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Oak Decline

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Periodic occurrences of decline and death of oaks over widespread areas have been recorded since 1900. These outbreaks, variously named oak decline, oak dieback, or oak mortality, are caused by a complex interaction of environmental stresses and pests and given the name oak decline.

Hosts

Although the most frequent outbreaks of oak decline have been in southern New England, the Middle Atlantic States, and the Southeastern States, the disease has occurred throughout the range of oak in both forest and urban situations (fig. 1). It is not limited to any one species or species group. Outbreaks have been most frequent and severe among red (*Quercus rubra*), scarlet (*Q. coccinea*), pin (*Q. palustris*), and black oak *(Q. velutina)* in the red oak group and among white *(Q. alba)* and chestnut oak *(Q. prinus)* in the white oak group.

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Other important tree species that have suffered serious declines include ash, birch, beech, and maple.

Disease Progression

Trees are weakened by environmental stresses such as drought, waterlogging, or frost or by pests such as defoliating or sucking insects.

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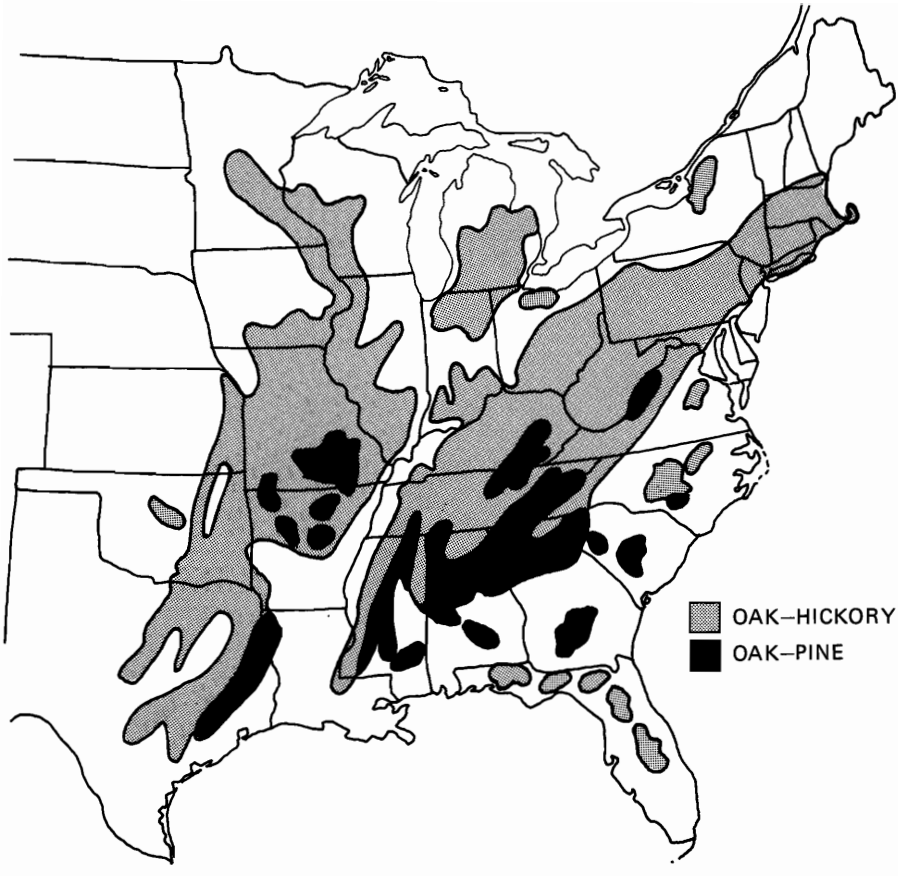

Figure 1.—*Range of oak—the oak-hickory and oak-pine forest types.*

Weakened trees are then invaded and killed by insects and diseases that cannot successfully attack healthy trees. Usually the progression of decline is slow, occurring over several years.

Trees affected by oak decline show a general and progressive dying back from the tips of the branches. (See cover.) Other symptoms include production of chlorotic, dwarfed, and sparse foliage; development of sprouts on main branches and stem; and premature autumn leaf color and leaf drop. Often, growth is reduced before the appearance of symptoms. The amount of food stored as starch is reduced, especially in the roots.

The initiating stress factors associated most frequently with oak decline are drought, frost injury, or insect defoliation. Trees on ridge tops and in wet areas suffer most severely from drought. Frost often affects trees growing in valleys and frost pockets. Defoliated trees that refoliate the same season may exhibit dieback symptoms the next year. Other factors such as leaf diseases and soils that are waterlogged, compacted, or shallow have occasionally been implicated in oak decline. Waterlogging is especially important in the heavier clay soils of the Midwest. Stress factors may be more frequent and severe in urban forests, where trees

are often subjected to disturbances associated with human activities.

These stress factors often weaken trees so much that they succumb, sometimes suddenly, to the root killing and girdling actions of insects and diseases. The two major pests associated with oak decline are *Armillaria mellea* (Vahl: Fr.) Kumm., a root disease fungus commonly called armillaria root rot, and *Agrilus bilineatus* (Weber), the twolined chestnut borer.

The common forest fungus *A. mellea* usually lives on stumps and roots of dead trees, but can attack the roots of stressed oaks. It produces rootlike structures—rhizomorphs—which grow through the soil and over the surface of healthy tree roots (fig. 2). When trees are stressed, chemical changes occurring in the roots allow the fungus to infect and kill them. Continued infection will eventually result in girdling of the large buttress roots and root collar (fig. 3). This, in turn, kills the tree. The roots of these killed trees serve as food sources for the fungus. In the autumn, clusters of honey-colored mushrooms may form at the base of invaded trees (fig. 4).

A. bilineatus (fig. 5) attacks the crowns and stems of weakened trees. The larvae bore into the inner bark, begin feeding, and form meandering galleries in the inner bark and outer wood (fig. 6). The larvae molt three times (fig. 7); and as they grow, they form larger galleries, which cause more damage. The meandering and overlapping feeding galleries of many larvae effectively block movement of

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Figure 2.—*Shoestringlike rhizomorphs of* A. mellea *growing on the surface of a white oak root.*

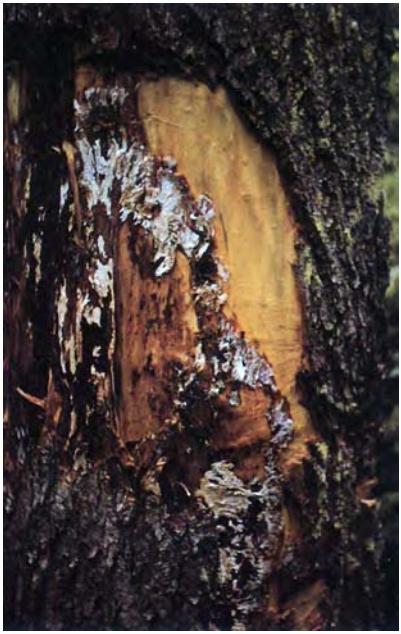

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Figure 3.—*White mycelial fans of* A. mellea *growing between the bark and wood at the root collar on a declining chestnut oak indicate that the tree is being girdled.*

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Figure 4.—*Clusters of mushrooms of* A. mellea *form in autumn at the base of invaded trees.*

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Figure 5.—*Adult of the twolined chestnut borer,* A. bilineatus.

food to the roots and water to the shoots. These borers first infest the upper crown; later infestations are lower down and often reach the base of the tree. The combined actions of the borer in the stem and the fungus in the roots can bring about rapid decline and death.

As dieback and reduced growth continue, larger branches die and form the characteristic stag-headed crown (fig. 8). Foliage is mainly limited to sprouts on the larger branches and main stem.

Diagnosing Oak Decline

Dieback symptoms can result from the effects of stress alone. Indeed, stress, if sufficiently severe or prolonged, can result in tree mortality. However, the continued decline and

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Figure 6.—*Feeding galleries of* A. bilineatus *cause girdling action.*

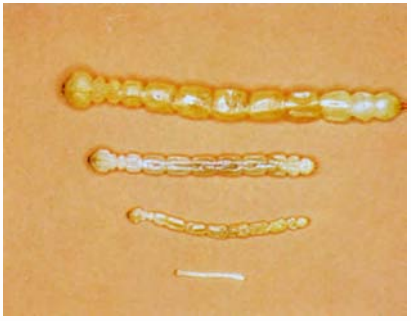

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Figure 7.—*Four larval stages of* A. bilineatus.

death of stressed oaks usually results from lethal attacks by armillaria root rot and twolined chestnut borers. Final symptoms of oak decline primarily reflect the root killing and girdling effects of these organisms. In attacked trees, leaves sometimes fail to develop in the spring or wilt shortly after budbreak; sometimes

they wilt or brown suddenly in the latter part of the growing season.

A characteristic of oak decline is that it may develop suddenly on many trees in the area affected by the initiating stress factor. Within the affected areas, however, decline and mortality occur in patterns, which may reflect the intensity and severity of the stress, the distribution of the hosts, the aggressiveness of armillaria root rot, and the abundance of twolined chestnut borers, coupled with site features such as poor or excessive soil drainage and frost pockets (fig. 9).

In many instances, the species that are affected and their location can provide clues to the cause of oak decline. For example, symptoms only on white oaks or only on red oaks might suggest that preferential insect defoliation was the cause. Frost may be implicated if damage is limited to trees growing in depressions or valley bottoms.

Symptom development can also indicate the stage of decline and approximate beginning of the problem. The age of bole sprouts and patterns of radial and terminal growth can be used to estimate the date of the events that triggered their development. Although some trees die soon after being stressed, others may not succumb for 5 years or more. The timing of peak mortality, if known, can give some indication of when the stress may have occurred. For example, mortality is usually highest 2 years after heavy insect defoliation. Such tree growth information, when coupled with an analysis of weather and forest records, can be used to develop a composite picture of the cause and stage of the oak decline problem.

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Figure 8.—*A stag-headed oak with bole sprouts.*

In the diagnosis of oak decline, it is important to determine if stress factors are associated with the specific problem and, at the same time, to rule out the involvement of primary pathogenic organisms such as the oak wilt fungus.

Oak wilt caused by the fungus *Ceratocystis fagacearum* (Bretz) Hunt has been reported from the Lake States east to Pennsylvania and south to Texas. It has not been found in New England, New York, or New Jersey. All oak species are susceptible to the fungus. Red oaks are more susceptible than white oaks.

Differences Between Oak Decline and Oak Wilt

Oak decline. Within both red and white oak groups, oak decline is characterized by (1) progressive terminal branch dieback; (2) branch and bole sprout and staghead development; (3) sudden foliage wilt and browning, but no leaf drop; (4) fans and rhizomorphs of *A. mellea*

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Figure 9.—*Pockets of oak mortality resulting from the interaction of stress, insects, diseases, and site factors.*

often present beneath bark of roots and root collars on dying trees; (5) galleries and exit holes of *A. bilineatus* often present in stems of dying or dead trees; (6) decline found throughout the range of oak; (7) mortality related to site features, tree stress, and effects of insects and diseases; and (8) tree mortality peaking 2 to 5 years following stress.

Oak wilt in the red oak group. In the red oak group, oak wilt is characterized by (1) leaf wilt and drop over entire crown, (2) leaf portions bronzing or browning, (3) rapid tree mortality, (4) no progressive branch dieback, (5) formation and then death of short-lived sprouts in the season after infection, and (6) vascular streaking (dark longitudinal streaks) found occasionally in outer growth ring.

Oak wilt in the white oak group. In the white oak group, oak wilt is characterized by (1) leaf wilt on scattered branches that die back and form sprouts and (2) vascular streaking common in outer growth ring. Some trees may continue to wilt and die back until all branches and sprouts are dead, yet other trees may survive.

In both red and white oaks, armillaria root rot and twolined chestnut borers are not usually associated with trees dying of oak wilt. In oak wilt, unlike oak decline, isolated trees or small pockets of trees can be diseased with no history of environmental stress. The infection centers are not related to site features. Laboratory diagnosis is usually required to conclusively identify oak wilt-diseased trees.

Control

The unique relationship of cause and effect and patterns of distribution of oak decline must be considered, and control efforts should focus on reducing or preventing the predisposing stress factors.

In the forest, factors such as drought and frost cannot be controlled. However, management can reduce their effects. Thinning can reduce competition for moisture and nutrients and promote better physiological condition of the remaining trees. Silvicultural practices designed to encourage species best adapted to the site can help reduce the effects of drought or frost. Removal of weak and dying trees may also reduce or delay population buildup of the twolined chestnut borer. Stress from insect defoliation can be reduced or eliminated in high-value forest stands by spraying the trees with insecticides.

Landowners can get specific information on insecticides available for control from cooperative extension agents or local forestry officials.

In urban sites, additional control measures are feasible. Moisture shortages can be alleviated by watering, mulching to reduce competition from sod, and reducing or avoiding soil compaction. Trees can also be treated to control sucking and defoliating insects and disease organisms that cause defoliation. Nutritional deficiencies can be corrected by fertilizing. These practices eliminate some forms of stress and promote good physiological condition.

Oak decline is initiated by stresses, which can disappear before effects are manifested. A systematic evaluation of the problem can usually reveal the initiating factors and the agents responsible for mortality. Practices to promote good tree health can reduce the potential impacts of damage by oak decline.

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