# Oak wilt and oak decline in the upper midwest USA

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## ABSTRACT

Oaks are a significant component of the hardwood forests of the Upper Midwest USA. Numerous species occur over vast areas in the region and are highly valued for a variety of reasons. Oak wilt caused by *C. fagacearum,* and oak decline associated with several factors are the major causes of the species, deterioration and death in the region. Urbanization and wind damage associated with spring storms have spurred the spread of oak wilt as well as contributed to general oak decline. Concern exists that additional increases in oak wilt may occur if the European oak bark beetle should become established in the eastern USA. Although sometimes difficult, distinguishing between oak wilt and oak decline is necessary for the appropriate application of control measures.

Key words: Oak wilt, oak decline, *C. fagacearum*

## INTRODUCTION

Oaks (*Quercus* spp.) are a dominant component of the expansive oak-hickory forests of the central USA that prevail from the northern boreal forest region to the states bordering the Gulf of Mexico (LEOPOLD et al., 1998). The species group is the most important aggregation of hardwoods in the United States (HARLOW and HARAAR, 1968). The significance of oaks in the Upper Midwest, USA, is discussed in this paper. Two primary maladies of oak, oak wilt and oak decline, are responsible for much of the observed oak deterioration and mortality in the oak- hickory forests of the Upper Midwest. Discussion of these maladies in this paper focuses on selected points that may be of interest to investigators of oak forest health in Europe.

## SIGNIFICANCE OF OAKS IN THE UPPER MIDWEST

Members of two subgenera of *Quercus* are found in the Upper Midwest Region of the Central Hardwood Forests in the USA (LEOPOLD, et al. 1998). Among the erythrobalanus or „red oaks", the predominant species in the region are the northern red (*Q. rubra* L.), northern pin (*Q. ellipsoidalis* E.J. Hill), black (*Q. velutina* Lam.), and blackjack oaks (*Q. marilandica* Muenchh.). Bur (*Q. macrocarpa* Michaux), white (*Q. alba* L.), chinkapin (*Q. muelhlenbergii* Engelm.), chestnut (*Q. prinus* L.), and post oak (*Q. stellata* Wangenh.) are the predominant species in the subgenus Leucobalanus of „white oaks".

Oak spp. occur on over 5 million ha of land in seven states of the Upper Midwest including Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, and Wisconsin (Table 1; Fig.1). The total land area of these states is approximately 1,220,000 $km^2$, roughly equivalent to the combined area of France, Germany and Poland (CARROLL, 1999). The distribution of oak species varies among and within the seven states in the region. The volume of oak growing stock covering all age classes on timberland in the region exceeds 503 million $m^3$, with the volumes also varying among and within each state (Table 1; Fig. 1).

Table 1. Area of land with oaks present and growing-stock volumes of timberland associated with oak species in the Upper Midwest, USA

| State | No. *Quercus* spp. represented | Area of land (ha) (x 1,000) | Volume (in M $m^3$) |
|---|---|---|---|
| Illinois | 15 | 1,080 | 58 |
| Indiana | 15 | 640 | 45 |
| Iowa | 11 | 403 | 17 |
| Michigan | 10 | 502 | 80 |
| Minnesota | 6 | 859 | 43 |
| Missouri | 15 | 454 | 166 |
| Wisconsin | 8 | 1,265 | 94 |

*Source*: HANSEN, et al. (1992).

Table 2. Annual volume and value of harvested oaks in the Upper Midwest, USA

| State | Harvest Volume (ave.) | Harvest Value (ave.) |
|---|---|---|
| | (X 1,000 $m^3$) | (X $1,000 USD) |
| Illinois | 1,056 | 26,400 |
| Indiana | 1,082 | 27,050 |
| Iowa | 300 | 7,500 |
| Michigan | 990 | 24,750 |
| Minnesota | 903 | 22,575 |
| Missouri | 2,772 | 69,300 |
| Wisconsin | 1,831 | 45,775 |
| Total | 8,934 | 223,350 |

*Source:* USDA Forest Service, North Central Research Station, Forest Inventory and Analysis Project.

Oaks are important in the region as providers of acorns as food for birds and mammals, wood for lumber and veneer, cooperage for the beverage industry, and as landscape trees (BURNS and HONKALA, 1990; DIRR, 1983; SCHMIDT, 2000). Within the seven-state Upper Midwest area, an average of 9 million $m^3$ of oak are harvested each year for timber products (Table 2). Stumpage prices for oak currently average $25 USD per $m^3$ (Missouri Dept. Conserv., 1999). Stumpage is the standing volume of wood in the main bole of the tree and also refers to timber sold on the stump. Stumpage value establishes a baseline that does not include „value-added" activities (e.g. wildlife, recreation, processed lumber). With a total annual re-

turn to the region's landowners of more than $223 million USD (Table 2), the potential losses to oak wilt and oak decline are of crucial importance, not only to landowners, but also to those in forest industries or involved in public policy determination. In four of the seven states in the region, oak wilt is considered the major disease of concern by the state's forestry agency (BILLINGS, 2000).

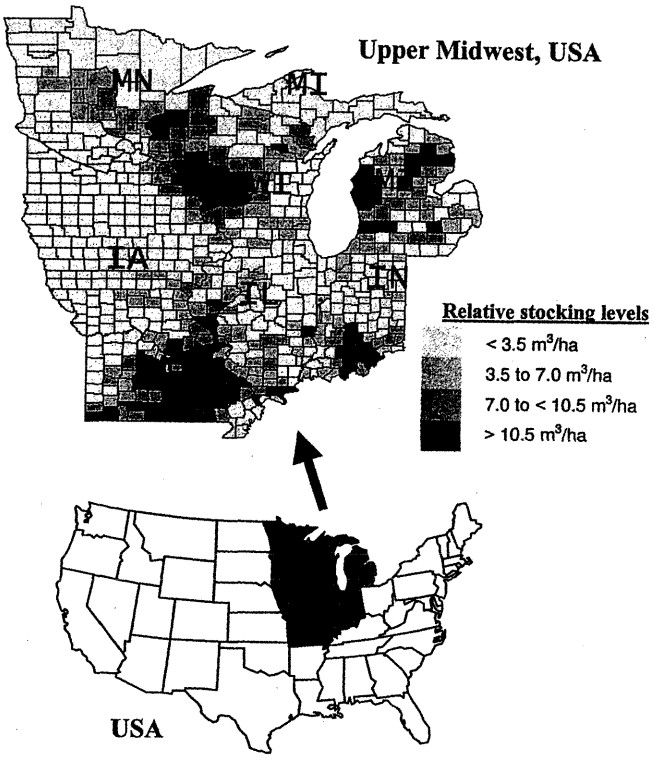


Fig. 1. Relative growing-stock volume of predominant oak species in seven states of the Upper Midwest, USA (IA = Iowa, IL = Illinois, IN = Indiana, MI = Michigan, MN = Minnesota, WI = Wisconsin).

## OAK WILT IN THE UPPER MIDWEST

Oak wilt caused by the fungus *Ceratocystis fagacearum* (Bretz) Hunt kills thousands of oaks annually in the Upper Midwest. The red oak species are highly susceptible to the pathogen, while white oak species in the region range from intermediate (e.g. bur oak) to tolerant (e.g. white oak) when it comes to their susceptibility to the pathogen (FRENCH and JUZWIK, 1998). Red oaks succumb quickly to the disease with foliage often wilting completely within 6 to 8 weeks of initial infection (TAINTER and BAKER, 1996). Bur oaks will often sustain increasing crown dieback associated with discolored and wilting foliage over one to several years before tree mortality occurs. In white oaks, oak wilt symptoms are often difficult to distinguish from those associated with other abiotic and biotic problems of the species. Scattered dieback oc-

curs in the crown of infected white oaks and vigorous trees may even compartmentalize *C. fagacearum* infections over time.

High rates of establishment of oak wilt centers in the Upper Midwest have been associated with several factors, including the urbanization and wind damage discussed in this paper. „Urban sprawl," attributable to migration of city-dwellers into outlying forested areas, has been associated with intensification of oak wilt in the Upper Midwest and in Texas (APPEL, 1989). As new residential and commercial sites are developed in oak woodlots during spring and early summer, wounding of healthy oaks may occur. Fresh, xylem-penetrating wounds are attractive to several species of sap beetles (*Coleoptera: Nitidulidae*) that also frequent oak wilt fungal mats on oaks recently killed by *C. fagacearum* (JUZWIK, et al. 1999; CEASE, et al. 1997). These insects acquire spores of the pathogen from the fungal mats and then transmit them to xylem-exposing wounds on healthy oaks, primarily during the spring months (GIBBS and FRENCH, 1980). It is in this manner that new infection centers of oak wilt are often established. Underground spread via root grafts to adjacent healthy oaks commonly follows from the initial infections attributed to insect transmission. Details on oak wilt infection centers in the Minneapolis – St. Paul metropolitan area have been documented annually since 1991 by the state forestry agency (Minnesota Department of Natural Resources, 1998). Graphical analysis of these data shows that infection centers are associated with recently developed „outer-ring" suburbs of this urban center, where the human population exceeds 2.5 million.

Violent spring storms accompanied by high winds, and sometimes tornadoes, are common events in the Upper Midwest. Wind damage to oaks often provides infection courts (i.e. wounds) where *C. fagacearum* can be introduced by insect vectors. Red oak group species are considered particularly susceptible to *C. fagacearum* infection during spring because of the large diameter springwood vessels that form in them at this time of year. In 1998, three major storms occurring in East Central Minnesota between mid-May and mid-June resulted in many xylem-exposing wounds that were aggravated when pruning was done to remove broken limbs. Oak wilt was subsequently observed in a number of oaks damaged in these ways (JUZWIK, pers. obsn.; C. EVENSON, pers. comm.).

Current cooperative research between the USDA Forest Service and the University of Minnesota is aimed at identifying the principal species of sap beetles that serve as vectors of the pathogen in the region. *Colopterus truncatus* Rand. and *Carpophilus sayi* Parsons have recently been implicated as the main species responsible for transmitting *C. fagacearum* from diseased to healthy oaks in Minnesota (JUZWIK, et al. 1999). Two oak bark beetle species, *Pseudopityophthorus minutissimus* (Zimmerman) and *P. pruinosus* (Eichhoff), are also known to transmit the pathogen in the Upper Midwest (REXRODE, et al. 1965; REXRODE and JONES 1970). Their significance in oak wilt spread is unknown, especially in relation to the importance of sap beetles (JUZWIK, 2000). Both native bark beetles and sap beetles are considered inefficient vectors of *C. fagacearum* in the USA.

The possible introduction and establishment of the European oak bark beetle, *Scolytus intricatus* (Ratzeburg), in the USA is of concern because the insect could potentially be a very effective vector (GIBBS and FRENCH, 1980; YATES 1984). *S. intricatus* has been intercepted by regulatory officials on several occasions recently at several US ports-of-entry (per HAACK, 2000). The common occurrence of S. intricatus in Europe and its high potential to serve as an efficient vector of C. *fagacearum* are major reasons for concern about the accidental introduction of the Latter to Europe (GIBBS 1978; SCHOPF et al. 1984; YATES 1984).

## OAK DECLINE IN THE UPPER MIDWEST

Oak decline and mortality attributable to biotic agents other than *C. fagacearum* along with abiotic factors are also common in the region. These factors differ in their roles as predisposing, inciting, and contributing agents of the decline, as defined by Manion (1991). Storm-related damage (e.g. wind or hail), drought, flooding and construction damage are some of the inciting abiotic events that we have observed in the Upper Midwest in the 1990's. Long- term observations have implicated drought as the primary factor in oak decline in the oak-hickory forest of the region (HOUSTON, 1987; HAACK and BLANK, 1991). Outbreaks of defoliating and/or boring insects on oaks often accompany or follow drought in this and other regions of the country (WARGO, 1993). The two primary insects involved in this way are the gypsy moth (*Lymantria dispar* L.) and the twolined chestnut borer (*Agrilus bilineatus* Weber). As the gypsy moth continues to expand westward in the USA into Wisconsin, Indiana and Illinois, its role in oak decline in the region is expected to increase. The twolined chestnut borer is well - established in the region and populations can quickly increase to epidemic levels leading to widespread oak mortality following drought and/or defoliation by other insects, disease organisms, or hail. Construction damage, soil compaction, and detrimental landscape-associated changes are predisposing or inciting factors that are accompanied by this borer in residential and urban settings (SINCLAIR et al., 1987; HAACK and ACCIAVATTI, 1992). Other contributing factors involved in the decline and mortality of oaks in the Upper Midwest include *Armillaria* root rot (primarily associated with *Armillaria gallica* Marxm. et. Rom.), several different root and stem decay fungi, and the bark colonizer *Hypoxylon atropunctatum* Schw.ex. Fr. (Cke.). The latter fungus is not common in the northernmost states in the region. As in Europe, strong regional differences in the abiotic and biotic agents associated with oak decline are observed in the USA.

## IMPORTANCE OF PROPER DIAGNOSIS OF OAK MALADIES

Oak wilt and oak decline commonly occur in the same localities and even within the same stands of mixed oak species. Correct diagnosis of the cause of oak mortality can be difficult. Cost-effective control methods are available for oak wilt but generally not for oak decline. Thus, the disease should be diagnosed properly if control treatments for oak wilt are to be used appropriately. Two examples illustrate this point.

Mortality of several northern red oaks was reported for an urban park in a southern Minneapolis suburb in July 1999. Because the trees appeared to be dying quickly following initial symptom onset, the management forester suspected oak wilt was present. Further investigation, however, implicated oak decline that was associated with the following sequence of events: 1) a major hailstorm during the previous July which had resulted in extensive defoliation of oaks in the park, with no occurrence of refoliation the same season; 2) an increase in twolined chestnut borer populations, and girdling the main stems of affected red oaks by the tunneling activity of these pest larvae; 3) rapid foliage death and, within a year, the decline or death of over 25 trees. Based on the diagnosis of the decline, oak wilt control activities were not undertaken.

The second example involves oak decline and mortality that occurs annually within several large tracts of forest parkland located south of the Minneapolis/St. Paul metropolitan area. Within one tract we observed pockets of oak decline associated with different agents (e.g. drought and *Armillaria* root rot in one and flooding and sequential dieback in the other), as well

as oak wilt in still other pockets of affected oaks. The oak wilt centers could be treated effectively to contain disease spread. The wise expenditure of funds for the suppression of oak wilt in these parklands depends on accurate diagnosis of the cause(s) of oak decline or death in each pocket.

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