OAK DECLINE AROUND THE WORLD

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WHAT IS OAK DECLINE?

Oak (*Quercus* spp.) decline is a malady related to the consequences of stress and successful attack of stressed trees by opportunistic (secondary) organisms (Wargo *et al.* 1983). It is a progressive process where trees decline in health for several years before they die. Houston (1981) developed a model of declines that is presented in Figure 1. So what is stress? It is pressure that brings about changes in a tree's physiology, form, or structure that predispose it to invasion by organisms that it ordinarily can resist. Stress can be biotic (defoliation by insects or fungi), abiotic (frost damage, defoliation by frost, drought, excess moisture, air pollution), or stand dynamics/life stage induced (low vigor due to competition or age). So what are secondary organisms? They are biotic agents, usually insects or fungi, that normally attack weakened trees and kill them but rarely can successfully attack healthy trees. These organisms play an important ecological role by killing trees that are weakened due to competition or other natural processes. Due to the numerous stress agents that can affect oak forests, oak decline can occur simultaneously in many different geographic areas, be triggered by entirely different or identical stress agents, and result in death of oaks from a wide variety of organisms.

One theory of decline is dependent on the simultaneous decline in vigor of entire stands or larger areas of trees that are all the same age (Mueller-Dombois 1986). This theory, called the cohort senescence theory, can be applied to mixed upland oak stands even though it was developed in Hawaii. As trees age and reach physiological maturity, their vigor declines. When vigor is reduced enough, the trees can be successfully invaded by secondary organisms and die en mass. Alternatively, a moderate stress could result in large-scale decline and mortality when stands are in this condition while a similar stress in younger stands would have little effect. The recent declines of scarlet (*Q. coccinea*) and black (*Q. velutina*) oak across the eastern United States may actually represent this type of decline as longer-lived oaks like white (*Q. alba*) and northern red (*Q. rubra*) were generally not affected even though they were growing in the same stands.

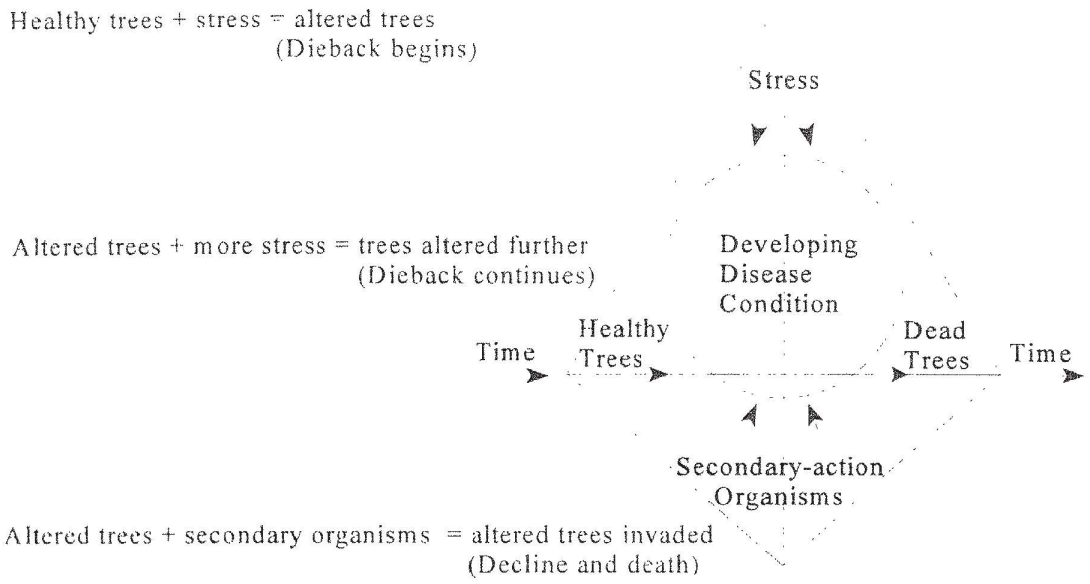

Figure 1. Decline disease schematic developed by Houston (1981).

OCCURRENCE OF OAK DECLINE

Oak decline is not a new phenomenon. Reports of declines of oak in Asia, Europe, and the United States have appeared in the scientific literature since the early 1900s. However, in the three most recent decades, reports of this malady in oak forests seem to have increased (Delatour 1983, Millers *et al.* 1989, Oleksyn and Przybl 1987, Ragassi *et al.* 1989, Tainter *et al.* 1984, Vannini 1987). In this section, we present the recent occurrences of oak decline throughout the world, the oak species involved, and their associations with stress agents and secondary organisms (Table 1).

Table 1. Recent occurrences of oak decline throughout the world including the oak species, stressors, and organisms involved in the decline process (see Literature Cited for sources).

Country/Continent	Species	Stressors	Organisms
North Africa			
Morocco & Tunisia	*Q. suber*	drought defoliation - insect	*Hypoxylon mediterraneum* *Cerambyx* beetles

Country/Continent	Species	Stressors	Organisms
Europe			
Portugal	*Q. suber* *Q. cerris* *Q. ilex*	drought cultural practices	*Armillaria* spp. *Hypoxylon mediterraneum* *Phytophthora cinnamomi*
Spain	*Q. canariensis* *Q. faginea* *Q. ilex* *Q. pyrenaica* *Q. suber*	drought	*Diplodia mutila* *Hypoxylon mediterraneum* *Phytophthora cinnamomi*
United Kingdom	*Q. petraea* *Q. robur*	drought frost damage	*Armillaria* spp. *Agrilus* spp.
Belgium/Netherlands	*Q. petraea* *Q. robur*	drought/excess moisture defoliation - fungal/insect frost damage	*Armillaria* spp.
France	*Q. ilex* *Q. petraea* *Q. pubescens* *Q. robur* *Q. suber*	drought defoliation - fungal/insect frost damage soil/site factors & off-site planting	*Agrilus* spp. *Armillaria* spp. *Ceratocystis* spp. *Ophiostoma* spp. *Collybia fusipes*
Italy	*Q. cerris* *Q. frainetto* *Q. ilex* *Q. pubescens* *Q. robur* *Q. suber*	drought defoliation - fungal/insect	*Armillaria* spp. *Collybia fusipes* *Ganoderma* *Diplodia mutila* *Hypoxylon mediterraneum* *Phomopsis quercina* *Stuartella formosa* Bacterial spp.
Germany	*Q. petraea* *Q. robur* *Q. rubra*	drought defoliation - fungal/insect frost damage excess nitrogen	*Armillaria* spp. *Ceratocystis* spp. *Agrilus* spp. Viruses
Poland	*Q. robur*	drought defoliation - fungal/insect frost damage	*Armillaria* spp. *Ceratocystis* spp. *Fusicoccum quercus* *Ophiostoma* spp.

Country/Continent	Species	Stressors	Organisms
Czech Republic & Slovakia	*Q. cerris* *Q. petraea* *Q. robur*	drought air pollution	*Agrilus* spp. *Ophiostoma* spp. *Diaporthe fasiculata*
Austria	*Q. petraea* *Q. robur*	mistletoe, *Loranthus europaeus* soil/site conditions	*Ceratocystis* spp.
Hungary	*Q. cerris* *Q. petraea* *Q. robur*	drought/excess moisture defoliation - fungal/insect frost damage soil/site conditions	*Armillaria* spp. *Ceratocystis* spp. *Ophiostoma* spp. *Collybia fusipes* *Agrilus* spp.
Romania	*Q. cerris* *Q. frainetto* *Q. pedunculiflora* *Q. petraea* *Q. pubescens* *Q. robur*	drought defoliation - fungal/insect soil/site conditions	*Armillaria* spp. Canker fungi
Bulgaria	*Q. cerris*	drought	*Armillaria* spp. *Ganoderma* *Diplodia mutila* *Hypoxylon mediterraneum*
Moldavia, Ukraine, Baltic States, & Western Russia	*Q. imeretina* *Q. longipes* *Q. petraea* *Q. robur*	drought defoliation - fungal/insect silvicultural manipulations	*Armillaria* spp. *Ophiostoma* spp. *Agrilus* spp.
Asia			
Far East Russia	*Q. dentata* *Q. mongolica*	drought defoliation - insect	*Armillaria* spp. ??
China	*Q. dentata* *Q. mongolica*	drought defoliation - insect	*Armillaria* spp. ??
Japan	*Q. serrata* *Q. mongolica*	drought	*Armillaria* spp. *Ophiostoma* spp. *Platypus quercivorus*

Country/Continent	Species	Stressors	Organisms
North America			
Western United States	*Q. douglasii* *Q. agrifolia* *Q. lobata* *Q. engelmannii* *Q. kelloggii*	drought/excess moisture leafy mistletoe - *Phoradendron villosum* air pollution defoliation - insect	*Armillaria* spp. *Phytophthora cinnamomi* *Diplodia quercina* *Cryptocline cinerescens* & *Discula quercina* *Agrilus* spp. ??
Canada	*Q. alba* *Q. coccinea* *Q. rubra*	drought defoliation - insect	*Armillaria* spp. *Agrilus* spp.
Eastern United States	North *Q. alba* *Q. coccinea* *Q. ellipsoidalis* *Q. palustris* *Q. prinus* *Q. rubra* *Q. velutina* South *Q. falcata* *Q. laurifolia* *Q. marilandica* *Q. nigra* *Q. phellos* *Q. stellata*	drought/excess moisture defoliation - frost/fungal/insect air pollution	*Armillaria* spp. *Hypoxylon atropunctatum* *Agrilus bilineatus* and other species

CONCLUSIONS

Oak decline occurs wherever oak occurs and because of the number and diversity of oak species, it occurs over a wide range of sites in most forested places of the northern hemisphere. While many oak species experience decline, some species are affected more than others, perhaps proportional to their abundance on the landscape, or their susceptibility to the major stress agents that affect oak.

The basic process of oak decline and therefore symptoms of oak decline are similar in all places where decline occurs. Trees are affected by stress agents, dieback in response to the stress, change in susceptibility to deleterious organisms, are attacked by these organisms, and decline and die. Drought and defoliation are the two most common stress agents and the *Armillaria* root

disease fungus is the most common secondary organism associated with oak decline worldwide. Age or physiological maturity may be involved in the current worldwide episode of oak decline. Major climatic events also have been proposed but not yet confirmed as common triggering factors.

It should also be noted that declines are not limited to oak species and forests. Many other hardwood species undergo declines including ash (*Fraxinus* spp.), maple (*Acer* spp.), birch (*Betula* spp.), and beech (*Fagus* spp.) among others (Millers *et al.* 1989). A number of these species also are widespread around the world and have decline problems in many locations other than the United States. When viewed from this perspective, understanding and managing decline diseases is an important world forest health issue.

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PROCEEDINGS

U. S. Department of Agriculture Interagency Gypsy Moth Research Forum 1996