Forest Stewardship Practices for

Oak-Hickory Ecosystems in Indiana

Figure 1. This forest stand in Indiana is dominated by oaks and hickories in the overstory and has a diverse herbaceous understory.

Historically, oak-hickory forests, woodlands, and savannas were abundant across Indiana. These areas were characterized by an abundance of oak and hickory species in the overstory and a highly diverse herbaceous understory. Cultural stewardship practices by Native Americans, such as frequent prescribed fires and natural disturbances such as high winds, icestorms, and tornados, increased and maintained these ecosystems across the landscape. The diversity of structure and plant life of oak-hickory ecosystems supported abundant wildlife, from white-tailed deer and Wild Turkey to migratory birds such as Red-headed Woodpecker, Eastern Whip-poor-will, and Prairie Warbler.

While most people understand the value of acorns and hickory nuts as food for wildlife, few realize that oaks are also invaluable to hundreds of species of insects, particularly the caterpillars of many moth and butterfly species. In fact, oaks support more life forms than any other tree genus in the United States. For these reasons, oaks are considered keystone species, which are species critical to the ecosystem's function and persistence.

A variety of forest types are found across Indiana with the two most common being oak-hickory and beech-maple. Oak-hickory forests are found throughout the state, but are particularly common within southern Indiana, especially on well-drained and sunny sites such as south- and west-facing slopes and ridgetops. Despite its name, the oak-hickory forest type is comprised of variety of different tree species, as well as high diversity of shrubs, grasses, sedges, and wildflowers.

Since beech-maple and oak-hickory forests have existed in Indiana, there has always been an interplay between these two forest community types. As a result of changes in climate, disturbances like windstorms, ice storms, tornados, wildfires, and Native American burning, oak-hickory forests would have retained or gained dominance in certain areas over time. As the time between disturbances increased or the climate cooled, beech-maple forests would dominate areas or encroach on oak-hickory sites. This interplay of disturbances and forest community types on the landscape created and maintained incredible diversity of forest types, structure, age class, and distribution. The long-term absence of fire, widespread forest loss and fragmentation, and overpopulation of deer, have altered forest dynamics to the point that natural disturbances such as wind and ice storms alone are not sufficient to maintain oak-hickory ecosystems on the landscape.

Given the importance of oak-hickory ecosystems to Indiana's biodiversity, ensuring these ecosystems thrive into the future is critical. Unfortunately, oak-hickory ecosystems are slowly being lost. While mature oak and hickory trees are still abundant in the overstory, the next generation

of these species, in the form of seedlings and saplings (referred to as regeneration), are uncommon in many of our forests. Young oaks are now being replaced by shade-tolerant species such as beech and maple. Losing oaks and hickories would lead to a significant loss of plant, animal, and insect biodiversity.

Various stewardship practices exist to help sustain and enhance oak-hickory ecosystems in Indiana. These practices have been actively researched by natural resources professionals through projects such as the Hardwood Ecosystem Experiment. This publication provides a brief introduction to a variety of stewardship practices beneficial to oak-hickory ecosystems.

Forest Stand Improvement Options

Midstory Removal

Many forests in Indiana are changing, and this change is most evident in the midstory of the forest. Present-day woodlands often have abundant mature oaks in the overstory and some oak seedlings in the understory. But the middle layer (midstory) of the forest, which is often trees from 2 to 10 inches in diameter at breast height (DBH), is often dominated by shade-tolerant species such as sugar maple and American beech. In these densely shaded forests, oak seedlings do not receive enough sunlight to grow into the midstory.

Once the midstory is occupied by shade-tolerant species on oak sites, midstory removal may be needed to give young oak seedlings a chance to grow and compete. The goal of midstory removal is to increase the amount of diffuse sunlight reaching the forest floor without opening up the canopy. Mistory removal can also benefit wildlife species such as Indiana bats by reducing clutter in the midstory layer, which improves bat flight maneuverability and foraging.

Midstory removal focuses on smaller trees around 2 to 10 inches in DBH and is often used before a shelterwood harvest (see later). Midstory removal is most effective when abundant oak seedlings are in the forest's understory. Midstory removal is accomplished by mechanically deadening shade-tolerant trees in the midstory of the forest using chainsaws, forestry mowers, or other methods. Herbicide applications are typically needed to keep the shade-tolerant trees from resprouting and outcompeting the young oak seedlings.

Figure 2. The midstory was removed from this oak stand prior to the first stages of a shelterwood harvest.

Overstory thinning

Oak sites with well-developed oak regeneration in the midstory of the forest may require some action to keep those oak saplings growing and healthy. This can be accomplished with an overstory thinning. The overstory thinning can be a non-commercial thinning or a commercial thinning.

A non-commercial overstory thinning would consist of a forest stand improvement activity focused on deadening poor-formed, low-quality, and shade-tolerant species that are dominant or co-dominant in the stand. Non-commercial thinning is often done as a 3–4-sided crop tree release where high-quality overstory trees are identified. Then the lower-quality trees surrounding that crop tree are deadened but left on site to become snags (e.g., standing dead trees). The goal is to let enough sunlight in through the canopy to keep the oak saplings healthy and growing. The resulting snags provide habitat for wildlife, including bats, woodpeckers, and songbirds.

A commercial overstory thinning can be thought of as an improvement harvest where primarily poor-formed, low-quality, or shade-tolerant species are harvested from the site to release high-quality overstory trees and allow sunlight through the canopy to keep oak regeneration healthy and growing. With commercial overstory thinning, the trees are removed from the site. Care needs to be taken to limit damage to the young oak regeneration you are trying to enhance.

Overstory thinning should only be done when there are vigorous oaks trees from 2 to 10 inches in diameter at breast height in the midstory, and the dominant overstory trees have not reached financial maturity. Overstory thinning can improve acorn production in oaks by allowing the remaining oak canopies to expand to fill the gaps created through thinning.

Figure 3. An example of an oak-hickory stand following thinning through a commercial harvest and midstory removal.
Photo by Chris Neggers, The Nature Conservancy

Figure 4. White oak, northern red oak, and other tree and shrub seedlings sprouting following a prescribed fire.

Prescribed fire

Prescribed fire is an important practice to encourage the regeneration of oak and hickory species. Oaks, especially, are adapted to prescribed fire because of their thick bark and extensive root system. Prescribed fire can reduce shade-tolerant midstory species like American beech and sugar maple and improve light conditions for oak regeneration. It can also enhance oak regeneration by reducing competition from fast-growing woody species like yellow poplar, which are less fire tolerant. Because of their extensive root systems, oak seedlings as young as 3+ years old can resprout following prescribed fire. Fire can also improve acorn survival, germination, and seedling emergence by reducing leaf litter and improving growing conditions after the fire. Prescribed fire is an important tool to enhance habitat for various wildlife species, including white-tailed deer, wild turkeys, and bats. Damage to the timber quality of overstory oaks is limited when using low-intensity fires with flame heights less than 3 feet tall.

Prescribed fire is often used in oak stands to improve the oak regeneration before an oak shelterwood or other regeneration method or in conjunction with midstory removal. It takes multiple fires before a timber harvest to positively impact oak regeneration. Following a timber harvest, fire can also be used to release the oak regeneration from competition with less fire-tolerant species. Prescribed fire should be conducted by experienced individuals.

Supplemental planting

Ideally, we could regenerate oak by encouraging the growth of oak seedlings from the forest's understory through the use of the activities already mentioned. In some cases, oak-dominated sites have been improperly harvested (i.e., high-graded) multiple times or suffered a natural disturbance that has dramatically reduced the amount of oak in the overstory of the forest. If there is not enough oak or hickory in the overstory of the forest to produce sufficient mast (acorns) for natural regeneration, supplemental planting of native oak and hickory species may be needed to help restore the forest. The goal of supplemental planting is to establish 150-300 competitive oak or hickory seedlings per acre that will be able to grow and compete once the overstory is removed. Supplemental planting can be done with bare-root seedlings or container seedlings. Regardless of seedling type, temporary protection is needed to prevent deer browse on the planted seedlings.

Controlling Deer Browsing

White-tailed deer present a challenge to oak regeneration when their population exceeds the amount the habitat can support (i.e., exceed carrying capacity). Deer preferentially browse young oak seedlings, especially northern red oak, which can reduce or eliminate oak regeneration by eventually killing it or reducing its ability to compete with non-oak species. There are several ways to reduce deer impact on oak regeneration, including hunting, habitat management, fencing, or tree tubes. Reducing the deer population through hunting by focusing on harvesting female deer (does) is the most practical way of reducing the negative impacts of deer herbivory. Managing woodlands by increasing light to the forest floor through forest stand improvement or timber harvest can also reduce deer impacts by creating an abundance of alternative food (besides oak) for deer. These practices also help to improve the light conditions for oak regeneration.

Professional wildlife biologists or foresters can help determine the impact deer are having and the appropriate number of deer to harvest to alleviate those impacts. If hunting is not an option, or deer browse is still too high for oak regeneration, fencing can effectively reduce deer impacts and improve regeneration. Fencing can be cost-shared through the Environmental Quality Incentives Program. If supplemental plantings are utilized, tree tubes or cages can protect seedlings from browse.

Figure 5. Oak and hickory seedlings in tree tubes planted in an oak shelterwood harvest. The tree tubes help to protect the planted seedlings from deer browse.

Figure 6. The crown of the white oak in the middle has been given room to expand following a crop tree release.

Crop Tree Release

Crop tree release is a form of forest stand improvement aimed at creating space around the best trees in the stand (crop trees) so that they can expand their crowns, continue to grow, mature, and produce more seed. On sites with abundant oak in the overstory but many years away from a harvest or regeneration event, crop tree release can be used to focus growth of the best trees in the stand and begin developing more abundant oak seedlings in the understory.

Crop tree release should focus on removing trees on 3-4 sides of the stand's highest quality and most vigorous oaks and hickories. The goal should be to release the crowns of the crop trees by deadening trees on 3-4 sides of the crop tree, creating roughly 15 feet of space between the crown of the crop tree and the nearest surrounding trees. The number of crop trees being released per acre can vary based on the diameter of the crop trees. With larger trees, you may only release 20-40 trees per acre. With smaller diameter trees, you may need to release 40-75 trees per acre.

Invasive Species Control

Many invasive plant species can outcompete native tree regeneration, such as oak and hickory, when provided with increased sunlight. Invasive species such as bush honeysuckle, Japanese stiltgrass, multiflora rose, and others should be controlled in a stand before, during, and after any other management practices are used. In particular, controlling invasive species prior to implementing other management such as midstory removal, crop tree release, or a timber harvest is especially important to ensure the invasive species do not expand with the increase in sunlight to the forest floor. Failing to control invasives before harvest or other management will degrade the quality of the forest restoration effort, reduce understory diversity, and stifle regeneration efforts. The cost and effort to control non-native invasive plants after opening the canopy can increase exponentially in a matter of years.

Forest Regeneration or Harvest Options

Timber harvest is a tool used to regenerate the next generation of a forest. Harvest can play an important role in maintaining and restoring our oak forests in Indiana. When combined with the appropriate forest stand improvement practices, well-planned and properly executed timber harvests can help restore the forest community types, structure, and age classes that benefit the diversity of life in Indiana's forests.

Group Openings

Group opening harvests, or group selection, create an uneven-aged stand structure when forest openings of at least 0.5 acres are created. The group openings only impact a portion of the stand acreage, leaving the remainder of the stand unharvested or lightly harvested using single-tree selection. As this process unfolds over several rotations, it creates a forest stand with various age classes in the different group openings (i.e., an uneven-aged stand). Group openings can be used to release competitive oak seedlings that may exist in the understory on a portion of a stand. This type of harvest allows a landowner to keep oak seedlings advancing on some sections of the property, while other sections can be maintained as a different forest community type or allowed to grow more before harvest. The group openings create a mosaic of age classes with an interconnected forest canopy of various heights. This benefits wildlife that prefer a diverse canopy structure and varying tree heights, such as the barred owl, American redstart, and yellow-breasted chat. The group opening method can be implemented on smaller properties where landowners wish to retain some different forest community types or areas of larger trees and higher canopy.

Figure 7. The graphic in the top left illustrates group opening across a property with mature forest in between. The picture is from a group (or regeneration) opening in southern Indiana that is surrounded by mature forest. Sun loving species such as tulip-poplar will grow quickly in the middle of the opening. Whereas, species like oak and hickory will proliferate around the edges of the opening. *Photo by Chris Neggers, The Nature Conservancy.*

Figure 8. These drone images provide a birds-eye-view (top) and overhead view (bottom) of a shelterwood harvest. Notice the dappled sunlight in the top picture created by the gaps in the canopy. *Photos by: Chris Neggers, The Nature Conservancy*

Shelterwood

Shelterwood harvesting is an even-aged timber harvesting method where two or three harvests are used over time to regenerate the forest stand. Shelterwood harvests tend to be larger than group openings and impact the entire stand as opposed to small portions of a stand. Following midstory removal and the establishment of a new group of healthy and vigorous oak regeneration, the first shelterwood harvest of mature overstory trees aims to increase sunlight to the forest floor to allow the oak regeneration to keep advancing without overstimulating sun-loving species like sassafras and yellow poplar that can outcompete the oaks. The first harvest leaves mainly oak and hickory trees in the overstory to provide partial shade to the site. Once the oak and hickory understory regeneration advances, the final harvest is made to remove the overstory trees and release the oak and hickory regeneration. The time between the first and last harvest can be anywhere from 5 to 20 years, depending

on the landowners' objectives, the success of advancing the oak regeneration, and the competition from other species. Prescribed fire and midstory removal are often used with shelterwood harvests to further enhance oak and hickory regeneration. Shelterwood harvesting can favor wildlife species like red-headed woodpeckers, Cooper's hawks, forest-dwelling bats, and cerulean warblers.

Two-age Deferment Cut

The two-age deferment-cutting system is an even-aged method of timber harvesting that creates two distinct age groups within a forest stand. A two-aged deferment cut may also be called a clear cut with reserves. This method can be used successfully to maintain and advance oak and hickory regeneration and is best in stands that contain long-lived species that can persist for two growing rotations. Once a site has competitive oak seedlings in the understory, a deferment harvest can be conducted to open up the stand and harvest the mature timber but retain a low number of long-lived trees per acre in the overstory. The retained trees will remain on site until the oak and hickory seedling have matured enough to be harvested. The retained (deferred) trees need to be able to survive another full rotation which could be 50-60+ years. As time progresses, the deferred trees can be harvested before the younger age group is ready to harvest. The decision to harvest the deferred trees can be decided based on the growth and development of the younger age group or the viability of the deferred trees. Caution should be used when harvesting the deferred trees to avoid excessive damage to the younger age group.

Selecting Stewardship Practices for Your Property

The best stewardship practices will depend on a suite of factors unique to your property, such as size, current forest condition, slope, aspect, and soils. We advise that you consult with professionals to help you determine if your site is suitable for oak-hickory management and which practices are best for your property. You can find forestry and wildlife professionals using the links below.

- **Indiana DNR Foresters –** https://www.in.gov/dnr/forestry/private-forestland-management/district-foresters/
- **Indiana Professional Foresters listing –** https://www.findindianaforester.org/find-a-forester/
- **Find Your County Conservation Contact –** https://extension.purdue.edu/pondwildlife

If you want to learn more about sustaining oak-hickory ecosystems, you will find additional resources using the links below.

- **Hardwood Ecosystem Experiment –** https://heeforeststudy.org/
- **Landowners for Oaks –** https://www.whiteoakinitiative.org/landowners-for-oaks
- **Oak Shelterwood Harvest –** https://www.in.gov/dnr/forestry/files/fo-OakShelterwoodHarvest.pdf
- **Forestry for the Birds: Pocket Guide for Landowners** https://www.nature.org/content/dam/tnc/nature/en/documents/Forestry-for-the-Bird-Pocket-Guide-April2022.pdf
- **Silvicultural Guide to Forestry for the Birds** https://www.nature.org/content/dam/tnc/nature/en/documents/TNC-Forestry-for-the-Birds-Silviculture-Guide.pdf

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