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Professional Hardwood Notes
Technical Information on Hardwood Silviculture for Foresters

UT Extension
SP675

Managing Oak Decline

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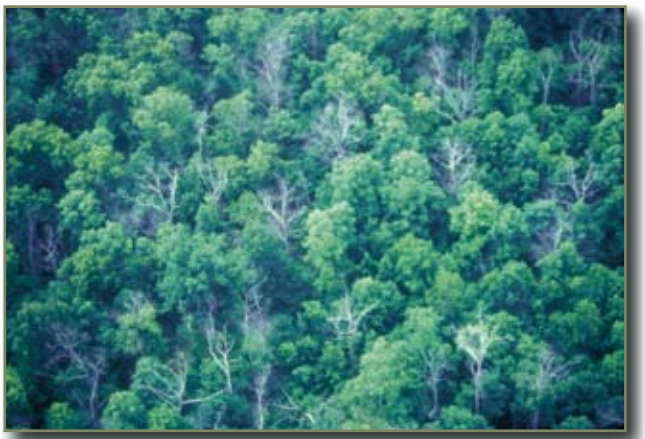
Oak decline is a slow-acting disease complex that involves the interaction of predisposing factors such as climate, site quality and advancing tree age. No single cause is responsible for the decline. Trees that are greater than 70 years of age and that occur on drier sites such as shallow, rocky soils on ridgetops and south- to west-facing upper slopes are most affected. Mortality of rootlets in the upper 12 inches of the soil initiates dieback in severe droughts. Secondary insects and diseases (red oak borers, two-lined chestnut borers, armillaria root rot, defoliating insects, hypoxylon cankers) are contributing factors that cause further stress and damage to the trees.



Bruce Kauffman

Decline of oaks on a southern upper slope in a mature stand.

What Are the Symptoms?

The first indication of oak decline is the progressive dieback of one-third to one-half of the upper crown leaves from the tips of the branches. Other accompanying symptoms may include chlorotic, dwarfed or sparse foliage; development of epicormic sprouts on the main bole and larger branches; premature autumn leaf color; and foliage browning but remaining on the tree (Wargo et al. 1983). Often, diameter growth is reduced before the appearance of the symptoms. Defoliated trees that refoliate the same season may exhibit dieback symptoms the next year. Usually the progression of decline is slow, with tree mortality occurring two to five years after the initial stress.

Most of the trees affected by oak decline are in the red oak family, commonly black oak, scarlet oak and southern red oak. Other species, such as hickories and species in the white oak family (chestnut oak, post oak, white oak, chinkapin oak), can also have decline.

How Does Oak Decline Kill Trees?

Trees react to the stress of prolonged drought and defoliation by converting starch stored in the roots to sugar to support continued metabolism (Starkey and Oak 1988). Once these stored reserves are depleted, trees are not able to maintain the status quo and begin to decline. The fungus armillaria is a

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saprophyte living on dead organic materials such as stumps or roots of dead trees. It produces rootlike structures (rhizomorphs) that grow through the soil and over the surface of healthy roots. Armillaria can successfully colonize living tree root systems that are under stress, resulting in the girdling of the roots. Stems also can be girdled by the hypoxylon fungus. The red oak borer and two-lined chestnut borer also attack weakened trees. Both adult insects lay eggs in bark crevices; the larvae then bore into the phloem and create meandering galleries. Two-lined chestnut oak borer attacks begin in the upper crown and progressively work their way down the tree in two or three years.

Root disease and stem girdling progressively impair the movement of internal water and food in the tree, causing the dieback of the crown (Starkey and Oak 1988). Although some trees die within a year, most decline two to five years before succumbing. Mature trees may not have the capacity to resume normal growth with the return of favorable growing conditions, because the tree demands more resources (internal water and stored food) than it possesses. Younger and smaller-sized trees recover more quickly and can rebuild their crowns because they require fewer resources to maintain themselves.

Factors Associated with Oak Decline

Both site and stand factors contribute to a tree's vulnerability to decline (Starkey et al. 1988). Sites that are moisture deficient, usually on ridgetops and south- and west-facing slopes, are most susceptible. Soils are usually coarse, shallow or rocky with limited moisture-holding capacity. These sites are generally of lower productivity and at greater risk for oak decline (Figure 1).

Stand factors that are associated with decline include tree age, species composition and stocking. Mature trees from 70 to 90+ years are the most vulnerable. Trees in these older age classes have less capacity to counteract stresses and resume growth. Often the stands are crowded (overstocked) with large numbers of trees (excessive basal areas) that exacerbate moisture stress during drought periods. Stands composed of few species, particularly red oaks on poorer sites, are more susceptible.

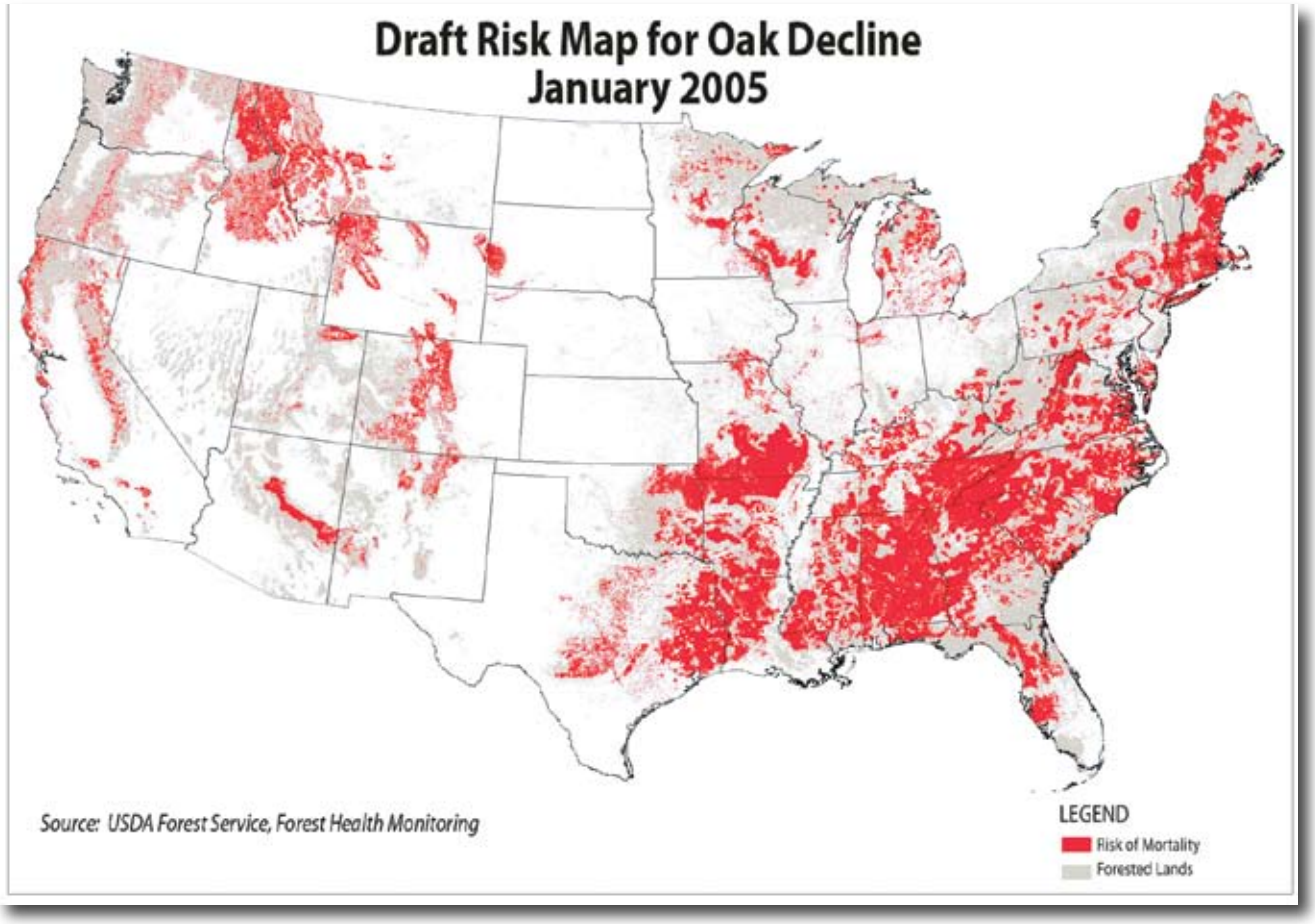

Figure 1. United States map indicating the risk of mortality of oak decline based on site factors.

Table 1. Conditions conducive to low or high risk of mortality associated with oak decline.

Low Mortality Risk	High Mortality Risk
Adequate growing-season moisture	Acute summer drought (2-3 years prior)
No recent spring defoliation	Recent spring defoliation
Immature (pole-size, <50 years old)	Mature (sawtimber, >50 years old)
Mostly white oaks	Mostly red oaks
High site index (> 70 feet at 50 years)	Poor site index (< 70 feet at 50 years)
Mesic site conditions Loamy soils, few rocks Deep (>18 inch) soils Coves terraces, bottoms, lower slopes North and east aspects	Xeric site conditions: Rocky soils Shallow (< 18 inch) soils Ridges and upper slopes South and west aspects

(Adapted from: Starkey et al. 1988).

Weather, particularly droughts and early frost injury, and insect defoliation are the initiating stress factors most associated with oak decline. Drought contributes by killing the trees directly or weakening trees, predisposing them to injury by insects or disease. As an initiating agent, drought is one cause of reduced-diameter growth prior to development of crown symptoms. The water stress accompanying drought also makes the tree more vulnerable to mortality following defoliation and more susceptible to root-disease fungi.

Factors associated with low or high risk of oak decline are summarized in Table 1.

Preventing Oak Decline

The best control for oak decline is through prevention by maintaining healthy and vigorous trees. When site index equals tree age, the risk of oak decline increases, especially for red oaks (Oak et al. 1991). Thinning reduces stocking, reduces competition for moisture and nutrients and promotes better physiological condition (health and vigor) of the remaining trees. Stands should be maintained with stocking close to the B line in the Gingrich (1967) stocking chart. In stands susceptible to oak decline, trees should be thinned when they are 30 to 40 years old, with a final harvest by 70 years old. Thinning should take place from late summer through winter to lessen the risk of wounding residual trees. Trees actively growing in the spring with loose bark are more susceptible to wounding during thinning operations. Wounds increase the risk of disease and insect attacks (Lawrence et al. 2002).

Silvicultural practices designed to encourage species best adapted to the site can reduce the effects of drought. Removal of older (mature and overmature), weak and dying trees may also reduce or delay fungal diseases and insect attack. Maintain a mixture of species and sizes. Stands with more than 25 percent of their stocking in any one species or group of species, particularly red oaks, increase the risk of oak decline.

Management Options

Short-term Treatments

Several options are available to promote healthy forests. These options can be customized for almost any forest, depending on the amount and distribution of dead and unhealthy trees, the age of trees and the susceptibility of trees to decline.

1. Salvage cutting should remove trees that have 30 percent or more crown dieback in the upper and mid-sections of the crown. These trees are unlikely to recover even under favorable

growing conditions. Decline trees should be removed to prevent further deterioration of the wood and before the trees become havens for disease and insects.

2. Silvicultural treatments such as mid-story removal and light thinnings (from below) encourage the development of oak advance reproduction. These treatments remove less desirable, shade-tolerant species and reduce the stocking of more susceptible species (red oaks) in favor of quality stems of less susceptible but acceptable species like white oak, chestnut oak and hickory.

3. Regenerate vulnerable stands with acceptable oak advance reproduction using group selection, patch or stand clearcutting, with the objective of reducing the inventory or stocking of species susceptible to decline.

4. Where heavy decline and mortality are widespread, cut patches or entire stands to give oaks a better opportunity to grow from stump sprouts and to give existing seedlings and saplings the sunlight they need to prosper.

Long-term Prevention

For areas with less decline or for areas that may be vulnerable to decline, the following options may be useful.

1. Improve the existing forest. Selectively cut smaller trees from the midstory and thin the forest by removing some of the larger trees to develop oak seedlings and saplings. These treatments also reduce the number of less desirable competitors. Harvest red oaks in favor of quality stems of less-susceptible species such as white oak and hickory.

2. Start a new forest. Cut all trees in declining areas if there are enough well-distributed and well-developed advance regeneration stems. A hardwood mixture with shortleaf pine is advisable on poor, moisture-deficient sites.

Oak decline and mortality can have serious consequences in regenerating stands (Starkey et al. 1988). If regeneration is delayed too long (i.e., 25 percent of stand with declining oaks), affected stands may not develop the advance reproduction necessary for successful regeneration of desired species, diseased root systems may not resprout with normal vigor or frequency and undesirable understory species may outcompete oak reproduction for available growing space. The species composition of declining stands is likely to shift away from red oaks to slower-growing white oaks and more tolerant species such as red maple and blackgum.

Unfortunately, many silvicultural treatments such as salvage cuts and light thinnings are not economically realistic to avert oak decline (Stringer et al. 1989). The cost of the treatment often exceeds the value of the harvested timber, especially on the less productive dry ridges and upper south slopes where oak decline is concentrated. Where higher-quality trees (black oak, southern red oak and various white oaks) occur, timber quality may be great enough to justify a silvicultural treatment to decrease the vulnerability of the stand to decline. However, on the poorer sites composed primarily of low-valued scarlet oak, an economical treatment is wanting. Species composition should be altered at an early age to a mix of species that is less susceptible to oak decline.

Wayne Clatterbuck

Examples of the progressive crown dieback from the tips of the branches toward the main stem that is characteristic of oak decline.

No pesticides are available or registered that are effective in treating oak decline, wood borer infestations or root diseases in forest stands. Use of these materials on a forest-wide basis is likely to have harmful effects on the ecosystem.

Other Oak Disorders

Oak decline is often confused with oak wilt and sudden oak death (O'Brien et al. 2002). A few distinguishing characteristics about each of these disorders in oaks are listed below.

1. Oak decline is characterized by progressive terminal branch dieback; epicormic sprouts on branches and stem; sudden foliage wilt and browning, but no leaf drop; presence of armillaria root disease and wood-boring insects and mortality due to tree stress peaking in two to five years.

2. Oak wilt is characterized by leaf wilt and drop over the entire crown with the leaf base remaining green; rapid tree mortality within one year; no progressive branch dieback; and vascular streaking present in the outer growth ring. Armillaria root disease and wood-boring insects are generally not present.

3. Sudden oak death is caused by the fungus *Phytophthora ramorum*, which produces a bleeding canker on the stem. Trees may survive for one to several years, but once crown dieback begins, leaves turn yellow, then brown within a few weeks. As of spring 2006, sudden oak death has been found on the coast of the western United States. However, the pathogen has the potential to infect oaks in the eastern deciduous forest. Movement of the disease is through infected nursery stock planted adjacent to forests. A pathway has already been established through West Coast introductions in Tennessee, but prompt eradication, nursery recalls of infected stock and close monitoring have controlled the disease to date.

Bruce Kauffman

Dieback associated with oak decline.

Summary

Oak decline is a normal part of ecosystem processes in aging upland hardwood stands. Dieback and death are expected results when mature oaks come under stress. It is a normal function of root disease fungi such as armillaria and insect pests such as two-lined chestnut borer to preferentially attack, kill and decompose weakened trees. Many forest values including wildlife (mast production), timber (degraded value) and recreation (visual attractiveness) will be influenced by decline. Whether these effects are positive, negative or neutral depends on the importance that oaks are deemed to have in the ecosystem (Starkey et al. 1995).

Unfortunately, decline will probably continue to be a recurring problem, especially with red oaks of advanced ages on the drier sites. Drought, an inciting factor with decline, generally occurs every decade. Thus, forests that may be susceptible to decline (Table 1) should be managed so they can best withstand these stresses.

Recommendations to Prevent or Reduce Oak Decline

1. Increase species diversity through thinnings or timber stand improvement, not allowing red oaks to compose more than 25 percent of the remaining stems.

2. Avoid effects of oak decline by regenerating oak stands before the trees become vulnerable at older ages. Harvest mature trees and allow seedling advance reproduction and sprouts to repopulate the site. Regeneration techniques should be initiated well before the harvest to ensure future oak forests.

USDA Forest Service

Mortality associated with oak decline.

3. Actively manage stands throughout their lifespan to maintain forest health and reduce the need for management intervention. Do not allow stands to become overstocked.

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