion of the tree. Read the diameter from the scale closest to the point where your line of sight and the tree intersect. This is the diameter of the tree in inches. Remember that trees are often not perfectly round. Be sure to take two measurements perpendicular to each other, keeping the stick 4½ feet off the ground on the uphill side of the tree.

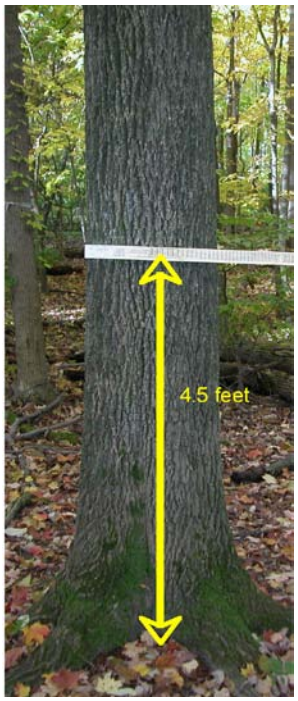


Figure 2a. The stick should be placed against the tree 4½ feet from the ground.

Estimating the Merchantable Height of a Tree (in 16 foot logs)

The merchantable height of a tree, the height to which logs can be cut, is commonly measured in 16 ft. logs and 8 ft. 1/2 logs. To measure merchantable height of a tree with the measuring stick, use the scale along the bottom edge of the "tree scale" side of the stick (Figure 4). When the stick is held vertically the numbers on the scale will be on the right (approximately 6 inches apart). This scale is calibrated to be used at a distance of 66 feet from the base of the tree. Since this scale is used to estimate heights to the nearest 1/2 log (8 ft) pacing 66 feet from the tree is usually an adequate distance measure.

1. Using the "Determining Your Pace" procedure described below, pace 66 feet from the base of the tree. It's a good idea to use a tape measure to verify that the paced distance is correct until you become consistent with your pacing. When possible, avoid pacing in a direction that is uphill or downhill. The accuracy of your pace will decrease if you are pacing on steep or uneven ground.

2. Face the tree to be measured and hold the stick vertically at a distance of 25 inches from your eye (Figure 3). Be sure that the scale "Number of 16 foot logs" is facing you. As with measuring diameter, this distance of 25 inches is critical to obtain accurate measurements. Make sure that the stick is as close to vertical as possible. A forward or backward lean in the stick will cause you to overestimate merchantable heights.

3. Align the base of the stick in line with the top of the stump (about 1 foot above the ground).

4. Sight past the right hand side of the stick to the point on the tree to be measured.

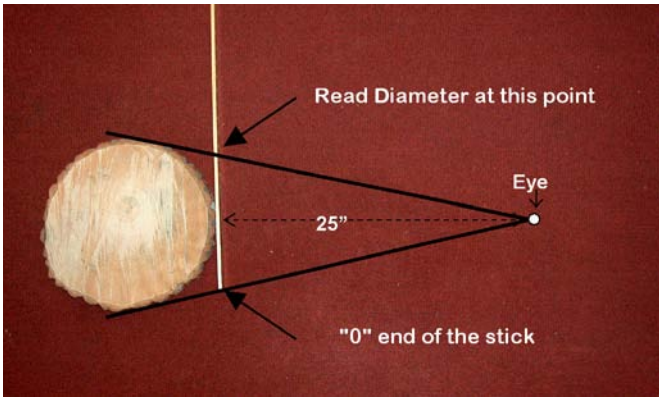


Figure 2b. Make sure the distance from your eye to the stick is 25 inches.

Determining Your Pace

A pace is the length of one or two of your steps. Measure 66 feet on a relatively flat surface, and beginning with your left foot, walk at a comfortable speed and count every time your right foot hits the ground. Determine the number of paces that it takes to cover the 66-foot distance. Repeat this process at least once and determine the average number of paces. Calculate your pace by dividing the distance by the number of paces.

Example: If your right foot hits the ground an average of 13 times over the 100-foot distance, divide 66 feet by 13 to get a pace of 5.1 feet.

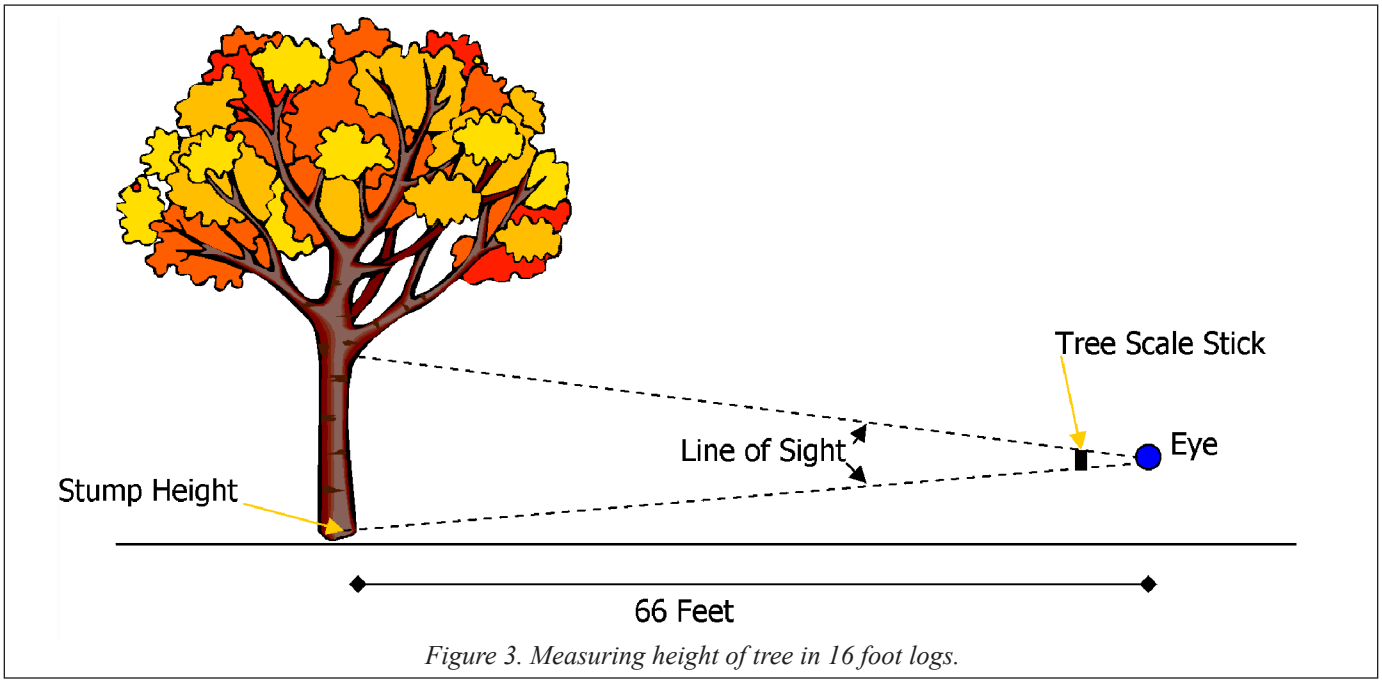


Figure 3. Measuring height of tree in 16 foot logs.

5. Read the height from the scale closest to the point where your line of sight and the tree intersect. This is the merchantable height of the tree in logs. The numbers on the scale marked 1, 2, 3, 4, and 5 correspond with the top of each 16 foot log. Dashes without numbers represent 1/2 logs. Measure the usable height only. That is usually at the point on the tree where it reaches a minimal usable diameter or is indicated by heavy branching, forks, etc. Ten and four inches are commonly used as minimum diameters for sawlogs and pulpwood, respectively. However, these can vary depending on the quality of the wood and the products to be produced.

Estimating Tree Volume

After the diameter and height in 16 foot logs have been determined for a tree, the tree's volume in board feet can be read from the table on the Tree Scale Stick (Figure 4).

1. Find the diameter of the tree (same scale used to measure tree diameter) at the top of the column.
2. Find the merchantable height of that tree in 16 foot logs along the left side of the table.

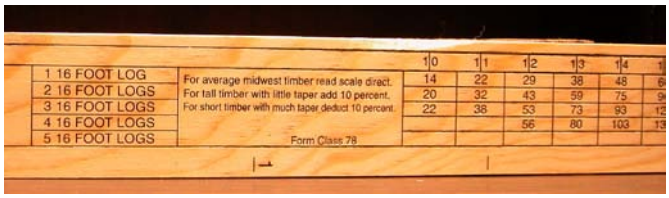


Figure 4. Using the diameter and height in 16 foot logs, read the volume of board feet in the tree.

3. Follow the corresponding height in 16 foot logs across the table until it intersects with the corresponding diameter. The number in the box represents the estimated board foot volume of the tree using the Doyle Log Rule with a Form Class of 78 (assumes that the tree diameter inside the bark at the top of the first log is 78% of the d.b.h.). There are numerous log rules used in the United States. Doyle is by far the most commonly used log rule in Ohio.

Example: A tree that measures 18 inches d.b.h. and is 3–16 foot logs in merchantable height would contain an estimated 215 board feet of timber.

What is a board foot?

A board foot is a piece of wood that contains 144 cubic inches, commonly visualized as a piece of wood 12 inches square and 1 inch thick.

Defect Deductions

It is very difficult to estimate the amount of defect present in a standing tree because the entire defect is not visible. Trees can have a number of defects (knots, holes, branch stubs, or hollows due to past fire or other damage) that can cause all or a portion of the tree to be unusable. Deductions should be made for estimated loss due to these defects. Trees that are over 50 percent defect are commonly labeled "cull" and are often not utilized for lumber. Based on the tree's apparent defects, use your judgment in making deductions that reduce the volume between 10 and 50 percent.

Estimating Cordwood

The amount of cordwood for use as firewood or to be sold as pulp can be estimated using the "Cords Per Tree" table found on the "Log Scale" of the stick (Figure 5).

1. Find the diameter of the tree under the DBH (inches) column located on the left side of the adjacent tables.
2. Find the estimated ***total height*** of the entire tree along the top edge of the table.
3. Follow the corresponding diameter across the table until it intersects with the corresponding total height. The number in the box represents the estimated number of cords of wood found in the tree. This is a rough estimate only as the actual amount depends greatly on the tree's branch structure.

Example: A 20-inch dbh tree that is 60 feet tall contains approximately 0.630 cords of wood.

Most 1/2-ton pickups can hold approximately 1/3 to 1/2 cord of wood depending on how high and how well the wood is stacked. In other words, most pickups haul about a rick of wood.

Considerable variation in solid wood content of a cord may be encountered due to such factors as how tightly the wood is stacked, the diameter of the wood (larger diameters usually stack better), how well the wood is trimmed, and whether it is split or round.

What is a cord?

The legal unit of measure for firewood in Ohio is the cord, which is the amount of tightly stacked wood contained in a space 4' wide x 4' high x 8' long and containing 128 cubic feet. A rick or face cord is another unit of measure often used and is 4' high x the length of preferred wood x 8' long. In other words, three 16" ricks (3 x 16" = 48") = 1 cord and two 24" ricks (2 x 24" = 48") = 1 cord.

Log Scale Stick (Doyle Rule)

The log scale stick is a tool for use in estimating the volume of logs. Use the following steps to estimate the volume of a log:

1. Measure the length of the log. Typically logs are measured in two-foot intervals. Keep in mind that a minimum of 6–8 inches must be provided for trimming of the lumber that the log will yield. Therefore, a log that measures 16'6" would be labeled a 16 foot log. If a log measures 16'1" it will be labeled a 14 foot log in order to allow enough trim allowance at the mill.
2. Measure the diameter of the log inside the bark (dib) at the small end utilizing the "inches" scale on the top of the "Log Scale" side of the stick (see Figure 6). If the log is obviously not round, measure at the narrowest and widest points and figure the average diameter.
3. Utilizing the log scale stick table (Figure 6), determine the estimated volume of the log in board feet (Doyle Rule). Find the diameter of the log that you measured in step 2 along the "inches" scale. Next locate the row on the "Log Scale Stick" table that corresponds to the length of the log being scaled. The number where the appropriate column and row intersect is the estimated board foot content of the log.

Example: A log with an average diameter of 15 inches on the small end (inside bark), and a shortest length of 14'6" would have an estimated volume of 106 board feet (Doyle Rule). If there is a need to take a deduction for defect in this log, it is done in the same manner as for standing trees.

Basal Area Factor

Basal area (B.A.) per acre is a method of expressing forest stand density. It is the sum, in square feet, of the cross-sections of all of the tree stems (at breast height)

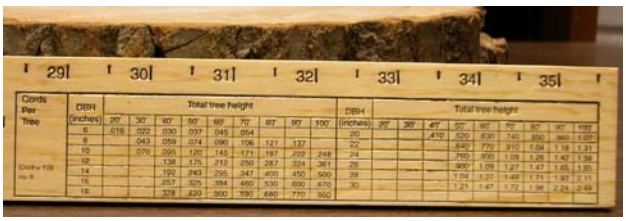


Figure 5. Utilize the "Cords Per Tree" chart to figure the amount of firewood cords in each tree.

Figure 6. Use the "Log Scale Stick Doyle Rule" with the "Diameter of Log (inches)" to estimate the volume of board feet in logs.

in an acre of forest. Basal area includes the bark with the wood. In simple terms, basal area is a measure of the level of crowding of trees in a forest, and it is used by foresters to make thinning, harvesting, and other forest management recommendations.

Near the end of the stick on the log scale side (Figure 7) is a 10 factor angle gauge used to estimate basal area. The gauge is the width of the black square. The factor of the gauge is 10 square feet basal area per acre if the stick is held vertically, with the square perpendicular to the line of sight, and at exactly 25 inches from the eye.

Figure 7. Basal Area Factor Gauge.

To estimate basal area at a given location:

1. Position yourself in the center of the area to be measured, hold the stick as described above, and compare the black square to each tree that can be seen.
2. Any tree whose trunk shows on both sides of the black square (i.e. is wider than the square; Figure 8) is counted. Keeping your feet centered over the same spot, move in a complete circle and tally any tree larger than the gauge. Do not count trees that appear smaller than the width of the square; if a tree appears equal to the width of the square, count it as 1/2 a tree (see Figure 8).
3. When the circle has been completed, multiply the count by 10, the BA factor. If six trees are tallied, the basal area at that sample point would be 60 square feet per acre. If 15 trees are tallied, the BA per acre would be 150 square feet.

To estimate the BA for a forest stand, a number of sample points should be taken, usually a minimum of 10 or at least 1 per acre in large stands. The BA for all sample points should be totaled and averaged to determine an estimate of BA for the stand.

Summary

All of the tools presented on the scale stick will help woodland owners better understand the forest resources found in their woodlands. This information along with the assistance of a professional forester will help woodland owners make informed decisions about the management of their woodlands.

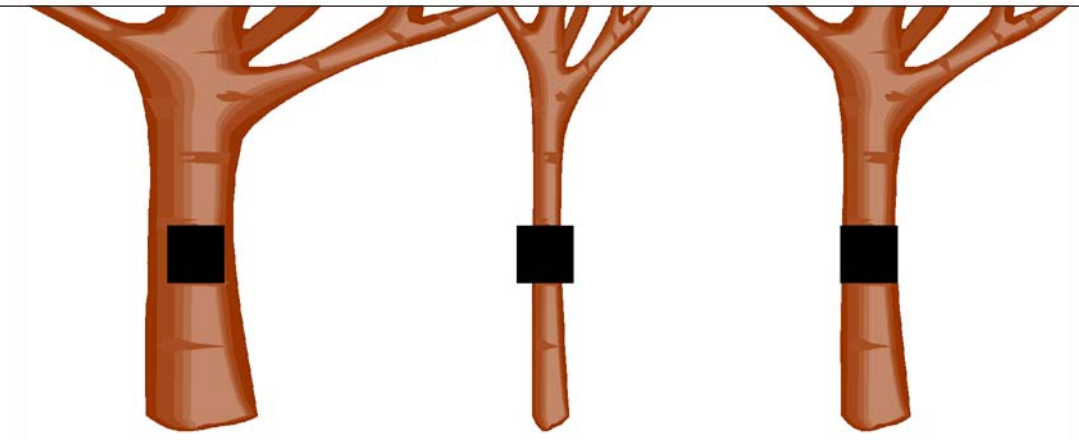


Figure 8. Using the Basal Area Factor Gauge to determine how crowded your forest is.

Visit Ohio State University Extension's web site "Ohioline" at: **http://ohioline.osu.edu**

ALABAMA COOPERATIVE Extension SYSTEM

ANR-1371

ALABAMA A&M AND AUBURN UNIVERSITIES

Basal Area: A Measure Made for Management

Assume you have 40 acres of forestland that was recently assessed by a natural resource professional. The resulting timber appraisal states that there is an estimated 90 square feet of basal area per acre and the trees have an average diameter of 10 inches. What does that really mean? From the description, can you picture what the forest looks like? Or more importantly, do you know how that number could be used to help you with future forest management options?

From time to time, you might encounter unfamiliar forestry terms as you interact with land management professionals or read forestry- and wildlife-related publications. Indeed, *basal area* might be one of these unfamiliar terms. For foresters, *basal area* is one of the most easily understood terms, but it may also be one of the most misused terms in forestry. This publication will help you better understand what basal area is and why it is an important forest measurement.

Basal area is used to determine more than just forest stand density; it is also linked with timber stand volume and growth. Therefore, it is often the basis for making important forest management decisions such as estimating forest regeneration needs and wildlife habitat requirements. The manipulation of stand basal area to achieve forest management goals can be as important as the use of prescribed fire or other vegetation treatments.

What Is Basal Area?

Part of the confusion about the term might have to do with the fact that basal area can be thought of in two different ways:

The basal area of a tree is defined as the cross-sectional area (usually in square feet) of a single tree at breast height, or 4½ feet above ground. The diameter of a tree at 4½ feet above the ground is called *diameter at breast height* (DBH).

The cross-sectional area of all stems of a species or all stems in a stand measured at breast height and expressed as per unit of land area.

Figure 1. This is a stand of longleaf pine (*Pinus palustris* Mill.) with an average basal area of 95 square feet per acre. Basal area is often stated simply as "95 square feet of basal area" or "95 BA."

Why Not Trees Per Acre?

Trees per acre (TPA) is a common measure of the number of standing trees that are found on an acre of land. It is also relatively easy to understand as a way to calculate *stand density*, or how crowded trees are in a stand. Trees per acre does not take into account the size of trees; instead it is based on the distance between or the spacing of trees on a site. In a plantation, the number of trees per acre can be estimated given the spacing within a row of trees and the distance between the rows.

Trees per acre is an appropriate term to describe stand density in young stands, whether a plantation or naturally regenerated stand. But as trees grow, this becomes less meaningful, especially when estimating timber volumes.

For instance, a stand of 6-inch DBH trees averaging 100 trees per acre does not contain the same volume of wood as 100 trees per acre of 16-inch DBH trees. Similarly, timber stands can have the same basal area yet look very different on the ground. The diameter of trees at DBH determines how many trees per acre it takes to make a given basal area. Figure 2 illustrates graphically how many 6-, 10-, 14-, and 18-inch trees you would have on a 1/5-acre circular plot to make 60 square feet of basal area per acre:

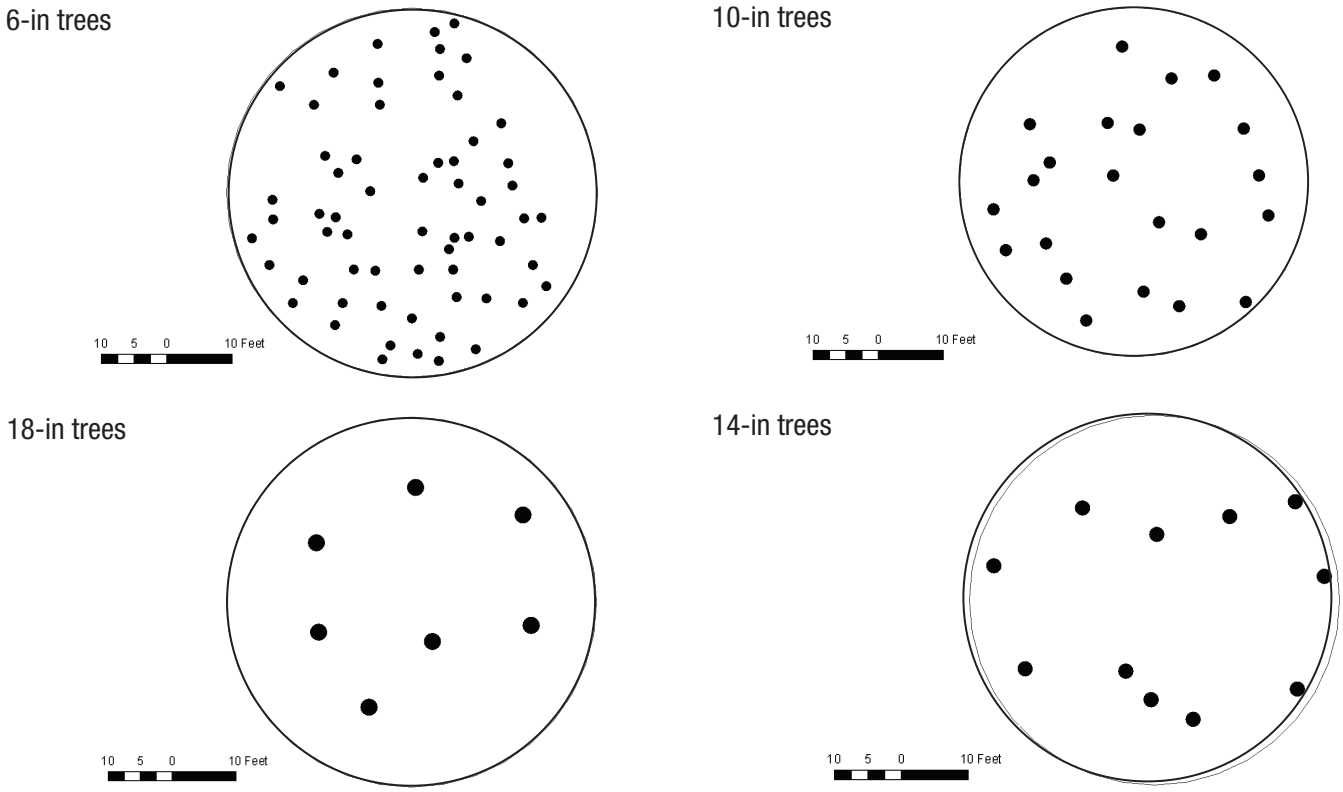


Figure 2. Representation of a 1/5-acre plot and the number of trees at 6, 10, 14, and 18 inches DBH that are needed to make 60 square feet of basal area per acre. (Graphic courtesy John Gilbert, Longleaf Pine Stand Dynamics Lab, School of Forestry and Wildlife Sciences, Auburn University)

How Is Basal Area Calculated?

Picture an acre of trees cut off at DBH (4½ feet). The total surface area of the stumps in square feet would be the basal area of that acre.

In mathematical terms:

Basal area (square feet) = (pi /(4 * 144))*DBH^2 = **$0.005454*DBH^2$**

Where pi = 3.14, DBH = diameter breast height.

The number 0.005454 is called the *foresters constant*, which converts the measured inches into square feet.

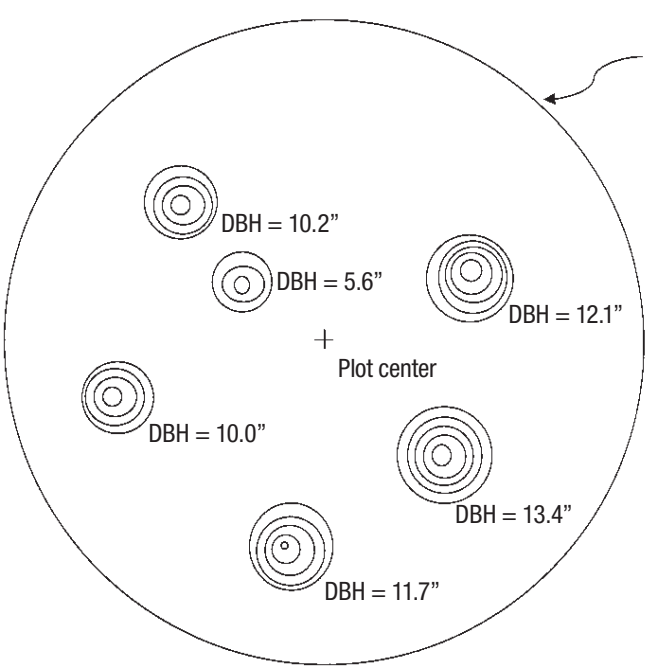
Based on the calculations above, table 1 illustrates the square feet of basal area per tree for several DBH classes. Table 2 can serve as a guide to assist landowners and natural resource professionals when estimating trees per acre from certain basal area measurements.

Table 1. Basal Area Per Tree, in Square Feet, for Trees That Are 1 to 30 Inches DBH

DBH (inches)	BA/tree (ft^2)	DBH (inches)	BA/tree (ft^2)
1	0.005	16	1.396
2	0.022	17	1.576
3	0.049	18	1.767
4	0.087	19	1.969
5	0.136	20	2.182
6	0.196	21	2.405
7	0.267	22	2.640
8	0.349	23	2.885
9	0.442	24	3.142
10	0.545	25	3.409
11	0.660	26	3.687
12	0.785	27	3.976
13	0.922	28	4.276
14	1.069	29	4.587
15	1.227	30	4.909

Table 2. Number of trees by 1-inch-diameter classes needed to achieve per acre square feet of basal area. Values are rounded to the nearest whole tree.

DBH (inches)	Basal area/acre													
	BA10	BA20	BA30	BA40	BA50	BA60	BA70	BA80	BA90	BA100	BA110	BA120	BA130	BA140
	Trees/acre													
1	1834	3667	5501	7334	9168	11001	12835	14668	16502	18335	20169	22002	23836	25669
2	458	917	1375	1834	2292	2750	3209	3667	4125	4584	5042	5501	5959	6417
3	204	407	611	815	1019	1222	1426	1630	1834	2037	2241	2445	2648	2852
4	115	229	344	458	573	688	802	917	1031	1146	1261	1375	1490	1604
5	73	147	220	293	367	440	513	587	660	733	807	880	953	1027
6	51	102	153	204	255	306	357	407	458	509	560	611	662	713
7	37	75	112	150	187	225	262	299	337	374	412	449	486	524
8	29	57	86	115	143	172	201	229	258	286	315	344	372	401
9	23	45	68	91	113	136	158	181	204	226	249	272	294	317
10	18	37	55	73	92	110	128	147	165	183	202	220	238	257
11	15	30	45	61	76	91	106	121	136	152	167	182	197	212
12	13	25	38	51	64	76	89	102	115	127	140	153	166	178
13	11	22	33	43	54	65	76	87	98	108	119	130	141	152
14	9	19	28	37	47	56	65	75	84	94	103	112	122	131
15	8	16	24	33	41	49	57	65	73	81	90	98	106	114
16	7	14	21	29	36	43	50	57	64	72	79	86	93	100
17	6	13	19	25	32	38	44	51	57	63	70	76	82	89
18	6	11	17	23	28	34	40	45	51	57	62	68	74	79
19	5	10	15	20	25	30	36	41	46	51	56	61	66	71
20	5	9	14	18	23	28	32	37	41	46	50	55	60	64
21	4	8	12	17	21	25	29	33	37	42	46	50	54	58
22	4	8	11	15	19	23	27	30	34	38	42	45	49	53
23	3	7	10	14	17	21	24	28	31	35	38	42	45	49
24	3	6	10	13	16	19	22	25	29	32	35	38	41	45
25	3	6	9	12	15	18	21	23	26	29	32	35	38	41
26	3	5	8	11	14	16	19	22	24	27	30	33	35	38
27	3	5	8	10	13	15	18	20	23	25	28	30	33	35
28	2	5	7	9	12	14	16	19	21	23	26	28	30	33
29	2	4	7	9	11	13	15	17	20	22	24	26	28	31
30	2	4	6	8	10	12	14	16	18	20	22	24	26	29



DBH (inches)	Basal Area (square feet)
10.2	0.567
5.6	0.171
12.1	0.799
8.4	0.385
13.4	0.979
11.7	0.747
10.0	0.545
Sum	4.193

Basal area on one 1/10-acre plot = 4.193 sq ft

Basal area per acre (BA/ac) = 4.193 sq ft per 1/10 acre or 41.93 sq ft/ac

Figure 3. Illustration of how per acre basal area can be calculated for seven trees in a 1/10-acre sample plot. Each stump is labeled with its DBH.

How Do I Determine the Basal Area of My Forest Stand?

Basal area per acre can be determined by simply measuring DBH of each tree on the acre, computing each tree's basal area, then adding each tree's basal area. Typically, a forested stand is cruised where a subsample of the total area is measured. The results of the subsample measurement is expanded or converted to a per-acre basis.

Another way that foresters may determine basal area is through the use of prisms or angle gauges to estimate basal area. Timber cruises of larger, sawtimber-sized pine stands and bottomland hardwood stands are often completed using this method. A prism or angle gauge is used to determine which trees are in (counted) or out (not counted). In the South, a 10-factor gauge or prism is most commonly used. With a 10-factor gauge or prism, the number of “in” trees is multiplied by 10 to get the basal area per acre. The average of measurements taken at several locations on a stand is used to estimate basal area.

If you do not have a prism or angle gauge, the following is a low-cost alternative.

Using a Penny and a Piece of String to Estimate Basal Area

An angle gauge of sorts can be made with a penny and a piece of string. Angles gauges and 10-factor prisms generate an angle of 1 inch in 33 inches. That is, a 1-inch DBH tree would have to be 33 inches or closer to be “in”; a 2-inch DBH tree would have to be 66 inches or closer to be in, and so on.

The diameter of a penny is 0.75 inches, so if it is held 24.75 inches from your eye, you have a 10-factor angle gauge.

Tie a knot in the end of a piece of string. Measure out 24.75 inches from the knot, and tie another knot. Hold one knot against your cheekbone or in your teeth, and hold the other knot at the penny, extending the penny until the string is taut.

If you want to measure a sample plot, pick a tree to measure first, such as the first tree to the right of due north on a compass heading. Extend the penny out the length of the string over a fixed point on the ground in front of you. If the sides of the tree appear to be beyond the edges of the penny, the tree is in (counted). If the edges of the penny appear to be beyond the sides of the tree, the tree is out (not

Figure 4. This tree is “in,” or counted.

Figure 5. This tree is "out," or not counted.

counted). If the edges and sides appear to be even, count every other tree. See figures 4 and 5.

Rotate around clockwise, holding the penny as you look at all trees in that area. Count all the "in" trees at that point, multiply by 10, and you have the basal area represented on that plot. To estimate basal area on your site, take the average of several points to gain a more accurate estimate.

How Can an Understanding of Basal Area Help Me More Effectively Manage My Forest Land?

An example: Naturally regenerating a mature longleaf pine (*Pinus palustris*) stand.

There are many benefits to the natural regeneration of your pine stands. There is no cost for seedlings, and no additional labor is needed for planting. Studies have shown that shelterwood cuts are one of the best ways to promote natural regeneration on longleaf pine forests.

It is recommended that small shelterwood harvest areas of 2 to 4 acres be thinned to approximately 30 square feet of basal area, leaving the highest quality seed-bearing trees in the overstory. To accomplish this, careful timber harvest is critical. Usually, it is recommended that remaining trees should be at least 30 years old and 10 inches or greater in DBH. Seed from these remaining overstory trees will regenerate the stand. Once the new stand of young trees is established, the older sawtimber-sized trees can be removed from the overstory through a series of thinnings.

Shelterwood systems can be used to create small, even-aged patches throughout the forest that mimic the natural regeneration process that evolved with the species. Using table 2 in this publication, you could determine just how many trees of a given DBH you would need to leave to achieve 30 square feet of basal area per acre. For example, if you had a stand that averaged 12 inches DBH, a basal area of 30 could be achieved with approximately thirty-eight 12-inch trees.

Can Understanding Basal Area Help Me Manage for Wildlife, Too?

An example: Managing forested habitats for Northern Bobwhite Quail (*Colinus virginianus*)

Assume that you have a forest stand and one of your primary objectives is to manage for Northern Bobwhite Quail habitat. The first step in establishing Northern Bobwhite habitat on your property is to understand what the habitat parameters are and then how those standards apply to forest management. Over the last 45 years Northern Bobwhite populations have declined throughout their range. This decline is due in part to the reduction of habitat quality and quantity. Forest management practices, such as timber harvesting and thinning, have been shown to improve forested habitat for Northern Bobwhite by reducing the density of forest stands.

Actual benefits to wildlife vary by species, timber type, and location; however, widely accepted standards for Northern Bobwhite habitat management suggest that a mosaic of forested and open landscapes is needed. Thinning and prescribed fire are key to effectively creating the open pine canopy with grassy understory that is optimum forested habitat for the species. When tree canopies close, sunlight that is needed for grasses and forbs to develop is unable to reach the forest floor. In many cases thinning prescriptions for forest management objectives are still too dense for Northern Bobwhite habitat management. Current recommendations state that young pine stands (12 to 18 years) should be thinned as early as possible, and sawtimber and pole stands should be thinned to an overall basal area of less than 40 square feet per acre. Using the BA40 column in table 2, you can determine the trees per acre needed on your stand to help achieve your management goals for Northern Bobwhite.

Basal Area Is Indeed a Measure Used for Management

It can represent the size of individual trees and the density of your forest stands, and it can describe wildlife habitat. Assessed either with special instruments, or everyday items, basal area is an important forest measurement. Remember, it is always best to have a qualified professional forester or wildlife biologist evaluate your property for the best evaluation of your forest resources. Becoming familiar with forestry terms and procedures, however, makes you an informed landowner, better able to make decisions regarding your property.

Glossary

basal area

The measurement of the cross-sectional area of tree trunks at 4½ feet above the ground and inclusive of the bark. Basal area gives an idea of the stocking of trees in a stand and is usually reported in square feet per acre.

diameter breast height (DBH)

The measurement of the diameter of a tree stem, outside the bark, taken 4½ feet above the ground on the uphill side of the tree.

stand density

The direct measure of crowding of trees in a stand; can be measured in terms of trees per acre, basal area, or volume per acre. Measurements of stand density may be used to determine silvicultural prescriptions.

trees per acre

A measure of stand density determined by the spacing between trees. Trees per acre can be used to estimate timber volumes and silvicultural prescriptions.

References

Burger, L. W. "Northern Bobwhite." *In Wildlife of Southern Forests: Habitat and Management,* edited by J. G. Dickson, 122–146. Blaine, WA: Hancock House, 2001.

Croker, T. C. Jr., and W. D. Boyer. "Regenerating Longleaf Pine Naturally," SO-105. Research paper, USDA Forest Service, Southern Forest Experiment Station, 1975.

Glover, G., and B. Barlow. Forestry Field Measurements Manual (unpublished). Auburn, AL: Auburn University, 2009.

ALABAMA COOPERATIVE Extension SYSTEM

ANR-1371

Jim Elledge, *Graduate Research Assistant,* and **Becky Barlow,** *Extension Specialist* and Assistant Professor, School of Forestry and Wildlife Sciences, Auburn University

For more information, call your county Extension office. Look in your telephone directory under your county's name to find the number.

Published by the Alabama Cooperative Extension System (Alabama A&M University and Auburn University), an equal opportunity educator and employer.

Web Only, **Revised July 2012**, ANR-1371

F-35-02

THE OHIO STATE UNIVERSITY EXTENSION

Extension FactSheet

School of Natural Resources, 2021 Coffey Road, Columbus, Ohio 43210

Measuring Standing Trees

Determining Diameter, Merchantable Height, and Volume

Randall B. Heiligmann
Extension Specialist, Forestry

Stephen M. Bratkovich
Former Extension Specialist, Forestry

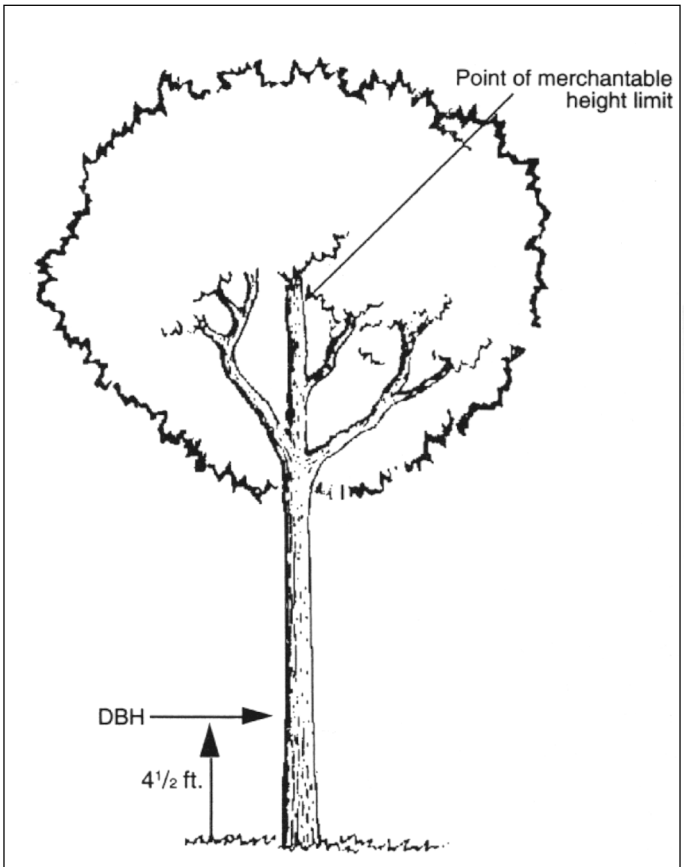
Woodland owners often need to measure the merchantable board-foot content (termed "volume") of certain trees in their woodland. In order to sell timber, for example, an estimate is needed of the quantity to be sold. If trees are to be cut to provide lumber, an estimate of volume is needed to determine what size and how many trees to cut. Using the methods described in this article, a woodland owner can estimate the board-foot volume in one or several trees. If an estimate is needed for several acres, however, it is recommended that the woodland owner engage the services of an Ohio Department of Natural Resources Division of Forestry Service Forester, a consulting forester, or an industry forester. Methods needed to accurately and efficiently inventory timber volume on large areas are beyond the scope of this publication.

Tree Volume Estimation

In the United States, the most common measure of lumber volume is the board foot, defined as a piece of wood containing 144 cubic inches. It can most easily be visualized as a board 12 inches square and one inch thick (12" x 12" x 1" = 144 cubic inches). However, any piece of wood containing 144 cubic inches is a board foot (e.g., 3" x 4" x 12"; 2" x 6" x 12"; etc). The board-foot content of any board may be determined by multiplying the length by the width by the thickness, all expressed in inches, and dividing by 144 cubic inches.

The board foot is also the most common volume measure for trees and logs to be used for lumber and veneer. The board-foot volume of a tree or log is an expression of the number of board feet of lumber that can be cut from that tree or log. The lumber volume that can be cut from a tree or a log depends on a great many variables, including how the tree is cut into logs, the dimensions of the lumber, how much of the log is lost in sawdust and waste, and the efficiency of the sawmill and workers. Because of these variables, the board-foot volume of a tree or log cannot be measured exactly but is estimated.

Numerous methods (called "rules") have been developed to estimate board-foot tree volume. Two board-foot volume rules are commonly used in Ohio, the Doyle and the International 1/4-Inch rules (Tables 1 and 2). Both of these rules provide an estimate of the board-foot content of a tree based on tree-trunk diameter breast high and merchantable tree height (discussed later). The Doyle rule is the most common rule in Ohio. It is used



Common reference points used to measure standing trees.

by the timber industry and many professional foresters. The International 1/4-Inch rule is used by state agencies and the U.S. Forest Service.

A comparison of these two volume tables will show that they are not identical. The International 1/4-Inch rule is generally considered to be the best estimate of the amount of lumber that can actually be sawn from a tree or a log under optimum conditions. The Doyle rule substantially underestimates the volume of trees in the smaller diameter classes. The International 1/4-Inch rule should, therefore, be used when the most accurate estimate of yield is important, as when determining how many trees to cut to obtain a specified amount of lumber. When marketing timber stumpage, however, the choice of volume rule is less critical. Confusion on quantity should not arise as long as both buyer and seller know which rule was used to estimate volumes. Timber stumpage prices are commonly adjusted based on which rule is used.

Measuring Tree Diameter

Tree-trunk diameters are measured at breast height (termed diameter at breast height or DBH), defined as the diameter of the tree 4-1/2 feet above ground on the uphill side of the tree. If a tree forks below breast height, each trunk is treated as a separate tree. DBH can be measured with a tree caliper, a Biltmore stick, a tree diameter tape, or a flexible measuring tape (e.g., cloth or steel). Tree calipers, Biltmore sticks, and tree-diameter tapes can be purchased through forestry equipment supply companies. The flexible measuring tape can be used to measure tree trunk circumference and circumference divided by 3.14 to determine diameter.

Measuring Merchantable Height

Merchantable height is the height of the tree (or the length of its trunk) up to which a particuar product may be obtained, usually minus a one-foot stump height. Merchantable tree heights for sawlogs and veneer are generally estimated to the height where the trunk diameter tapers to 10 inches, or until heavy branching or defects are encountered. The merchantable height of very valuable trees, such as veneer black walnut, may be measured to the nearest foot or two feet. The merchantable height of most other trees is measured in units of 16-foot logs and 8-foot half-logs. Merchantable height measurements are rounded to the nearest half-log. Thus, a tree with a merchantable height of 42 feet would be measured as having 2-1/2 logs of merchantable height.

Merchantable heights may be measured with a number of special instruments designed specifically for tree-height measurements such as clinometers, altimeters, relascopes, or hypsometers. These instruments are available through forestry equipment supply companies. Merchantable heights can also be measured with a long pole if only a few trees are being measured and they have relatively short merchantable heights. With some practice, merchantable heights in log and half-log units can be estimated quite accurately, particularly for trees with short merchantable heights.

Using the Tables to Estimate Merchantable Tree Volume

Once the diameter at breast height and the merchantable height of a tree have been measured, Table 1 or 2 may be used to estimate its volume in board feet. For example, a 20-inch DBH oak tree with a merchantable height of 2-1/2 logs contains 260 board feet Doyle rule or 350 board feet International 1/4-Inch rule.

When using these tables, it is important to remember that only that portion of the trunk that will produce a useable product should be measured. Portions of the trunk or entire trunks that are hollow, excessively crooked, rotten, etc., should not be measured. You may hear foresters or buyers talking about gross and net volume. Gross volume is the estimated tree volume without deduction for defects (i.e., the DBH and merchantable heights of all of the trees were measured ignoring defects, volumes were determined, and the volumes were added up). Net volume is the estimated tree volume with proper deductions made for defects.

2/2002-jaf

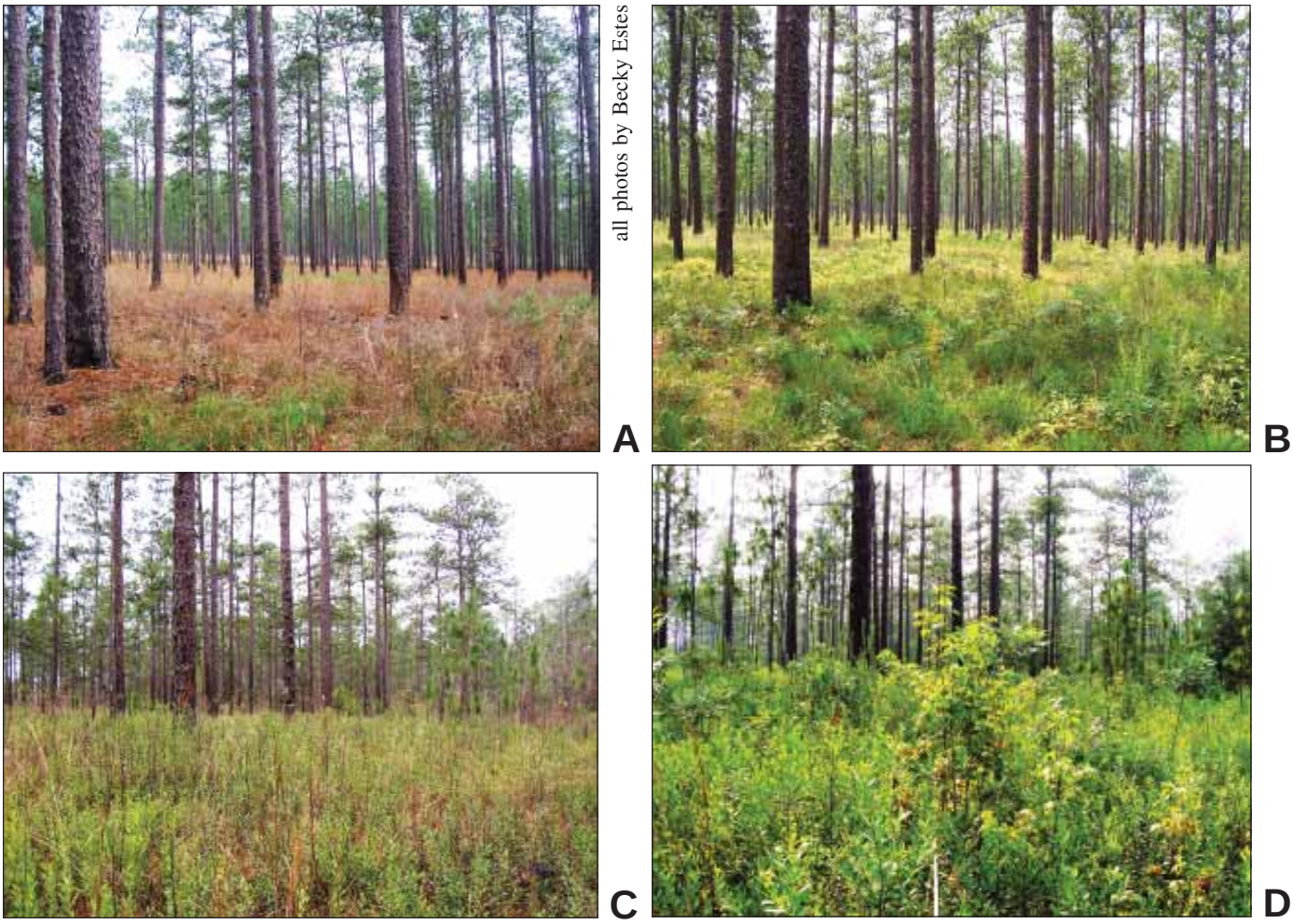


Figure 20—Longleaf pine stands on the Escambia Experimental Forest, near Brewton, Alabama, that have been managed with prescribed fire for multiple decades, showing both the phenology of vegetation at different times of the year and vegetation changes owing to timing of the fire treatments. The top two photos are from a unit managed with a mix of growing- and dormant-season burns, with photos taken in (a) March—dormant season and (b) July—growing season. The bottom two photos are from a unit managed with primarily dormant-season burns, with photos taken in (c) March—dormant season and (d) July—growing season. Note that the growing season burns appear to have more effectively reduced shrubby understory vegetation. The mechanisms of burning-season effects are often difficult to isolate because fire frequency, fuel loading, and canopy cover can confound the role season may play in determining the outcome.

Understory Vegetation

Shrubs and hardwoods—

Maintaining adequate regeneration of overstory trees is a common goal in the management of pine forests. To reduce competition for light, fire is used to selectively top-kill the hardwood midstory and shrub understory, while minimizing the impact to overstory pines. Numerous research results have suggested that burning during the peak of the historical fire season (May) reduces stem density of understory hardwoods more so than burns at other times of the year (Boyer 1993, Drewa et al. 2006, Glitzenstein et al. 1995b, Streng et al. 1993, Waldrop et al. 1987, White et al. 1991). This is particularly true if burns are repeated at annual or biennial intervals. A single burn in any season will not kill enough plants to control hardwood resprouting (Boyer 1990). However, following 43 years of burning on the Santee Experimental Forest in

South Carolina, fewer hardwood sprouts survived with a fire regime of annual late spring/early summer (June) burns than annual winter (December) burns (Waldrop and Lloyd 1991). With late spring/early summer burns, the woody vegetation was gradually replaced by an understory dominated by forbs and grasses (Waldrop et al. 1987) (fig. 20). In contrast, more oaks and other hardwoods were maintained with repeated burns during the fall/winter dormant season (October—January) (Jacqmain et al. 1999). In another study in shortleaf pine—grassland ecosystems of Arkansas, late-growing-season (September—October) burns were found to be less effective for reducing understory hardwoods than late-dormant-season (March—April) burns (Sparks et al. 1999).

It is important to note that the regime of annual growing-season burning that most successfully reduced competing hardwoods and shrubs in two of the most widely cited studies (Santee Experimental Forest study (Waldrop et al. 1987, Waldrop and Lloyd 1991), and St. Mark's National Wildlife Refuge study (Glitzenstein et al. 1995a, 1995b; Streng et al. 1993) was considerably more frequent and invariant than was likely the case historically and therefore may not be the most beneficial for other components of the ecosystem. Although fires as frequent as 1 to 2 years apart have been recorded in the tree ring record of eastern pine forests, the overall historical fire-return interval averaged 3 to 7 years (Henderson 2006). Annual prescribed burning may not even be possible in some stands, if fuel accumulation rates are slower. For pines to regenerate naturally, longer fire-free periods may be necessary so that seedlings can establish and grow above the zone of lethal heat. Depending on the management objective, a prescribed burning regime of variable frequency and seasonality (within the historical ranges) may be preferred.

There are several explanations relating both to the physiological status of the plant and to fire intensity for the difference in midstory hardwood and shrub mortality following burns in different seasons. Physiological status appears to play a role in the greater shrub and hardwood reductions noted with growing-season burns in many studies. During the dormant season, shrubs store more of their carbohydrates underground, and these carbohydrates enable resprouting when the aboveground portion is killed by fire (Drewa et al. 2002). During the growing season, more of the carbohydrates are allocated aboveground, and are lost with topkill, leaving fewer reserves for resprouting. Drewa et al. (2002) evaluated shrub response to fires of different temperatures in different seasons and found changes were not associated with fire intensity, suggesting that the physiological status of the shrub at the time of burning may be playing a greater role. Studies of defoliation of evergreen shrub species in different seasons also point to a physiological influence, with one study reporting complete kill following leaf removal in October, but a much reduced effect in April (Kramer and Wetmore 1943). Other studies suggest an effect of fire intensity differences among burn seasons (Drewa et al. 2006, Glitzenstein et al. 2003). Shorter statured vegetation, such as midstory hardwoods and shrubs, is more likely to be affected by seasonal differences in scorch height (Robbins and Myers 1992). In the Sparks et al. (1999) study, the dormant-season burns (March—April) were both more intense and more effective at thinning the midstory hardwoods than the late-growing-season burns (September—October), suggesting that differential intensity may have overwhelmed effects of phenology. Indeed, some burning-season studies have reported fire intensity to be just as important as phenology in shaping the outcome (Glitzenstein et al. 1995b, Sparks and Masters 1996).

Less is known about effects of burning season on understory shrubs in areas north of the southeastern pine zone. In one of the few studies on the topic, Schwartz and Heim (1996) noted that 95 percent of small saplings and shrubs in an Illinois forest were top-killed by either a single dormant-season (March) burn or a single growing-season (May) burn. In another study of understory response in mixed-hardwood and pine forests of Minnesota, both spring dormant-season and summer growing-season burns completely top killed hazel (*Corylus* L.), but resprouting was enhanced by repeated spring burning and reduced by repeated summer burning (Buckman 1964). Because humus was combustible during dry summer conditions,

fires at this time of year were more likely to kill the roots. Carbohydrate reserves were also more likely to be exhausted following repeated summer burning.

Herbaceous understory—
Burning during the historical fire season has been hypothesized as important because organisms are presumably best adapted to disturbance at this time of year. Studies show that this may indeed be the case for some understory plant species of southern pine forests. At the St. Marks National Wildlife Refuge in Florida, greater increases in shoot number and flowering of narrowleaf goldenaster (*Pityopsis graminifolia* (Michx.) Nutt.) were observed following burns in May than burns in January or August (Brewer and Platt 1994a, 1994b; Brewer et al. 1996). The increases in shoot numbers did not lead to long-term increases in stem densities, however, suggesting that there may be some cost to using resources for reproduction (Brewer 2006). Although the flowering response indicates an adaptation to and dependence on growing-season fire, Brewer (2006) hypothesized that this species would likely benefit from "modest variability in fire frequency and fire season." Numerous grass species, including the commonly studied wiregrass (*Aristida beyrichiana* Trin. & Rupr.), also flower more vigorously after growing-season burns (Main and Barry 2002, Outcalt 1994, Streng et al. 1993). Saw palmetto produced more flowers and fruits with periodic growing-season (April—July) burns than with dormant-season (November—February) burns (Carrington and Mullahey 2006). Growing-season burns have also been shown to increase flowering synchrony of forbs and shrubs by decreasing the flowering duration (Platt et al. 1988). Flowering synchrony may lead to a higher probability of cross pollination. In another study, no difference in the density of reproductive American chaffseed (*Schwalbea americana* L.) plants was noted between burning-season treatments (Kirkman et al. 1998). Numbers increased following burning in either the growing or dormant season. However, burning season did influence the timing of flowering, with plants flowering earlier after dormant-season burns than after growing-season burns.

The positive response of some species to growing-season burning provides evidence for fire at this time of year being an important part of the natural disturbance regime. However, what is best for one species may not be for all, with some species also responding more strongly to dormant-season burns (Hiers et al. 2000, Liu and Menges 2005, Sparks et al. 1998). Many species do not appear to be influenced by burning season at all. For example, of the more than 150 plant species evaluated for response to late growing-season (September—October) and late dormant-season (March—April) burns in a shortleaf pine-grassland community in Arkansas, fewer than 10 percent were differentially affected by burning season (Sparks et al. 1998). The variable response of understory species to fire season suggests that a heterogeneous fire regime (including variation in the seasonal timing of fire) may help conserve biodiversity (Hiers et al. 2000, Liu et al. 2005).

For species with growth or flowering influenced by burning season, response has sometimes been shown to differ at fine temporal scales—i.e., for fires within the same growing season (Negron-Ortiz and Gorchov 2000, Rideout et al. 2003), or among plant growth stages (Spier and Snyder 1998). Negron-Ortiz and Gorchov (2000) reported that early wet-season (May—June) fires were beneficial and late wet season (July—September) fires detrimental to the cycad species *Zamia pumila* L. The variation in response of herbs and woody plants observed among burns within the growing season by Rideout et al. (2003) was attributed mainly to climatic differences. Liu and Menges (2005) noted that slight differences in burn timing within the wet (growing) season had substantial effects on survival and growth of big pine partridge pea (*Chamaecrista lineata* (Sw.) var. *keyensis* (Pennell) Irwin & Barneby), and concluded that comparing fires by seasons may be too broad and not useful to managers.

In a study of response of multiple growth stages, small plants of the forest herb pineland Jacquemontia (*Jacquemontia curtisii* Peter ex Hallier f.) suffered greater mortality with growing-season (June) prescribed burns than dormant-season (January) burns, even though the latter

burns were hotter (Spier and Snyder 1998). However, the plants surviving the growing-season burns produced more flowers. Therefore, different parts of the plant life-cycle were variably affected by burning season. Similar findings have been reported for wiregrass, where growing-season burns promote flowering, but also cause higher mortality of established seedlings than dormant-season burns (Mulligan et al. 2002, Streng et al. 1993), and big pine partridge pea, where stem growth was greater but plant survival lower following growing-season (summer) burns (Liu and Menges 2005). These results all highlight the importance of variability in the fire regime.

At the plant community level, repeated growing-season burning generally increases the cover of grasses and diversity of herbaceous species (Drewa et al. 2002, 2006; Lewis and Harshbarger 1976; Waldrop et al. 1987; White et al. 1991). This shift is likely because of release from shrub competition (shrubs are selected against by growing-season burns) and removal of the litter layer (Lewis et al. 1982). The robustness of the understory herbaceous layer is not only important for biodiversity conservation, but also for grazing animals. Studies focused on livestock management have reported grass productivity gains with early growing-season burns (Grelen and Epps 1967, Lewis and Harshbarger 1976), which is likely also tied to reduced shrub competition. However, overall productivity (herbs and shrubs) was found to be greater following fall burns than spring burns (Schneider 1988). Other studies that have followed productivity over several years have been unable to document any increase in biomass and cover of grasses and forbs with burns in different seasons (Streng et al. 1993).

Sparks et al. (1998) suggested that understory composition was, in part, influenced by fire intensity through its effect on litter consumption and woody shrub removal. However, fire intensity did not appear to play much of a role in another study. Hierro and Menges (2002) burned plots containing between 2.6 and 7.1 tons/ac of surface fuel with and without 54.0 tons/ac of additional fuel, and found little effect on understory shrub species richness or density although the fuel addition treatment significantly increased fire temperatures and soil heating. The authors suggested that species are well adapted to variation in fire intensity. In another study, plant mortality did not differ with fuel consumption differences, suggesting that seasonal timing may be more important than fire intensity (Liu and Menges 2005). However, a big picture view suggests that the effect of season of burning is less critical to maintaining understory biodiversity in the longleaf pine system, than frequency of burning (Palik et al. 2002).

One cautionary note on repeated burning: despite the many benefits of growing-season burning that have been reported in the literature, a recent publication from the St. Marks study in Florida indicates that growing-season burns, if applied annually, may over time actually reduce the cover of plants such as wiregrass that are stimulated to flower by fire (Glitzenstein et al. 2008). These results warrant closer scrutiny to determine whether invariable and frequent growing-season burns cause the grasses to invest an excessive amount of carbohydrate reserves into reproduction, thereby reducing the plants' ability to grow vegetatively over the long term (Brewer et al. 2009).

Much less literature is available for the understory of eastern hardwood ecosystems than southern pine-dominated ecosystems. Perennial herbs in oak forests generally emerge from rhizomes and are dormant during the typical spring and fall burning periods. Because heat penetration into the soil with the burning of leaf litter is generally minimal, resprouting from dormant rhizomes is likely little affected by burning at either time. Any change in the understory as a result of burning season is expected to result more from indirect effects, such as reduced competition with top kill of midstory shrubs, or consumption of the litter layer (Keyser et al. 2004). Keyser et al. (2004) found that plant cover and species richness in an oak-dominated forest increased following fire regardless of whether burning occurred in February, April, or August, but the more intense spring and summer burns led to a shift toward herbaceous species, whereas the winter burn resulted in dominance by shrubs. In a degraded Illinois woodland, growing-season (May) burns were more effective than dormant-season (March) burns at controlling an

exotic species (Schwartz and Heim 1996). However, May burns also caused different and longer lasting effects to the native herbaceous understory than March burns, with composition in the March (dormant season) burn plots appearing more similar to the unburned control.

Soils

Consumption of surface and live fuels releases nutrients, some of which may be leached from the system unless they are taken back up by micro-organisms or growing vegetation. It is therefore believed that prescribed fire close to the onset of growth or during the active season when growing tissue is accumulating nutrients might lead to less leaching from the system (Robbins and Myers 1992). Another possibility is that more nutrients could be volatilized when actively growing tissues are burned than when tissues are burned during the dormant season. By the time of the dormant season, at least some of the nutrients from aboveground structures have already been translocated to underground storage structures and therefore escape being volatilized (Robbins and Myers 1992). However, as Robbins and Myers (1992) noted, very little data are available to back up either the leaching or volatilization theories. In longleaf pine forests, Boring et al. (2004) documented greater nitrogen loss with growing-season (June) burns than dormant-season (March—April) burns, presumably as a result of live fuels being volatilized. However, nitrogen fixation and atmospheric deposition were believed sufficient to compensate for this loss if the fire regime is not exclusively growing season—i.e., including a mix of seasons. There was no difference in phosphorous with burning-season treatments (Boring et al. 2004). Temperatures were apparently not high enough for any of the burns to volatilize this nutrient. Another recent study reported very little effect of burning season on soil variables in an oak-pine forest in Massachusetts (Neill et al. 2007). The organic horizon (duff layer) was reduced more by summer burns than by spring burns, and replacement with mineral soil caused the bulk density to also be higher. All other variables including pH, acidity, base saturation, total exchangeable cations, carbon, and nitrogen did not differ between burn seasons.

Some other potential impacts of fire in different seasons on soils are likely associated with variation in fire intensity or extent of soil exposure. Soil is exposed for a longer period after burns in fall and winter (dormant season), and this could alter the rate of erosion. In their literature review, Robbins and Myers (1992) found only a single study addressing erosion and season of burning. Dobrowolski et al. (1987) reported greater sediment yields after winter burns than spring and summer burns, attributing this to direct exposure of the soil to raindrops for a longer period with winter burns. Summer burning produced the least erosion, possibly because these burns were patchier. The lack of studies on erosion with prescribed fire in the Eastern region may be due, in part, to the relative lack of topography in many areas with active prescribed burning programs.

Wildlife

Early forest managers generally avoided burning southeastern pine forests during the late spring and early summer, because of concerns about harming wildlife species. However, with this time of year being the peak historical fire season, others concluded that wildlife must have evolved means to survive (Komarek 1965). Direct effects to wildlife are perhaps less of a concern in the eastern hardwood forest ecosystems because especially in the north, fire historically occurred primarily during the dormant season when many species are less active.

Birds—

Timing of early prescribed burning in the Southeastern United States was strongly influenced by concerns about game birds and other ground-nesting species (Stoddard 1931). Late winter to early spring burning became popular because this period occurred after the end of hunting season but prior to nesting season for quail and other species (Brennan et al. 1998). To reduce the feared catastrophic effect on clutch success of ground-nesting species, burning at this time of year became “ingrained in the culture

of the Southeast" (Brennan et al. 1998). However, the majority of studies have since shown few strong effects of burn season on direct mortality, breeding success, or survival of birds (Cox and Widener 2008; Engstrom et al. 1996; Tucker et al. 2004, 2006). In fact, overwinter survival of Henslow's sparrow (*Ammodramus henslowii*) was found to be greater in areas previously burned in the growing season than in areas previously burned in the dormant season (Thatcher et al. 2006). In another study, abundance of wintering bird communities did not differ one year after burns conducted in the growing season (April—August) or the dormant season (January—March) (King et al. 1998).

Many bird species prefer to nest in stands that have been burned within 1 or 2 years (Cox and Widener 2008). For example, the majority of Bachman's sparrow (*Aimophila aestivalis*) nests (>85 percent) were found in areas that were recently burned during the growing season, and the majority of wild turkey nests (62 percent) were found in forest that had experienced a growing-season burn within the past 2 years (Cox and Widener 2008, Sisson et al. 1990). Management using a regime of growing-season burns 3 or more years apart, but within a patchy landscape with units varying in time since last fire, would therefore likely impact relatively few ground nests.

Changes in vegetation brought about by burning in different seasons can indirectly influence bird populations (Engstrom 1993). Dormant-season burning in longleaf pine forests can impact the structure and composition preferred by different bird species by promoting hardwoods over grasses and forbs (Abrahamson and Hartnett 1990). Red-cockaded woodpecker (*Picoides borealis*) and other bird species are generally less abundant in forests where understory hardwoods have encroached (Provencher et al. 2002, Sparks et al. 1999). Although lengthening of fire intervals is believed to be the main cause of red-cockaded woodpecker decline, growing-season burns have been shown to more effectively suppress midstory hardwoods and promote a ground cover composition favorable for arthropod food sources for these birds (James et al. 1997). In a study of bird community response to fire, Fitzgerald and Tanner (1992) found that neither January nor June prescribed burns in a dry prairie in south Florida altered bird species richness, compared with the unburned control. Both of the burning-season treatments reduced shrub cover.

Ground cover is beneficial to some overwintering migratory birds such as Henslow's sparrow—burns in the winter (February—March) eliminate this ground cover, and research shows that growing-season burns improve survival over dormant-season winter burns (Thatcher et al. 2006). Spatial patchiness is another characteristic of fires potentially important for birds and other wildlife (Sparks et al. 1999), and spatial patchiness can differ among burning seasons because of variation in fuel moisture.

Overall, reviews of the limited literature show few if any effects of burning season on bird populations. Although growing-season burns may cause some direct mortality by destroying nests and killing young birds, many bird species renest, and the indirect benefits of habitat alteration are usually far more important and likely compensate or more than compensate for losses (Engstrom et al. 2005, Robbins and Myers 1992).

Small mammals—

The effect of different prescribed burning seasons on small mammal populations remains poorly studied. Both historical fires and prescribed burns in eastern forests may be of sufficiently low intensity and patchy enough that the variable needs of small mammal populations are met, regardless of burn season (Keyser and Ford 2006). A study in oak stands in Virginia that compared effects of winter, spring, and summer prescribed burns reported no detectable short-term losses of ground-dwelling species such as shrews (*Sorex* and *Blarina*) and white-footed mice (*Peromyscus leucopus*) (Keyser et al. 1996, 2001). Longer term habitat changes, such as differences in hardwood midstory cover or ground exposure owing to variation in the burning season, could potentially affect small mammal populations. Fires conducted in March or August annually for 3 years in Florida longleaf pine sandhill forests resulted in no difference in pocket gopher (*Geomys pinetis*)

mounding or body size (Gates and Tanner 1988). Although a minor increase in herbaceous biomass was noted following March burns, this apparently did not influence gopher behavior (Gates and Tanner 1988). Overall, consistent trends in small mammal response to habitat changes with burning season have not emerged (Ahlgren 1966, Brose and Van Lear 1999, Kirkland et al. 1996).

Amphibians and reptiles—
Direct effects of fire are not expected to be strong for amphibian species occupying moist habitats that are less flammable than the surrounding landscape. Prescribed burns during cool weather in the winter, or any time of the year when moisture is high, have a lower probability of passing through and consuming fuels in wetter areas. However, burns at these times of year may also coincide with winter mating migrations when individuals can be more vulnerable. Varying the burn season to include growing-season burns as well as dormant-season burns has been suggested as one means of reducing the potential impact of fire (Schurbon and Fauth 2003).

It is possible that amphibian and reptile species are indirectly influenced by burning season through differential effects on habitat structure. For example, certain species of longleaf pine forests require bare sandy habitats and are thus benefited most by relatively intense and spatially variable burns (Russell et al. 1999), which are more likely in some seasons than others. Growing-season burns have been reported to be more intense and more likely to clear overgrown vegetation surrounding wetlands; some amphibians apparently prefer the higher light levels and warmer temperatures that result (Bishop and Haas 2005). In a study by Yager et al. (2007), reduction of midstory cover of longleaf pine forests through application of a mixture of dormant-season and growing-season burns increased habitat usage by gopher tortoises (*Gopherus polyphemus*). Burn seasons most effective at reducing the height of understory vegetation are likely to favor not only the gopher tortoise but other species that utilize gopher tortoise burrows such as the Florida pine snake (*Pituophis melanoleucus mugatis*) and Florida gopher frog (*Rana capito aesopus*).

Several studies have compared amphibian and reptile populations after dormant- and growing-season prescribed burns and none have found a significant difference in numbers (Floyd et al. 2002, Keyser et al. 2004). The lack of an effect can be attributed to incomplete consumption of coarse woody debris and duff, the existence of moist environments such as tunnels and cracks in the soil or under rocks that escape heating, mobility of the organisms, relatively few changes to the overstory canopy, and generally quick regrowth of understory vegetation (Renken 2006).

Arthropods—
Hall and Schweitzer 1992 (cited in Hermann et al. 1998) hypothesized that burning during the growing season may have fewer detrimental effects on arthropods than burning during the dormant season because a greater number of individuals have wings and are mobile at this time of year. Arthropod abundance was found to be equal or greater following growing-season burns than following dormant-season burns (Hermann et al. 1998). However, a fall survey in Florida oak scrub found that garden orbweaver spider (*Argiope* sp.) numbers were not affected by burns in February, but were substantially reduced by burns in July and August (Carrel 2008). Spiderlings disperse in April and May through ballooning, so the low numbers immediately following summer fires may simply be due to lack of dispersal opportunities between the time of the fire and the time of sampling. In a hardwood stand in Kentucky, a single March prescribed fire reduced the invertebrate mass by 36 percent, with the majority of this loss occurring among species associated with the forest floor (Kalisz and Powell 2000).

Neither burns in July nor November altered the population size of the Karner Blue butterfly (*Lycaeides melissa samuelis*) 1 to 3 years later, compared with unburned controls (King 2003). The July burns were during the period of the second flight of the summer, whereas the November burns occurred after activity had ceased for the year. Burns in both seasons were described as "cool" (i.e., not at times of the year when flame lengths are greatest), which may have allowed some of the eggs on vegetation in this oak savanna system to survive.

Overall, it is apparent that how fire affects arthropods will differ greatly by species and functional group, with burning potentially most detrimental if the timing coincides with a particularly vulnerable life history stage (Robbins and Myers 1992). Several authors have recommended that prescribed burning be done in such a way as to maximize patchiness so that invertebrates are able to survive in refugia and recolonize the burned areas (Kalisz and Powell 2000, Knight and Holt 2005).

Implications for Managers

The majority of studies on burning-season effects in eastern forest ecosystems have been conducted in pine- and pine-oak-dominated forests of the Southeast. In this forest type, the literature provides compelling evidence that growing-season fire can lead to shifts in the plant community, relative to a regime of dormant-season fire. Repeated burns during the growing season (especially in May, early in the growing season) curtail resprouting and eventually suppress the less fire-resistant midstory hardwood vegetation more so than burns at other times of the year. On the other hand, the pine overstory appears to be minimally affected by burns in any season. This is particularly true for longleaf pine, a strongly fire-adapted species. The end result is that repeated growing-season burning leads to greater grass and herbaceous species abundance and diversity under the pine canopy, whereas more shrubs may be maintained with a regime of dormant-season burning.

Key Points—Eastern Region

- There is little evidence that mortality or growth of southern pines differs after growing- or dormant-season prescribed burns.
- Phenology does influence the response of midstory hardwoods in pine forests, with early-growing-season (May) burns (coupled with short fire-return intervals) more likely to control or kill these species than dormant-season burns. The result of early-growing-season burns is often an understory with greater cover of grasses and forbs.
- Burning season has little effect on growth and mortality of overstory oak species, but higher intensity fire (in whatever season fuels are sufficiently dry to burn at higher intensity) likely favors oaks over the long term, by killing competing mesophytic species such as yellow poplar or maple.
- Although some understory plant species respond positively to fire in the growing season and others respond positively to fire in the dormant season, the majority do not appear to be significantly affected by burning season.
- Few strong direct impacts to wildlife from prescribed fire in any season have been documented; effects, both positive and negative, appear to be mostly indirect, and primarily the result of fire-season-specific habitat changes.
- Whether the ecosystem is burned or not (fire frequency) appears to play a stronger role in the response of most species than the relatively minor effect caused by different burning seasons.
- Differences in fire effects among species suggests that a variable fire regime, including a mix of growing- and dormant-season burns and different burn intensities may maximize biodiversity.

Early prescribed burning was often done during the dormant season to avoid conflicts with wildlife reproduction, including bird nesting. However, recent research generally does not show that burns in the growing season affect bird populations more than burns at other times of the year. In the few cases where differences in animal communities with varying burning seasons have been reported, the mechanism is usually indirect, involving some alteration of understory structure. Understory vegetation of the Southern United States grows so rapidly in the absence of fire that the effect of burning or not (fire frequency) is generally much greater than the effect of burning season.

Both phenology and fire intensity appear to play a role in determining fire effects in forests of the Eastern region, with the outcome depending on the species and the differences in intensity between burn seasons. As with fire in the Western and Central regions, phenology and intensity are often confounded, making their relative contributions a challenge to determine. Several of the more robust studies of burning season concluded that for many species, fire intensity plays a significant role in determining the outcome. Differences in intensity, if any, are often due to higher ambient temperatures and greater use of heading fires during the growing season. However, lower fuel moisture levels can also sometimes result in dormant-season burns being more intense, particularly in hardwood forests that lack the pyrogenic vegetation of the southeastern pine zone.

The importance of phenology relative to fire intensity in the Eastern region appears to be intermediate between the Western region and the Central grasslands; this goes along with apparent differences in the amount of fuel consumed between seasons, which are in most cases less than differences among burning seasons in the Western region, but greater than differences among burning seasons in the Central grasslands. For some species, fire intensity may override the effects of phenology at the time of the burn, especially if the difference in fire intensity among seasons is substantial.

Data from the many long-term burning studies conducted in the Southeastern United States indicate that substantial changes likely require many burn cycles to achieve. A single burn in any season generally does little to alter plant or animal communities. Therefore one burn or a few burns outside of normal season is/are unlikely to have a major impact. In addition, the importance of burning generally outweighs any effect of season of burning. Because prescribed burns are usually easier to conduct during the dormant season than during the growing season/lightning season, more acres may ultimately be treated by employing a regime of both dormant- and growing-season burns.

One key point mentioned repeatedly in the literature is that a frequent yet heterogeneous fire regime, including a range of fire seasons, may be necessary to sustain species diversity, or even to maximally benefit individual species where different parts of the life cycle are variably affected by burning season. To mimic the variability inherent in the historical fire regime, Robbins and Myers (1992) created a table of random fire frequencies and seasons (within specified ranges) for xeric to mesic longleaf pine habitats, with a weighting so that two growing-season (May-June) burns are conducted for each dormant-season burn. The objective of such a table is to ensure that rigid burning schedules, which would tend to favor some species over others, are avoided. Also, occasional longer (8 to 10 years) rest periods are incorporated that would allow seedlings of certain species to become established (Robbins and Myers 1992).

Acknowledgments

This synthesis was funded by the Joint Fire Science Program (07-S-08), and was inspired by observations and results from the Fire and Fire Surrogate study site in Sequoia National Park, where the ecological differences between early summer and fall prescribed burns were evaluated, and through conversations with many who have been involved with season-of-burning research.

Using Midstory Removal to Enhance Oak Development

by David L. Parrott, John M. Lhotka, Jeff W. Stringer

Managing for oaks is an objective shared by many woodland owners. Oaks are among the most valuable timber species within the region and serve as a valuable source of nutrition for wildlife. While a historically dominant tree species within Kentucky and other central hardwood forests, changes in disturbance patterns have created difficulties in maintaining oak dominated forests, particularly on medium and high quality sites. After clearcuts and other harvests that create open environments, fast growing species like yellow-poplar and understory species like maples are replacing oaks. Investigation of methods that can improve the regeneration of oak are needed to help woodland owners and foresters retain oaks in our woodlands.

Problem

Previous research has shown that the difficulties in keeping oak in our woodlands following regeneration harvests are due to lack of tall and vigorous oak seedlings being present in the woodlands prior to harvests. Oak seedlings should be at least 3 feet tall in order to be competitive after a harvest. Although some oaks, particularly white oak, can persist as seedlings in shade, they require intermediate levels of light in order to grow to competitive sizes. Because of changes in disturbances and the absence of fire, species that can grow in low light environments such as red maple and American beech have often developed dense understories in many woodlands, especially those of medium or high quality. Under these understories, light levels are extremely low and inhibit the development of oak seedlings. Therefore, management activities to improve the abundance of competitive oak seedlings must include increasing light levels while ensuring that too much light does not stimulate competitors such as yellow-poplar. This fine-tuning of the light allows oak seedlings that are present to grow in height and vigor so that they can compete when the stand is harvested. Studies have shown that removing the midstory can increase the growth and survival of various oak species. Determining how to implement these midstory removals is a necessary step to ensure the continued presence of oaks in Kentucky forests.

Photos courtesy: David Parrott

Oak seedlings are finding it challenging to successfully compete under heavy midstory canopies. Research is ongoing to find ways to ensure that oaks will be a part of Kentucky's forests in the future.

Research Project

In 2004, the University of Kentucky Department of Forestry began investigating the effects of midstory removal on intermediate quality sites within Berea College Forest in Madison County, Kentucky. This study, initiated by Dr. Jeff Stringer and Dylan Dillaway, was designed to monitor the impact removal of the midstory had on the survival and growth of natural and underplanted white and black oaks as well as red maple, which is an oak competitor. Plots were established throughout the forest, a number of them receiving a midstory removal where red maple and beech were killed (midstory removal treatment) and a number of them where these species were left in place (control). Midstory removal treatments were performed by removing sapling and pole-sized red maple, beech, blackgum and similar species. Trees were taken out by starting with the smallest trees with 1-inch diameters and working up to taking out larger trees until approximately 20 percent of the basal area was removed. This treatment did not remove any main canopy (dominant or codominant) trees. All stumps were treated with herbicide to prevent resprouting. Within each plot, white and black oak 1-0 bareroot seedlings were planted, and natural white and black oak and red maple seedlings were tagged, measured and followed. Initial research by Dillaway and Stringer found that oak seedlings responded in diameter and root carbohydrate levels, indicating that the midstory removal was working. However it would take time to determine if treatment was helping the oaks in a meaningful way. Seven years after this initial work, Dr. John Lhotka, Dr. Stringer, and David Parrott returned to these plots to measure the height, ground line diameter, and survival of the trees as well as the light levels in plots.

Results

Light measurements indicated that the midstory removal increased light levels from 5.3 percent of full sunlight in the control (undisturbed) plots to 14 percent full sunlight in the midstory removal plots.

A. Dense midstory canopies (a) limit light availability to oak seedlings below the midstory canopy.

B. The removal of the midstory (b) prior to the harvest increases the amount of light that reaches the developing oak seedlings.

C. Seven years following the midstory canopy removal (c) the oak seedlings a have responded and are much more likely to be a part of the dominant canopy following a harvest of the overstory trees.

Photos courtesy: Jeff Stringer

This change in light had a significant impact on the oak seedlings. Before midstory removal, all natural and underplanted seedlings were the same size, but after seven years, natural and underplanted white and black oak seedlings were 7.6 to 18.5 inches taller in the midstory removal plots. Within the treated areas, seedling heights ranged from 1.5 to 2.5 feet, and ground line diameters were 0.1 to 0.2 inches larger than in the control. In addition to size, treatment increased survival 16 to 32 percent among species and reproduction types.

When looking at potential competitors, red maple also exhibited a positive response to the midstory removal. While red maple continued to remain a potential competitor, seedling inventories showed that the light levels created in the midstory removal did not encourage an emergence of fast growing species that can take advantage of high levels of light.

Management Implications

Results from this study show that a midstory removal can increase the survival and growth of oak seedlings. Before performing a midstory removal, an abundance of oak seedlings must be present in order to take advantage of the treatment. As seen in this study, underplanting oaks is a viable option. This treatment is designed to be an initial step in a system to develop oaks that can be competitive and contribute to future stands. Since it can take 10 or more years for seedlings to reach competitive heights, implementation should occur several years before a final harvest. Following a midstory removal, seedlings should be monitored to ensure that oaks are responding to treatment. If further oak development is needed, removal of some overstory trees may be necessary in order to provide additional light. Once oaks have reached competitive heights, a final harvest can take place. Prior to or immediately following harvest, operations such as burning or competitor removal may be necessary to increase the probability of oak success.

About the Authors:

This research was conducted as part of a Masters research project by David Parrott (david.parrott@uky.edu), who is currently a technician in Dr. John Lhotka's silviculture lab at the University of Kentucky Department of Forestry. This research project was overseen and directed by Dr. John Lhotka (jmlhot2@uky.edu), Assistant Professor of Silviculture, and Dr. Jeff Stringer (stringer@uky.edu), Extension Forestry Professor, of the University of Kentucky Department of Forestry.

OHIO PRESCRIBED FIRE Prescribed fire at our Strait Creek Preserve at the Edge of Appalachia © The Nature Conservancy

For decades, fire suppression policies and land management practices removed nearly all fire from the landscape, preventing it from conducting its natural role in the environment. This has led to the failing health of many natural habitats and the buildup of thick brush and undergrowth that can lead to **dangerous and unnaturally intense wildfires.** But now, land managers are working with scientists to use prescribed fires – intentionally ignited and carefully managed– to mimic **natural, low-intensity fire.** The correct use of fire can save money, protect lives and improve wildlife habitat.

FIRE IS A NATURAL ACT

Like rain or sunshine, fire is a **natural event** that plays an important role in the health of many habitats across Ohio. Without fire, many plant and animal species would disappear.

Prescribed fires help return landscapes to their natural balance with fire. They can enhance community safety by reducing the buildup of dead wood and other debris that can contribute to unnaturally intense wildfires. Fire can also improve **watershed conditions** by thinning dense stands of trees that absorb a great deal of water and reduce the flow of springs and streams.

Prior to European settlement, fire was a powerful force in shaping the forests and grasslands of Ohio. This was especially true in the western and southern regions of the state, due to climate, land forms and the presence of Native American people (who used fire extensively to encourage wild food plants, provide open hunting areas and clear undergrowth to allow for planting crops). Fire, much of it caused by early human activity, led to the development of Ohio's extensive grassland, savannas and oak woodlands, and oak dominated forests.

"Altered fire regimes" – too much, too little or the wrong kind of fire – are a **major threat** to the Earth's natural habitats and biodiversity. The Conservancy is working at many locations in Ohio – with private citizens, government agencies and others – to bring critical habitats back into balance with fire. The Conservancy has recently worked with several government and non-governmental group to create the Ohio Prescribed Fire Council, Inc. The mission of this group is to foster cooperation among the prescribed fire community, while promoting the safe use of prescribed fire as a natural resource management tool for Ohio's ecosystems.

SOME OHIO EXAMPLES INCLUDE:

-- The endangered Karner blue butterfly has only one food source as a caterpillar: the lupine plant which needs fire to open up forest canopies and allow sunlight to reach the ground where it grows. The Conservancy is using prescribed burns at our Kitty Todd Preserve – the only known home in Ohio for the Karner – to regenerate lupine and other native plants.

-- At the Edge of Appalachia Preserve system, fire is used to restore and maintain xeric limestone prairies, a globally rare plant community, for the benefit of many species of rare plants.