Appendix E

Vegetation Management for Oak Ecosystem Maintenance

Introduction

This appendix briefly describes the problems of maintaining and perpetuating the mixed oaks on the landscape. It also offers possible solutions, including the most commonly prescribed techniques, and discusses the effectiveness of these treatments.

Overview

Oaks are not regenerating where they have been for many years, and other species are taking their place. Oak regeneration problems are not confined to southeast Ohio but are a concern over most of the species range in the eastern United States. Research has found that oak regeneration problems are not related to the decline of the American chestnut or to forest fragmentation (Lorimer, 1992).

Acorn Production and Predation

Because successful oak regeneration usually depends on the existence of seedlings in the understory before harvest, poor seed crops and high rates of consumption by animals can significantly limit the ability of oaks to compete with other tree species. Unfavorable weather and insect damage can also lead to poor acorn crops. Most eastern upland oak species have good seed crops at intervals of three to five years. Intervals between good seed years in white oak may be longer, but local factors occasionally can contribute to regeneration failures from this cause.

Destruction of acorns by insects, rodents, and deer are an important factor in most areas; the loss of 90 percent of an acorn crop is not unusual. In a recent Pennsylvania study, rodents removed virtually every unprotected acorn on the ground surface and 78 percent of the buried acorns. Insects destroyed 63 percent of the surface acorns protected from rodents. (Lorimer, 1992)

Deer browsing can retard oak regeneration, and the substantial growth of deer populations in many areas around the 1930s coincided with the beginning of widespread oak problems. However, the occurrence of oak regeneration failures in places where deer are not especially numerous has led a number of researchers to see deer as more of an aggravating, rather than a primary limiting, factor. (Lorimer, 1992)

Shade Effects

The effect of a shaded forest floor resulting from closed crown canopies and dense understory vegetation is one factor that helps explain the slow growth and high mortality of understory oak seedlings. The growth strategy of oak species directs energy from photosynthesis to promote seedling root growth at the expense of shoot development. Seedlings can develop a substantial taproot, and if an adequate amount of sunlight is available, a seedling can persist for many years despite repeated shoot dieback. When an opening in the crown allows more light into the understory, seedlings with an extensive root system can grow rapidly. (Lorimer, 1992)

Shade-tolerant species such as maples often have an advantage over oaks because they can grow significantly in height despite a closed canopy (in more shade than an oak can develop). Maples can steadily increase in both size and number until a nearly continuous subcanopy or a multi-storied layer of vegetation develops. These added layers of foliage beneath a closed upper canopy intercept so much light that often less than one percent of full sunlight reaches the seedling layer. As a result, oak seedlings often die once acorn reserves are exhausted. Even among the survivors, a vigorous root system doesn't ordinarily develop. The ability to persist under dense shade appears to vary among oak species. White oak and chestnut oak, for example, are often considered to be moderately shade-tolerant. However, the shade tolerance of oaks is markedly less than for many of its mesic competitors. The average 5-year mortality rate for large, overtopped saplings in a dry-mesic stand in southern New York was 45 percent for northern red oak and 26 percent for chestnut oak, but only 11 percent for red maple. On a dry-mesic site in central Massachusetts, overtopped red oak had a 19-year mortality rate of 90 percent compared to only 16 percent for red maple (Lorimer, 1983).

On mesic sites, advanced oak reproduction that can compete does not accumulate in mature stands because of the deep shade under the closed canopy. The advanced oak reproduction cannot develop into a size that would be competitive if it were released by overstory removal. Rather, it cycles in and out of the system with new seedling establishment after good acorn crops followed by mortality. Interrupting this cycle of establishment and mortality to enhance survival and growth of advance oak reproduction requires a silvicultural treatment that alters stand structure so that more light is available to the seedlings in the understory. (Loftis, 2004)

Advanced oak regeneration in large numbers will not necessarily assure acceptable oak regeneration even if released by complete clearcutting. Even though the overstory is removed, small oak seedlings may still have to compete with a dense understory of larger and usually more shade tolerant seedlings, saplings, and sprouts. These species usually have well-developed root systems and ample foliage which enable them to respond faster to release than small oak seedlings. If, at the time of release, the oak seedling does not have a large root system and adequate shoot height, shoot growth will be slow until the root system develops. Therefore, the mere presence of oak seedlings does not mean that oaks, if released, will become part of the future stand. On mesic sites, competition also can be expected from shade intolerant plants such as yellow-poplar and cherry.

In summary, an oak seedling can become a dominant part of the new forest type if it has developed a strong root system, and when released to adequate sunlight, it is not encumbered by an established shade-intolerant, mesic tree seedling.

The Role of Oak Stump Sprouts

Sprouts that develop from harvested trees can contribute to the stocking of the regenerated stand after harvests. Oak species vary in their capacity to sprout, but the diameter of the stump seems to be a larger factor in determining the number of sprouts that appears after a harvest. Table E - 1 shows the ability of different species to sprout at different size classes. As can be seen, white oak and black oaks are not reliable sprouters after they reach a stump diameter approaching 16 inches and larger. So, if a stand has a large number of trees greater than 16 inches at the stump for these species, the future stand will be regenerated mostly by advanced regeneration. (Sander, Johnson, Watt)

Table E - 1. Expected percentage of oak stumps that will sprout after cutting.

Diameter of Parent Tree in inches	Black Oak	Scarlet Oak	Northern Red Oak	White Oak	Chestnut Oak
2 – 5	85	100	100	80	100
6 – 11	65	85	60	50	90
12 – 16	20	50	45	15	75
17 +	5	20	30	0	50

(Sander, Johnson, Watt)

Although decay in stump sprouts has sometimes been a concern, when the sprouts originate at or below ground level, the probability of becoming infected via the parent stump is low.

Effects of Fire on Tree Growth and Regeneration

Fire has numerous functions which alleviate some of the problems outlined above. Applied at the appropriate time and place, fire can improve oak regeneration.

Fire removes excessive litter buildup from the forest floor, thereby preparing a favorable seedbed. Squirrels and bluejays prefer areas of thin litter for acorn burial. Also, jays collect and disperse only sound nuts. This important ecological finding implies that acorns which escape predation can result in well-established first-year seedlings.

Seedlings from freshly germinated acorns cannot emerge through a heavy litter cover. Germination and first-year survival are best when acorns are buried about three centimeters deep in mineral soil. While removal of thick litter may expedite germination by encouraging squirrels and jays to cache acorns, some humus layer needs to be retained. The humus layer keeps the soil surface porous, so that uncached acorns can more easily penetrate the soil, retain moisture, and provide support for the new seedling. (Van Lear, Watt, 1992)

Fire helps to control insect predators of acorns and new seedlings. Insect pests act as primary invaders, secondary invaders, parasites, or scavengers on or in acorns. Many of these insects spend all or part of their lives on the forest floor. Infestations, which can vary from year to year and even from tree to tree in some areas, are a major contributor to the oak regeneration problem. Annually, about 50 percent of the acorn crop in Ohio is destroyed by the larvae of Curculio weevils, acorn moths, and gall wasps. However, recent studies indicate that prescribed burning may reduce populations of oak insect pests when conducted under proper conditions. A reduction in insect predation would allow more acorns to be scattered and buried by jays and squirrels. This enhances the probability of successful germination and helps subsequent seedlings become established. Burning may also reduce rodent habitat, eliminating another source of acorn predation. (Van Lear, Watt, 1992)

A regime of frequent burning over a long period creates a more open understory. In hardwood stands, long-term burning tends to eliminate small understory stems outright and gradually reduces the midstory and overstory canopies through mortality resulting from fire wounds. Increased light reaching the forest floor in these open stands will maintain the vigor of oak advanced regeneration. Frequent fires result in a slightly drier site by removing some of the fuels and small shrubs on the forest floor as well as by exposing the site to greater solar radiation through canopy reduction. (Van Lear, Watt, 1992)

The absence of fire since the early 20th century has allowed fire-intolerant species to become established and grow to sizes with bark thick enough to resist fire. At greater than five centimeters (2 inches) dbh, yellow-poplar becomes almost as fire resistant as oaks. Fire suppression over the years has allowed shrubby understory species to occupy drier sites where fire was once frequent and oak more dominant. Yellow-poplar produces an abundance of seed almost annually. Although the seed has low viability, many remain viable in the litter and duff layer for several years. Yellow-poplar seed germinate readily after some of the fuels on the ground are burned. However, in a regime of frequent fire, small yellow-poplar seedlings are likely to be killed and the reservoir of stored seed in the duff gradually depleted. Thus, frequent fires would, to a large degree, help control this major competitor of oaks on high-quality sites. (Van Lear, Watt, 1992)

The graph in Figure E - 1 shows the percentage of mortality for hickory, oak, red maple, and yellow-poplar advanced regeneration as fire intensity increases during prescribed burns of shelterwood stands in the spring (Van Lear, David H. and Brose, Patrick H, 1998). Note that the mortality rates experienced by yellow-poplar and red maple are much higher for all intensities than for oak or hickory.

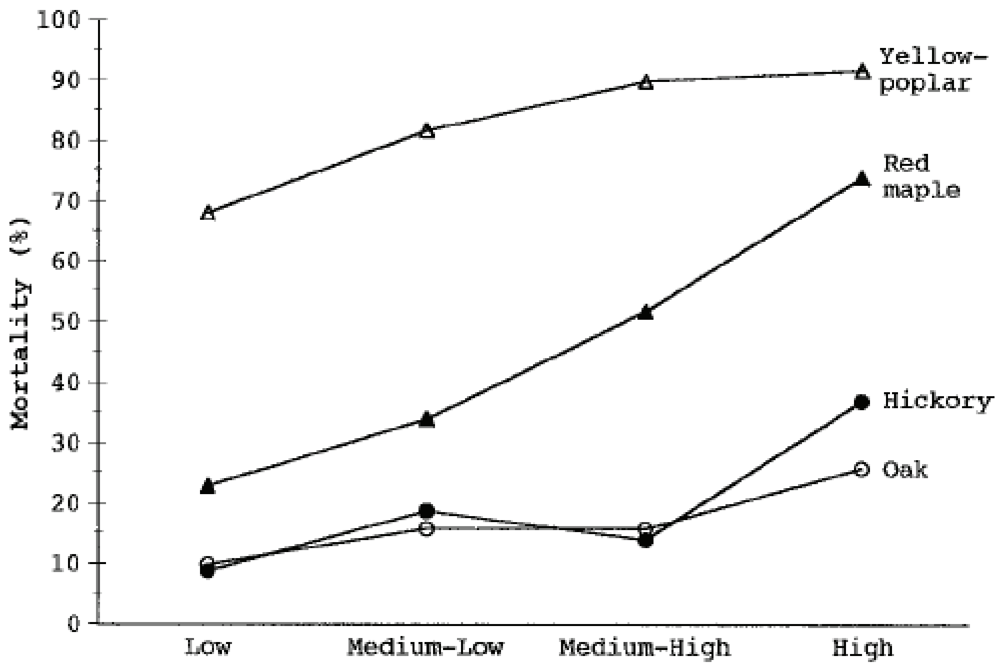

Figure E - 1. Mortality (%) of hickory, oak, red maple, and yellow-poplar as fire intensity increases during prescribed burns of shelterwood stands in the spring.

When repeated burning occurs in stands with mixed advanced regeneration, oaks have an advantage over less fire-resistant vegetation which is killed by fewer fires of lower intensity. This loss usually exceeds species gain through invasion, since the frequency of the fires is as important to reduction of fire-susceptible species as the intensity of the fire.

Thus, a regime of frequent understory burns, perhaps including both growing-season and winter burns during a period of 5 to 20 years prior to harvest, should promote a favorable root/shoot ratio during oak seedling establishment (Van Lear, Watt, 1992). This fire frequency would replicate fire-returns from the mid-1800s to 1925 that are likely an important reason why mature oaks are here now, as discussed in this document earlier. With a fire regime based on historical norms, the harvest of the overstory should release the established seedlings from the dense shade of the overstory, and oak seedlings could then develop into a future oak stand.

The timing of the burns would depend on the observed vigor of the oak advanced regeneration and its competitors. A series of burns over an indefinite preharvest period will likely be required to favor oak regeneration. The first burn may be detrimental to oak advanced regeneration because small rootstocks may be killed. However, over the long-run, oaks will be less adversely affected than competitors and will, therefore, enjoy a competitive advantage that will enable them to favorably respond to subsequent release. (Van Lear, Watt, 1992)

Herbicides may be required to remove midstory trees that have grown too large to be killed by low-intensity fire. Herbicides provide initial selectivity of midstory stems to be eliminated prior to burning. A combination of herbicide treatment and frequent fire may be required to secure oak regeneration and allow it to maintain its vigor in mixed hardwood forests which have not been burned for decades. (Van Lear, Watt, 1992)

Forest Regeneration

Even-aged Management

Even-aged forests occur naturally after a major disturbance initiates the processes of stand regeneration. Even-aged stands generally have one age class, although two age classes can be found in some two-layered natural or managed stands. These stands generally have a well-developed canopy with a regular top at a uniform height.

Purely even-aged stands generally have a nearly bell-shaped diameter distribution. This means that most trees are in the average diameter class. However, diameter distributions should be viewed cautiously because diameter can be a poor criterion for age. The smallest trees in natural even-aged stands are generally spindly with vigor suppressed by the overstory.

Clearcutting

In a clearcut system the stand overstory is generally removed in one harvest.

If adequate numbers of advanced oak seedlings over 4½ feet tall are vigorous and have well-developed root systems, clearcutting is the most effective method to regenerate the stand to species dominated by oak and hickory. Although understory species may appear to dominate the stand for about 10 years following clearcutting, the oaks and other overstory species begin to assert dominance, and by age 10-15 the understory species are generally in a subdominant position. (Sander, Graney, 1992)

Clearcut stands should be a minimum of two acres in size. If the existing advanced oak reproduction potential is not adequate and the stand is clearcut, the new stand will be dominated by a varying mixture of species, but oaks and hickories likely will not dominate the site. With the exception of yellow-poplar, the species that dominate the advanced reproduction will be predominant in the new stand. Yellow-poplar will also be abundant if it is present in the overstory, and some oaks will probably be present. (Sander, Graney, 1992)

If the clearcut stand is on southeast or northwest middle and upper slopes, we can expect at about age 20 to have a stand that can be molded by thinning into an essentially pure oak stand. On north and east aspects and lower slopes, the stand composition may be highly variable. Yellow-poplar will likely be abundant. Other species such as white ash, black cherry, and red and sugar maples will also be present. However, if the oak advanced regeneration is adequate, expect to have a predominantly oak stand 20 years after clearcutting. (Sander, Graney, 1992)

In practice, the Wayne National Forest will not normally prescribe true clearcuts, in which *all* merchantable trees would be cut from an area. The Wayne is likely to prescribe "clearcutting with reserves," a method in which varying numbers of reserve trees are left standing to attain goals other than regeneration. Overstory trees to be retained, called reserve trees, may be small or large trees, or combinations of small and large trees. These will be retained for future growth, certain species components, current or future den trees, future sources of snags or coarse woody debris, or some level of visual quality.

Shelterwood

In general, a shelterwood treatment is the cutting of most of the trees, but leaving those needed to produce seedlings in a moderated microclimate (The Dictionary of Forestry). In particular on the Wayne and in the central hardwoods, when the regeneration potential of the existing oak advanced reproduction is not adequate to replace the stand, the shelterwood method can be used to develop the required advanced reproduction. The minimum number of advanced reproduction is determined by inventorying the area to discover the amount and size of oak seedlings and estimating the number of stump sprouts after cutting. The procedure is outlined in the USDA General Technical Report NC-23, "A Guide for Evaluating the Adequacy of Oak Reproduction" (Sander, Johnson, Watt).

When oak advanced reproduction is small, scarce, or absent, the shelterwood regeneration method will most likely produce the best results. However, for successful seedling establishment and early seedling growth, this method must be tailored to produce the micro-environments required by oaks. (Sander, Graney, 1992)

Without treating the micro-climate of the forest floor, such as providing more sunlight or controlling competition, oak advanced reproduction is most likely to be inadequate on the middle and lower north- and east-facing slopes. South-facing slopes and ridge tops may develop advanced oak regeneration without specific treatments because of the dry and open microclimate. (Sander, Graney, 1992)

When applying the shelterwood method to develop oak regeneration, following are some general practices that should be considered (Sander, Graney, 1992). Depending on site-specific conditions some or all of these treatments are probable:

- Control the understory by cutting or preferably killing the non-oak species that will compete with the small oaks by prescribed burning or applying herbicides.
- Reduce the overstory to 40 to 80 percent stocking. Leave the best dominant and co-dominant oaks as uniformly spaced as possible.
- If possible, apply the understory and overstory treatments before seedfall in a good seed year.
- Monitor seedling establishment and growth; make additional light cuts to keep the overstory from restricting growth.
- Apply additional understory control if the understory redevelops to a point where it restricts the oak reproduction growth. This control may be desirable 5 to 10 years after the original treatment; treatment could be prescribed burning or application of herbicides.
- When the regeneration potential of the oak reproduction is adequate to replace the stand, remove the remaining overstory sufficiently to allow the oaks to develop fully. After the shelterwood harvest and associated treatments are initiated, 10 to 20 years will likely be needed to establish enough oak seedlings and grow them to adequate sizes so that oaks would likely develop into dominant or co-dominant components of the future forest.

More than one burn may be prescribed if oak regeneration is not adequate after one burn. In many situations within the Central Hardwood Region and beyond, decades of fire exclusion have allowed oak competitors to become so firmly established that oak regeneration may not be as plentiful as desired. Oak dominance of the advanced regeneration should increase with repetitive burning. (Van Lear, D.H., 2004)

Another silvicultural treatment that has proved effective on more mesic sites is to remove mid-canopy and some lower-canopy trees and leaving a main canopy with no large gaps, the survival and growth of small oak advanced reproduction increases. This treatment allows the population of small oak advanced reproduction to develop after a few years into a population of larger advanced reproduction, making oaks more competitive after release. Plus, this process also reduces competition from other species. Potential sprouts from mid-canopy and lower-canopy trees are treated with herbicides or prescribed fire, thereby directly reducing competition from these trees both before and after overwood removal. The reduction in competition from yellow-poplar is more subtle. First, while the residual canopy with no canopy gaps is sufficient to allow oak seedlings to develop, it is not sufficient to allow the establishment and development of yellow-poplar. Secondly, new yellow-poplar seedlings that become established after overwood removal will be in an inferior competitive position, at least on a patch-wise basis, because of the development of large advanced reproduction of oaks and other species. (Loftis, 2004)

Two-aged Management

The two-aged system regenerates a timber stand and maintains two age classes (The Dictionary of Forestry). Various other publications refer to this type of management scenario to deferment cutting, irregular shelterwood, or a shelterwood with reserves. As applied on the Wayne, harvest objectives would include the need to develop early-successional wildlife habitat, while at the same time retaining an important overstory component. The Forest would retain 15 to 20 square feet of basal area per acre of the original overstory; the selection of the “leave trees” would be based on wildlife habitat needs. For example, if the average diameter of the retained trees was 18 inches, this would be approximately 9 to 12 trees per acre. To regenerate the two-aged areas to an oak-hickory forest type, the same adequate numbers of healthy and well distributed oak seedlings must exist as was discussed for clearcut harvests prior to applying the two-aged harvest.

The Northeastern Area – State and Private Forestry reports the following observations regarding the development of two-aged stands after a regeneration cut in the central Appalachians (Perkey, Miller and Schuler, 1999).

- Leaving 12 to 15 residual overstory trees per acre and cutting all other trees 1-inch dbh and larger resulted in hardwood reproduction similar to that expected after clearcutting.
- In the Fish Trough treatment area, a sample of 10 yellow-poplar overstory crop trees was remeasured at about age 94 to determine if they were still growing well; they were. During the first 16 years of the study they grew at a rate of 2.9 inches per decade. During the last 3 years they grew at a rate of 3.2 inches per decade.

- Residual overstory trees (the older age class) were still free to grow, with an average of 20 feet of growing space between adjacent crowns; these trees were scattered over the area, not left in clumps or corridors.
- At 10 years, 70 to 85 percent of co-dominant reproduction had the potential to become timber crop trees. Three of the four treatment areas can be regarded as successfully regenerated with acceptable quality stems.
- The canopy of the younger age class was nearly closed after 10 years.
- Frequently, grapevine control work is needed in the younger age class of two-aged stands, just as it is needed in young stands regenerating after a clearcut.

Tree regeneration in the two-age harvest areas would be adequate if implemented as described. Experimental harvests on the Monongahela national Forest applied from 1979 to 1983 indicated that the reproduction that developed included a wide variety of species, similar to that observed after clearcutting. Also, the experiments found that 89 percent of the larger trees left uncut had survived, 76 to 100 percent of the survivors maintained their initial grade, and diameter growth increased for most species. (Miller, Johnson, Baumgras, 1997)

Uneven-aged Management

Uneven-aged management treatments work towards the goal of creating and maintaining an area in an uneven-aged condition. An uneven-aged stand has trees of three or more distinct age classes, either intimately mixed or in small groups (The Dictionary of Forestry). Also, uneven-aged stands have an uneven and highly broken or irregular canopy (often with many gaps). This broken canopy allows for greater light penetration and encourages deeper crowns and greater vertical structure in a stand. Most stems occur in the smallest age/size class, as regeneration quickly fills the canopy gaps. The number of small trees declines through normal species competition as age/size classes increase, to the point where the large trees are low in number and scattered (although distribution may be highly regular). In its ideal form, where diameters approximate age, distribution of diameters in uneven-aged management will approach the classic inverted-J form. Progressing through the diameter classes, the number of stems per acre drops in an inverted geometric fashion, giving a dipping curves relationship which looks like the mirror image of a "J" without the top. The graph in Figure E - 2 shows the distribution of trees in an uneven-aged condition. Note that there are a large number of very small trees and very few large trees per acre.

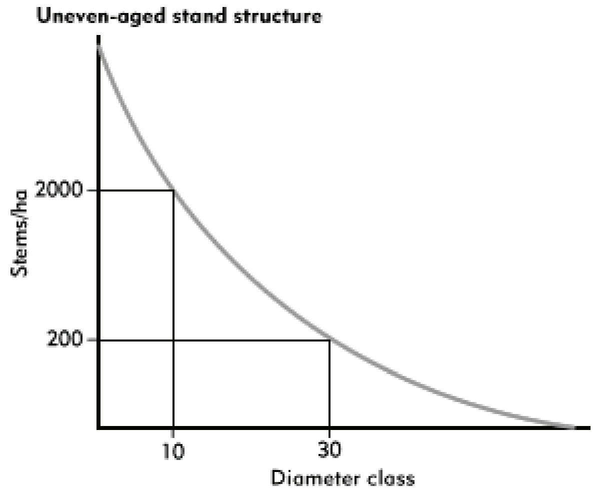

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Figure E - 2. Distribution of trees in an uneven-aged condition.

In managing an uneven-aged stand of trees, the forest manager often uses a formula to mold the stand's structure according the relative numbers of trees of various sizes. This formula is often referred to as a Q-Factor. The Q-Factor describes the distribution of size classes and is expressed in terms of the ratio between numbers of trees in successive 2-inch diameter classes. For example a Q-Factor of 1.5 means that there would be 1.5 times as many 10-inch trees as there are 12-inch trees, and 1.5 times as many 12-inch trees as there are 14-inch trees. The lower the Q-factor, the more larger trees there would be in relation to small trees.

Initially, to convert an even-aged stand to an uneven-age stand, the objective is to develop new age classes, but not to immediately create a structure as pictured in Figure E - 2. Eventually, a more formalized uneven-aged regulation method can be implemented to supplement and guide the retention of given levels of stocking in the different age classes. Although a q-based (or similar) approach is essential for maintaining an uneven-aged structure after the uneven-aged structure is established, q is not applicable when initially converting even-aged stands into an uneven aged stand.

Conversion of a stand to an uneven-aged structure cannot be accomplished in the same manner as the maintenance of stand structure in an existing uneven-aged stand. Generally with the objective of changing the stand's structure to uneven-aged, the first harvest in the stand would be a reduction across the stand of one-third but no more than 60 percent stocking. Depending on the stand's age or species mix, the cutting could target different trees. Considerations would include such concerns as whether the stand has a component of short-lived trees which could not survive through the time that would be required to develop the uneven-aged structure. Therefore, the exact prescription must be tailored to each stand. (Loewenstein and Guldin 2004)

Single-tree selection system

Single-tree selection methods are most appropriate for stands in which the desired species composition is to consist primarily of such shade-tolerant species as beech and maple. Single tree selection, therefore, is generally considered inappropriate for regenerating oak forests. (Hicks, 1998)

The establishment and development of oak regeneration is not as probable or as consistent with the single-tree selection system. While harvesting single trees to achieve and maintain a specific diameter distribution does not provide the microclimate needed for oak regeneration, it does provide the conditions needed for the establishment and growth of shade-tolerant species. (Sander, Graney, 1992) Over time, single-tree selection in a mature oak stand will convert the area to predominantly shade-tolerant species such as beech and maple.

However, empirical and experimental data suggest that under certain conditions, oak stands can be managed using uneven-aged methods. (Loewenstein and Guldin, 2004) By applying oak advanced regeneration techniques, such as controlling mesic seedlings, the resulting uneven-aged stand's oak component can be increased. It is unlikely, however, that oak and hickory will be majority components of the stands in the long term. If the more shade tolerant and mesic species are controlled, the more xeric parts of the stand, such as south-facing slopes and ridgetops, may have significant oak and hickory components. Then the mesic parts of a stand, such as the lower elevations, coves and north slopes, will likely be occupied by more mesic species such as yellow-poplar, maple, and beech.

Oak seedlings have been found to show greatest response and successful establishment in the centers of forest clearings. A retardation of oak seedling growth, however, is found on the edges of openings. High levels of sun light are required for the survival and growth of advanced oak regeneration, and these light conditions cannot be achieved by the single tree selection method. (Fischer, 1979)

Group Selection Systems

The objective of group selection is creation of an uneven-aged stand by cutting and regenerating small parts or "groups" in a stand. The entire stand continues to be managed as a single unit, including both the groups that have been cut and the uncut portions in between. Individual groups are not managed as individual stands. As applied on the WNF to regenerate oak-hickory types, a group should be up to two acres in size. When the objective is to regenerate shade tolerant species, such as maple and beech, the groups should have a diameter of approximately up to the height of two mature trees (0.4 to 0.7 acres).

Group selection can be used to reproduce oaks satisfactorily, assuming (Sander, Graney, 1992):

- The oak advanced reproduction is adequate
- Culls and small trees within the groups are cut or killed, unless specifically retained for wildlife or other purposes.

The growth and development of the reproduction by group selection will resemble responses that follow clearcutting, except the influence of the surrounding stand will retard reproduction growth in a large part of the open area. (Sander, Graney, 1992)

If the oak advanced reproduction is not adequate, cutting the trees to create the opening will not result in oak reproduction. The opening will be filled by the species present in the understory and by species with seeds on the site, such as yellow-poplar. Without adequate advanced oak regeneration, the procedures for developing it, as described above for the shelterwood, could be implemented first if oak is an objective for the future stand (Sander, Graney, 1992).

Frequently, as groups are cut to create a young age-class, other parts of the stand will be thinned to enhance oak reproduction establishment and growth throughout the stand.

Oak Management in the Historic Forest Management Area

One of the main visions portrayed in the desired future condition for the Historic Forest management area is land that eventually mimics the conditions of several hundred years ago when oak dominated the landscape. Treatments likely to help achieve that condition include:

- Intensive thinning (to maintain a 50% to 60% stocking)
- Frequent prescribed burns (to control the more mesic species and promote oak regeneration)
- Herbicide treatment.

Herbicide treatment may be necessary initially, when the land is being transformed into the desired conditions, because mesic species such as maples and poplars will be too large to control with prescribed burns. Once the land has been transformed and the number of maples and poplars are minimal and their sizes small, periodic fires will likely control them.

For the first two or three decades, the stands treated in this management area will likely need to be thinned as the crowns of trees expand to a degree that do not contribute to attainment of desired conditions. After the historic forest system is in place and functioning (in 30 to 50 years), some periodic timber removal may be necessary to release seedlings to grow.

Intermediate Silvicultural Treatments

Effects Of Cleaning Treatments And Precommercial Thinning

Cleanings are release treatments performed during the sapling stage to free selected trees from competition of overtopping trees of comparable age (or woody vines and shrubs). Cleanings also favor trees needed to meet wildlife habitat or other management objectives.

It is better to wait until the stand is well into the sapling stage and has a closed canopy before making decisions regarding future crop trees. This delay will also assure that stump sprouts will not overtake desirable trees. Simply cutting most broadleaved trees and shrubs will normally stimulate sprouting, often with increased vigor. To prevent this, herbicide may be applied. (Nyland, 1996)

Benefits of release from cleaning vary with species, age, degree of suppression, and completeness of a treatment. Generally, cleaning works best in young stands while the preferred trees still have sufficient vigor to respond to release.

Timber crop tree management can provide high-quality timber products from individual trees growing at a rapid rate. The limiting factors in managing for crop trees are:

- The existing number of good-quality trees
- Increasing their growth while retaining their valuable characteristics.

Crop tree selection criteria:

- Select dominant/co-dominant trees at least 20 feet tall with large healthy crowns. On the WNF, this height would be attained when the regeneration is from 10 to 20 years old.
- Select low-origin stump sprouts with U-shaped connections. Stump sprouts that originate close to the ground are suitable crop tree candidates if they are stable and have good form.
- Select trees with no epicormic branches. For most species, dominant/co-dominant trees with large crowns and good vigor are not likely to epicormic branch to a significant degree.
- Select trees without leans or forks.

Grape Vine Control

When wild grapevines grow into tree crowns, especially in young trees, they can damage trees by breaking the tops and limbs, twisting and bending the tree boles, even uprooting trees. Wild grapevines grow best on moist soils and in full sun. Prolonged shade reduces growth and will kill the vines. Vines sprout prolifically when cut, however.

Since grapevines are intolerant of shade, the vines will generally die or not be a problem if they are cut near ground level and the crown of the surrounding stand has closed so that the ground is well shaded.

If grapevines are present in the stand before harvest, and an even-aged harvest is planned, grapevines likely will be a problem in the regenerating stand. The combination of sprouting vines and multiple seedlings after harvest, plus the increase in available sunlight, will promote grapevine growth. Grape seed remains viable for many years.

Common solutions to a grapevine problem include (Smith, H. Clay, 1984):

- After an even-aged or group selection harvest, in the first 10 years after the forest floor has become shaded, sever the grapevines at ground level; the vines will resprout, but will die because of the shaded conditions.
- At least four to five years before an even-aged or group selection harvest, sever the grape vine at ground level; the vines will resprout, but will die before the harvest.
- If a harvest is planned within four years, treat the vines with herbicide. (Note: If the area is treated before the harvest, a post-harvest treatment may be necessary, particularly on better than average sites. Herbicide may also be needed to treat seedlings that start from seed already on the forest floor. However, the growth rate of the vines from seedlings would be much less than from established roots. Their damage would be less.)

All grape vines will not be eliminated from an area. Any sensitive or rare species of grape will be retained. Grape arbors (large concentrations of vines in a small localized area) will be left untreated. The impact on wildlife habitat will be considered before any control is begun.

Commercial Thinning

As trees in a stand of timber grow, they compete with each other for nutrients, water, space, and sunlight. Each tree attempts to grow as fast and large as possible to remain competitive in the quest for food, water, and sunlight. As time passes, however, some limiting factor will prevent many trees from reaching their full potential. The species or genetic make-up of some individuals may pre-dispose them to be less effective competitors. Trees that do not grow as fast as others become weakened rendering them even less competitive for sunlight, water, nutrients, and/or space. Because these trees are shorter than their less vigorous competitors, they cannot reach direct sunlight and have smaller live crowns. They are also more vulnerable to damage from insects and diseases and less likely to live a normal life span.

Also, even trees that have succeeded in becoming dominant or co-dominant often have different natural life spans. For example, on the WNF individual white oak trees can live to be 200 to 600 years old, whereas scarlet oak trees normally live only 100 to 150 years. These ages are for individual trees; like people, some die young while others live beyond their averages. As in the contrast between the longevity of scarlet and white oak, however, some species tend to live longer than others.

In otherwise comparable stands of trees, healthier and larger individuals will be found on sites with less tree density. Available nutrients, water, space, and sunlight are shared by fewer individuals on the less dense site.

Thinning a forest, or reducing tree density, is usually done to accomplish one or more of these objectives:

- Improve growth of the remaining trees
- Enhance the overall health of the forest's trees so they can withstand insects and diseases
- Recover potential mortality
- Favor the species of trees that will best meet the objectives of the area
- Increase light to the forest floor to encourage advanced oak reproduction.

Relative stand density is determined by using one of several stocking guides or charts developed for eastern hardwoods. The stand's relative density is then compared to management stocking levels. Acceptable growing stock (AGS) is defined as trees of acceptable species, form, and quality that could be selected as crop trees. A common method of quantifying and comparing relative stocking follows the graph in Figure E - 3 developed by Gingrich in 1967. A stocking level of 80 percent defines the upper management zone (sufficient mortality increase, growth decline, and volume present to thin). The lower management zone is 60 percent or B-level stocking (minimum residual level to thin to). Stands between 60 and 80 percent stocked usually do not need to be thinned. (Gottschalk, 1993)

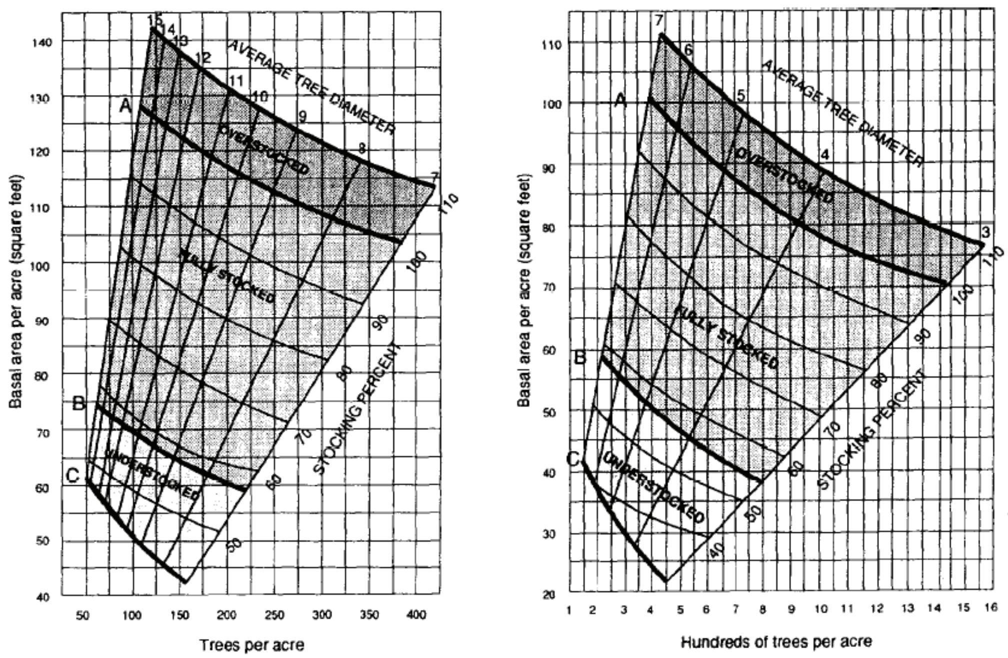

Figure E - 3. Relative stand density for upland hardwood stands, including oak.

Oak and other stands could be thinned when they have greater than B-level density of acceptable growing stock that is more than 15 years from maturity and with more than 80 percent relative density. Under normal management, they would receive a commercial thinning from below. Commercial thinning would reduce relative stand density to 60 percent, but not remove more than 35 percent in any one cut. It should remove unacceptable growing stock, harvest some of the anticipated mortality, increase the growing space for residual trees, increase in average stand diameter, and improve stand quality. (Gottschalk, 1993)

Gypsy Moth Control

As described previously, the gypsy moth (a non-native) is advancing across the northeastern United States. Infestation has reached the northeastern edge of the WNF and will likely spread across the remainder of the Forest in the next 10 to 15 years.

To preserve the health and future composition of the Forest, several treatments, such as the "Slow-the-Spread" campaign will likely be instituted by different agencies such as the USDA Forest Service and the Ohio Department of Natural Resources. In addition to these tactics, thinning the Forest before and after the gypsy moth infestations can help minimize the damage and guard against significant impacts to the oak component of the WNF. Presalvage thinning is designed to reduce damage by removing highly vulnerable (high hazard) trees before they are defoliated and die; the major objective is to reduce stand vulnerability. Secondary objectives of treatment (Gottschalk, 1993) include:

- Improved stand and tree vigor as well as crown condition
- Removal of structural features that offer refuge to gypsy moth larvae and pupae
- Promotion of gypsy moth predator and parasite habitat.

The likelihood of oak tree death after gypsy moth infestation is tied to the health and position of the tree's crown. Graphs in Figure E - 4 show rates of tree mortality based on crown health and position. As illustrated, crown in the suppressed crown position and with poor crown health conditions most often die after an infestation. (Gottschalk, 1993)

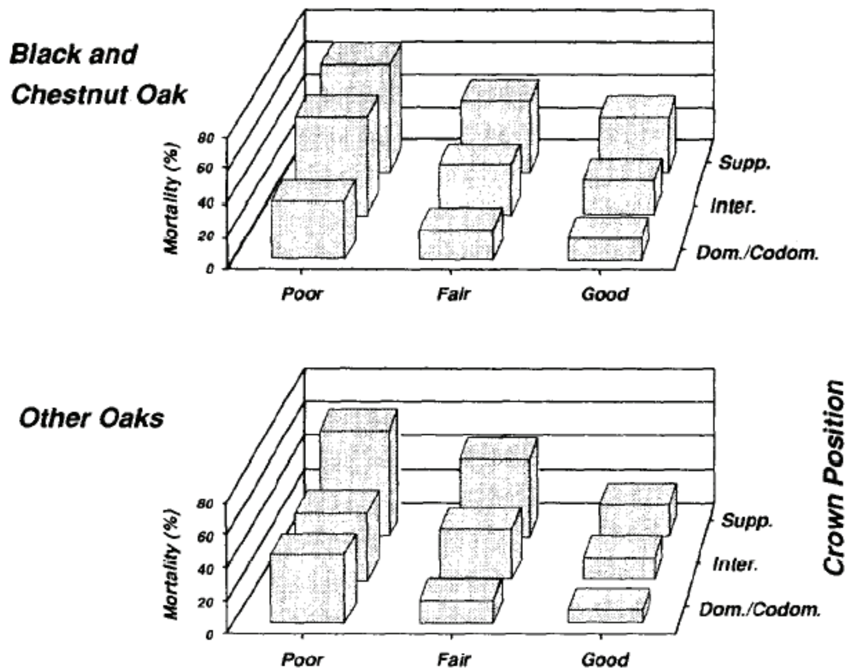

Figure E - 4. Rate of tree mortality based on crown health and position of tree crown.

To be effective, a presalvage thinning before arrival of the gypsy moth must vary slightly from the normal thinning prescription. In stands with more than 50 percent of their basal area in gypsy moth-preferred food species, as is the case for most of the WNF, normal thinning prescriptions will not reduce the preferred food species significantly enough to reduce a stand's susceptibility. Presalvage thinning focuses on reducing vulnerability.

Presalvage thinning is necessary one to three years before defoliation, because the stand will need time to recover from the stress and disturbance caused by thinning. The stress induced by thinning may temporarily expose a stand to attack by certain damaging agents. For example, presalvage thinning may provide favorable conditions for increasing populations of shoestring root rot and twolined chestnut borer. However, these risks are gradually reduced by the increased tree growth and vigor that eventually occur. (Gottschalk, 1993)

As a supplement to normal thinning guidelines (such as removing unacceptable growing stock and targeting a specific density), priorities for marking trees to be removed are (highest to lowest):

- Oaks with poor crowns
- Non-oak species with poor crowns
- Oaks with fair crowns
- Non-oak species with fair crowns.

Figure E - 5 depicts a presalvage thinning in an older stand, showing marking priorities (-) before and result of thinning afterward (WO = white oak, RO = red oak, HI = hickory, RM = red maple).

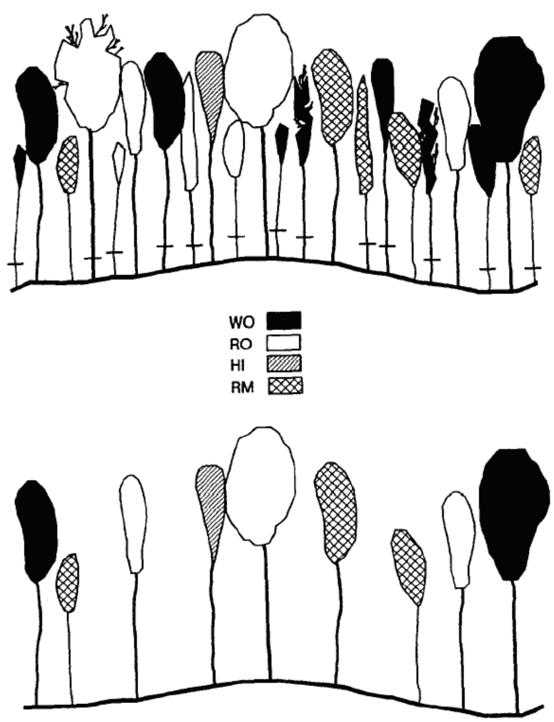

Figure E - 5. Marking priorities in a presalvage thinning of an older stand.

Sudden Oak Death (SOD)

Sudden Oak Death (SOD) is a new disease that has spread rapidly since 1995 in California. It is caused by a newly discovered pathogen (Phytophtora ramorum). The disease has been found in nursery stock in the eastern United States, so infection of natural stands is possible. Fire suppression has been effective where SOD has emerged in the west. Analysis by Moritz and Odion demonstrates a strong and consistent negative relationship between locations of confirmed SODS and areas that have been burned since 1950. The potential for fire to influence the growth of spores and mycelia of fungal pathogens through direct effects of heat and/or smoke has long been known. (Moritz and Odion, 2005)

Oak Decline

Periodic occurrences of decline and death of oaks over widespread areas have been recorded since 1900. The condition is often caused by a complex interaction of stresses and pests. Generally trees are weakened by environmental stresses such as droughts, frosts, of pests such as defoliating or sucking insects. Weakened trees are then invaded by other insects or diseases and the trees subsequently die. Healthy trees can withstand secondary pests, but in a weakened condition, they lack sufficient energy reserve to survive. Usually, the progression of decline is slow, occurring over several years. Control of oak decline is generally considered to involve keeping the trees healthy, and thus able to withstand pests and diseases. Certain causal factors such as drought and frost cannot be controlled, but management actions such as thinning can reduce competition for moisture and nutrients and thus promote a better physiological condition of the remaining trees. (Wargo, Houston, LaMadeleine, 1983)

Summary Of Effectiveness Of Management Practices

Effects of Fire on Tree Growth and Regeneration

Prescribed fire is very effective in maintaining and restoring oak in areas that have adequate light reaching the forest floor. Primarily, fire's effects enhance the development of advanced oak seedlings. Prescribed fire also controls tree species such as maple and yellow-poplar that would out-compete oak seedlings.

Herbicide Treatment of Non-oak

Controlling non-oak competitors in the understory with herbicide is very effective in maintaining and restoring oak. Some larger trees in the understory are less likely to be killed by prescribed fire. Fire treatments alone would leave them free to out-compete the oaks. Also, if successive years of unacceptable burning weather results in a backlog of areas needing to be burned, herbicide treatment can allow mangers to "catch-up" in promoting the conditions for advanced oak regeneration.

Clearcutting and Two-aged Management (Even-aged Management)

These two even-aged management techniques for regenerating timber stands are effective in maintaining and restoring oak, provided the following conditions exist:

- An adequate amount of vigorous advanced oak regeneration exists and has large root development
- The advanced reproduction of more competitive species, such as maples and yellow-poplar, are not in large numbers

Given these conditions, a predominantly oak forest would be regenerated.

Shelterwood Cutting (Even aged Management)

A shelterwood harvest can be very effective in creating conditions in which oaks will develop in the understory so that the subsequent regeneration harvest can release the oaks to fully develop. Note that other treatments will often be necessary in conjunction with the shelterwood harvest, such as prescribed burns and/or herbicide treatments.

Single Tree Selection (Uneven aged Management)

This method of cutting is unlikely to be effective in maintaining the predominantly mixed-oak stand conditions. More shade-tolerant species are more likely to occupy the site in the future because not enough light reaches the forest floor to allow the oak seedlings to develop and compete successfully. Treatments such as prescribed burning and/or herbicide application would increase the oak component of the future stand, but the oak component would likely be well below the existing oak component.

Group Selection (Uneven aged Management)

This method of cutting would likely result in the oak component of the future stand to be greater than under single tree selection, but likely less than the component created with even-aged treatments. One reason for the less effective oak regeneration is the large amount of edge in each group. The more mesic and shade-tolerant species would have an advantage along these shaded edges, while the oaks may thrive in the centers and northern edges of each group. Eventually, the amount of oak in the entire stand will decrease so that only the dry south slopes and ridgetops would be stocked with significant numbers of oaks.

Precommercial Thinning

Precommercial thinning would allow mangers to favor oaks when releasing the stand or part of a stand. Therefore, the oaks of the future stand would be better able to establish themselves as dominant and co-dominant trees. Also, the stand will be healthier.

Grapevine Control

Grapevine control would allow the oaks and all other species to grow without being broken or deformed by vigorous grape vines.

Commercial Thinning

Reducing the stocking through a commercial sale would have the same effect as described under precommercial thinning. A healthy tree can withstand insects and diseases and not die or become weakened and then vulnerable to other problems, such as other insects, disease, or drought. As discussed earlier, the gypsy moth will eventually affect the WNF, and oak trees are the moth's preferred host. So, the ill effects of the moth on the oak component will be less lethal if the trees already enjoy robust health.

No Treatment

If no silvicultural treatments are done, the current stands of oak and hickory will likely be replaced by species such as maple and beech. The stress induced by the overstocking will decrease the health and vigor of the forest, inviting disease and insect attacks. Very dry ridgetops and south-facing slopes will likely retain some oak trees, but without treatments, the oak-hickory forest will eventually disappear.

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