A DESCRIPTION OF DECLINING AND BLIGHTED PIN OAKS IN EASTERN VIRGINIA

by D. N. Appel and R. J. Stipes

Abstract. *Endothia gyrosa*, the pin oak blight fungus, commonly colonizes pruned branches and other wounds on pin oaks in Eastern Virginia communities. Sometimes the disease causes serious losses of valuable shade trees. In one outbreak of pin oak blight, diseased trees had a greater rate of decline in increment growth over a 25 yr. period than healthy, uninfected trees. As a result of this growth decline and the remedial pruning needed to remove dead and injured branches, blighted trees had smaller heights and diameters than healthy, uninfected trees. No single environmental factor, i.e., nutrients, precipitation, or root disturbance caused by the installation of underground utilities, was responsible for the occurrence of pin oak blight.

Endothia gyrosa has been found causing cankers on a wide variety of hosts including various oak (*Quercus* spp.) (9, 12, 13, 14, 15), chestnut (*Castanea* spp.) (11), sweet gum (*Liquidambar* spp.) (10), beech (*Fagus* spp.) (9) and holly (*Ilex opaca*) (15). The range of this fungus in the United States extends from Ohio south to South Carolina, and westward through Mississippi into Texas. Pruning wounds or other, naturally occurring wounds on trees are reported to be important infection courts for the fungus (5, 10, 12, 15). Also, *E. gyrosa* has been described as a facultative parasite that infects trees weakened by environmental stress (5, 11).

We present additional experimental evidence to support the involvement of drought in pin oak caused by *E. gyrosa* on *Q. palustris*. The colonization of artificially inoculated, pruned branches on pin oaks in field plots was found to be greatest during July and August, the hotter and sometimes driest months of the year in the research area (5). Cankers caused by *E. gyrosa* on inoculated, containerized pin oaks elongated only when trees were exposed to water stress (1). Regularly watered trees were not significantly colonized by the fungus.

Pin oak blight in Tidewater, Virginia is described as the most damaging of those diseases caused by *E. gyrosa* (1, 12, 14). The problem is particularly serious because pin oak is an important component of the urban forests of eastern Virginia communities. The fungus causes girdling cankers leading to premature defoliation, dieback, and general decline of trees. Severely girdled, dying trees are often found adjacent to unaffected, healthy trees. Remedial pruning and fertilization are routinely used by homeowners to control the disease, but there is no evidence these measures are effective.

A site was selected for study of pin oak blight at Langley Air Force Base (LAFB) near Hampton, VA, where large numbers of trees were infected by *E. gyrosa*. The objective of the study was to measure disease severity, and to classify site and tree characteristics to aid in determining factors responsible for the increasing incidence and severity of pin oak blight in the Tidewater region. This report discusses results from that study.

Materials and Methods

The pin oak population in the Langley community was systematically surveyed and inventoried in stages. In the first stage, 179 pin oaks located on nine residential streets were surveyed in 1977. Data collected during the survey included tree heights, diameters at breast height (dbh = 4.5 ft), and vigor assessment based on a 1-10 scale, where 10 represented a disease-free tree and 1 represented a dead tree. This subjective health rating consisted of assessing crown loss to disease and subsequent pruning. Also, the amount of dead limbs and branches in the crown, leaf color, and presence of suspected pathogens were considered in rating the trees. In 1978 and 1979, the survey was expanded in a second stage to include all 566 pin oaks in the community.

Increment cores were removed from 33 selected trees in 1979. Cores were taken at 4.5 ft above ground, and measured by the Tree Growth Analysis Service, Department of Plant Pathology, Physiology and Weed Science, VPI &

SU, Blacksburg, VA. Measurements were made for years 1954-1978 and were accurate to the nearest 0.01 mm. The ring widths were correlated with receding years (1-25) using regression analysis to determine growth trends in the different groups of trees.

Leaves were harvested from selected trees for elemental analysis in June 1977. For nitrogen (N) analysis, samples were removed from top, middle, and bottom crown positions of 12 trees with the aid of a bucket truck. Leaves and petioles were removed from branches, placed in paper bags, and dried in an oven overnight at 70°C. A Wiley mill was used to grind the dried leaves and petioles. Total N content of leaves and petioles was determined using the micro-Kjeldahl method (3). Three repetitions were run on each sample for total N content.

In a different sample of 24 trees, foliar elemental analysis was used to measure various nutrients in leaves removed from middle crown positions. The amount of iron (Fe) in each sample was determined with atomic absorption spectrometry (17). Phosphorous (P), potassium (K), calcium (Ca) and magnesium (Mg) were analyzed in selected leaf-petiole samples by the Forest Testing Services, Department of Forestry, VPI & SU, Blacksburg, VA. Analysis was repeated three times for each of these samples.

Pruning records for the 12-year period 1966-1978 and utility maps were available for the Langley community. The maps contained the locations of three underground utilities, including sewage, electrical and water distribution systems. This information was examined for details relating to incidence and severity of pin oak blight in the community.

Results

All of the 179 pin oaks included in the first stage of the inventory were located within 8-10 ft of the curb; most were planted between curb and sidewalk. The trees ranged 10-26 m in height, and ranged 31-81 cm dbh. A majority of the trees were approximately 50 years old, and were considered to be among the most valuable in the entire community. Trees less than 33 cm dbh were omitted to restrict analyses to the older, mature trees.

There were 114 trees rated 8-10 in the initial survey (Figure 1). These trees had full crowns and exhibited no signs or symptoms of stress or disease. The 39 trees rated 6-7 (Figure 1) were either heavily pruned or contained large amounts of deadwood. The pruned limbs and branch stubs were infected by *E. gyrosa* causing diffuse cankers, girdled limbs, and dead branches. On other trees, cankers were inhibited by callus growth and the branches appeared to be recovering. Trees rated 5 or less were nearly dead, with little chance of recovery. These three categories (1-5, 6-7, and 8-10) were considered to be functional groups and were used for studying pin oak blight. In Table 1, the heights and diameters of 81 trees selected from the first stage of the inventory are shown. Those rated 8-10 were put in Class A and were larger than those rated 6-7 (class B) or 1-5 (class C). Class B trees were intermediate in size while those in class C were the smallest.

The increment cores were removed from 11 class A, 10 class B, and 12 class C trees. Yearly growth increments for trees in all 3 classes have been progressively decreasing in width during the 25-year period (Figure 2). In class A, for example, average tree increments decreased from 8.30 mm in 1954 to 5.52 mm in 1978. Class B trees decreased in growth at a similar rate from 7.36 mm to 2.76 mm. Class C trees decreased in growth at a significantly ($P = 0.01$) greater rate (7.36-2.76 mm) during the period of measure-

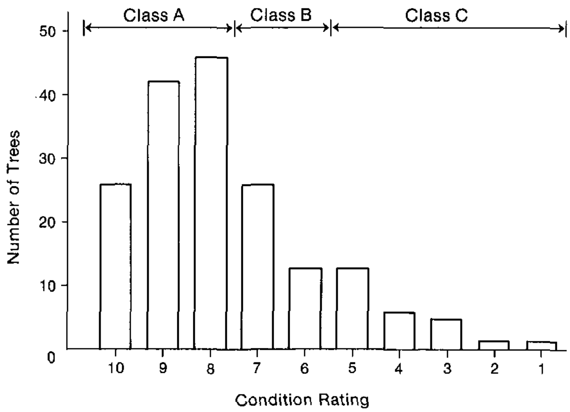

Figure 1. The numbers of trees delegated to each of 10 tree-health categories on the basis of vigor. Category 10 includes the healthiest trees, while 1 represents dead trees. The health classes A, B, and C were established as functional groups to aid in data analysis.

ment. No significant correlations were found between increment widths and average, annual precipitation.

The foliar N concentrations of four randomly selected class A trees were 2.32%, 2.32%, and 2.39% at the top, middle, and bottom crown positions, respectively. For class C trees at the same positions, the foliar N concentrations were 2.44%, 2.48%, and 2.76%, respectively. This consistent increase in foliar N in the lower health class was not statistically significant. This same trend was true of foliar P, K, Mg, and Ca, with the average foliar Ca content being significantly different between the 13 class A (4397 mg/gm) and 11 class C trees (6721 mg/gm).

In the sample used for increment measurements, the class C trees were pruned during 1966-1978 an average of 2.67 times each, while class A and B trees were pruned 1.7 and 1.8 times, respectively.

The average diameters of trees having root zones intercepted by 0, 1, 2, or 3 underground utilities did not significantly differ. The greatest number of trees, 88, were free of any utilities and had an average health rating of 8 and dbh of 56.34 cm. Thirty-two were intercepted by 3 utilities, having an average health rating of 8, and dbh of 53.28 cm.

Discussion

We believe that *Endothia gyrosa* is a contributing factor (7) in the decline of pin oaks in eastern Virginia, rather than a primary or single incitant of the disease. One factor possibly acting as an incitant in pin oak blight is water stress, shown experimentally to predispose pin oak toward increased susceptibility to the fungus (1). Under natural conditions, the fungus behaves like a typical, facultative parasite when found extensively colonizing pruned branches and other wounds on declining trees. On healthy, class A trees, *E. gyrosa* was commonly found colonizing small twigs, branches, and wounded surface roots with no apparent harm.

The decreasing increments of class A trees during 1954-1978 were the result of normal growth and maturation processes (4), and were not a symptom of any loss in vigor. Trees in class B exhibited a similar rate of decline, but also had less increment growth than the class A trees during the 25 years (Figure 2). The increments of class C trees were similar to those of class A from 1954-1960, but thereafter began to decline at a significantly greater rate. No periods of drought were recorded at the initiation of this declining growth. There also was no correlation between the rates of increment growth and mean annual precipitation for trees in any of the three classes, but statistical methods are available that might improve this analysis (4). Daily or weekly precipitation patterns may correlate with tree growth better than average annual precipitation. For example, drought that occurs during the resumption and progress of growth in spring and early summer may be more devastating to tree health than drought occurring at other times of the year.

Although foliar elemental analysis has proven useful in understanding other declines (2, 6), it was not a useful tool for distinguishing healthy and diseased trees at LAFB. None of the elements was deficient in the class C trees, providing no evidence that nutrient stress might be responsible for the decline in tree vigor. There are several sources of variability, such as tissue age, crown position, genetic influences, and soil nutrient levels and availability that will influence foliar elemental concentrations (16). Also, when foliar nutrients are measured and expressed on a percentage dry weight basis, growth rate, or the accumulation of organic matter, will influence the

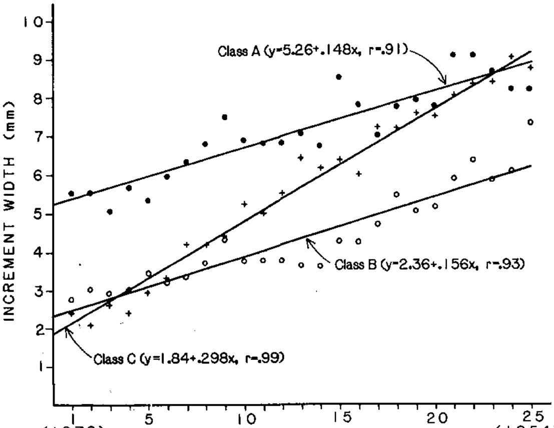

Figure 2. Average increment measurements for 11 class A pin oaks, 10 class B, and 12 class C trees during 25 years growth.

Table 1. Average heights and diameters at breast height (dbh) for mature pin oaks designated to three health classes.

Health class[x]	*Number of trees*	*Average height (m)*[y]	*Average dbh (cm)*[y]
A	40	18.9 a	55.37 a
B	14	15.5 b	49.09 b
C	27	12.5 c	43.51 b

[x]Health class A includes trees rated 8-10, class B includes trees rated 6-7, class C includes trees rated 1-5, on a 1-10 scale based on preferred shade tree criteria.
[y]Average values in a column followed by different letters are significantly different ($p = 0.05$).

relative concentrations of inorganic nutrients in the tissues. This dilution effect (16) may be responsible for the generally higher concentration of foliar nutrients found in the slower growing class C trees as opposed to those found in class A.

The presence of underground utilities at LAFB did not appear to be a specific factor relating to the incidence of decline. It is unlikely that there is any single factor causing pin oak decline, but rather a variety of environmental stresses that cause trees to eventually succumb to blight caused by *E. gyrosa*. In the pin oak populations at LAFB, many trees such as those in class A appear suited to the environment and serve as ideal street and shade trees. Such trees are considered valuable as sources of seed for tree improvement and breeding programs (8). Others, however, require frequent expensive pruning at great expense and eventually die. These trees, represented by those in class C at LAFB, should be identified as early as possible and promptly removed. Some trees were recovering from decline and subsequent blight, and these were designated to class B along with others that were in the early stages of decline and would never recover. The detection of the surviving trees and factors responsible for their recovery would be extremely helpful in managing pin oak blight and other similar declines.

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