Reprinted from
THE CORNELL PLANTATIONS
VOLUME XX WINTER 1964-65 No. 4

Comparisons of Recent Declines of White Ash, Oaks and Sugar Maple in Northeastern Woodlands

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WITHIN THE past 10 years widespread declines of hardwoods, including white ash, red, black and scarlet oaks and sugar maple, have caused concern among foresters, landowners and the general public in the Northeast. Studies of ash die-back conducted by Dr. Eldon Ross at the New York State College of Forestry at Syracuse University and of maple decline and oak mortality carried out by Drs. Craig Hibben and John Staley, respectively, at the College of Agriculture at Cornell have emphasized the complexity of these diseases. Although no single cause of any of the declines has been implicated to the exclusion of others, there are points of similarity that invite comparisons.

Symptoms of the Diseases.

A number of symptoms are common to all 3 diseases; relatively few symptoms are peculiar to one of the declines. The first indications of decline are reductions in radial increment and terminal twig growth which occur one to several years before other symptoms appear. These growth reductions are often rapid and drastic, causing tufting of foliage and an apparent thinning of crowns as leaves are borne close together on the shortened internodes of twigs. The leaves also show abnormalities including chlorosis and dwarfing which contribute to the thin-crowned appearance of affected trees. Declining maple and ash trees take on fall color prematurely and the leaves may be cupped or show chlorotic patterns throughout the growing season.

Twigs and small branches, particularly in the upper parts of the crown, fail to survive the dormant period, and larger branches follow them in succeeding dormant seasons. Frequently accompanying the death of branches in the crown is the production of sprouts along the trunk and larger limbs, imparting a bushy appearance to the center of the tree. This stage of decline is regularly followed by death of white ash and oaks. Decline in sugar maple is often arrested at or before this stage, the appearance of affected trees changing little from year to year.

Cankers caused by fungi are usually but not always found on the trunks and branches of declining ash trees. Their enlargement, principally during the dormant season, is responsible for the girdling and death of many branches or even entire trees. Cankers are less frequently associated with maple decline and contribute little to the deterioration of the trees. Oaks in late stages of decline are attacked by a boring insect, *Agrilus bilineatus* (Web.) which plays a major role in their demise. The tiny larvae tunnel extensively in the region of the cambium and cankers develop around many of their galleries. The combination of galleries and associated bark necrosis may girdle a dying tree and thus hasten its death.

Progressive deterioration of fine rootlets is a constant feature of the decline of oaks but occurs inconsistently in declining maples and is absent in the ash disease. Invasion of the larger roots and butts of dying oaks by the shoestring fungus, *Armillaria mellea,* (Vahl.) Quel. plus an unidentified fungus, is common; only *A. mellea* is often isolated from dead roots of sugar maple, and neither fungus is known to be associated with declining white ash.

Hibben found that the nitrogen content of leaves of sugar maples in early stages of decline is less than in leaves of nearby healthy maples, but this point has not been tested with regard to the other 2 declines. Staley showed that a progressive depletion of carbohydrate reserves is a constant feature of the oak disease, but the status of food reserves in declining ash and maple has not been checked. However, because these symptoms are general indicators of malfunctions within plants, and in view of other similarities among the 3 diseases, there is some justification for assuming that reduction of foliar nitrogen content and progressive depletion of carbohydrate reserves occur in all 3 declines.

Causal Factors.

More similarities become apparent in a consideration of the many possible causes of these disorders. Potential causes include fungi and bacteria, viruses, nematodes, insects and other arthropods, adverse soil-site factors, aberrant weather patterns including

drought and extremes of temperature, changes in climate, atmospheric constituents including pollutants, and other factors singly or in combinations. Several of these possibilities have been studied in some detail.

Fungi and bacteria: Of the many fungi and bacteria found associated with declining and dying trees, relatively few appeared consistently enough to warrant close attention of the research workers. Four fungi, *Cytophoma pruinosa, Fusicoccum sp. Coniothyrium* sp. and a species of *Alternaria* were the microorganisms most frequently isolated from stem and branch cankers of diseased ash trees. Only *C. pruinosa* and *Fusicoccum* sp. were shown to be capable of causing cankers when inoculated into healthy trees, and then only when the trees were under moisture stress. This fact and the earlier determinations that not all diseased trees were cankered and that naturally occurring cankers had been formed principally during dry periods led Ross to the conclusion that the canker fungi are only able to cause damage in ash trees previously weakened by some other agent.

During his study of oak decline Staley isolated a variety of fungi and bacteria from cankers and dying branches, but none were consistently associated with the disease. Dead or dying oak roots, on the other hand, frequently yielded *Armillaria mellea* plus an unidentified fungus. Staley found evidence that the unidentified fungus preceded *A. mellea* in invasion of oak roots but that neither fungus was strongly pathogenic even toward weakened trees. He concluded that root disease caused by fungi is at most a contributing factor in the decline and mortality of red and scarlet oaks.

Hibben reached the same conclusion regarding the importance of a variety of fungi including *A. mellea* isolated from roots and tops of diseased maples. *A. mellea* was associated with less than half of the trees he studied. Inoculations of roots, stems, branches and leaves with several of the other fungi under various conditions yielded no evidence of pathogenicity.

Viruses: In all three studies, attempts were made to transmit symptoms of disease by grafting symptomatic scions onto healthy stocks. Results were negative. Hibben failed to show symptom transmission when leafhoppers collected on and near diseased sugar maples were caged with young healthy trees, and Ross obtained no symptoms on virus indicator plants after inoculation with sap extracted from leaves of diseased ash trees. Serological tests also gave negative evidence of a virus etiology 6f ash dieback. More recently, Hibben has reported mechanical transmission of ringspot symptoms from ash leaves collected in Dutchess County, New York to bean and cowpea plants. However, the geographical distribution of the virus is not known, and the ringspot symptoms do not occur on all declining ash trees.

Nematodes: Populations of plant-parasitic nematodes in and around roots of declining ash, maple and oak trees were shown to be generally low in comparison with populations usually associated with damage to plants. In the few cases where substantial populations were found (some soil samples from root zones of ash and maple) there was no relationship between numbers of nematodes and the health of trees.

Insects and other arthropods: There is presently no evidence that insects are significantly involved in the ash dieback disease. Hibben observed that severe outbreaks of the forest tent caterpillar, *Malacosoma disstria* Hbn., had contributed to mortality

of maples in northern New York but found no evidence that such outbreaks were a prerequisite for maple decline. Decline and mortality of oaks, on the other hand, may be caused in part by defoliation by the oak leaf roller, *Argyrotoxa sermipurpurana* Kearfott. Production of new leaves following untimely defoliation would reduce carbohydrate reserves, rendering the trees more susceptible to damage by a number of other factors including drought. Boring activities of *Agrilus bilineatus* in oak trees nearing death have already been described.

Adverse soil-site factors: In his study of ash dieback Ross analyzed soil from areas where dieback was prevalent as well as areas where the disease was not present. He reported no differences between areas with regard to content of major nutrient elements or organic matter, but found that soils where ash trees showed decline symptoms contained higher proportions of silt and clay than did soils from beneath healthy trees. Although Ross did not make the point, it might be expected for a number of reasons that trees growing in these "heavier" soils would also be more severely affected by factors such as drought.

With regard to oak decline Staley found a general coincidence of unfavorable soil characteristics and occurrence of the disease. Oak decline is most likely to occur on shallow soils of rapid internal drainage or soils of variable depth but having claypans less than 30 inches below the surface, occurring on slopes or ridgetops and plateaus. Because reserves of available water are low in such soils, trees growing in them may be under acute moisture stress during drought periods.

Hibben found no soil or site factor constantly associated with maple decline, but observed that the decline was restricted to areas with a history of logging or other cutting operations. Such operations are known to cause local environmental changes, and foresters for many years have recognized declines of several hardwood species (termed "decadence") following logging operations in closed stands. It is not difficult to envision some of the same factors associated with "decadence" (higher temperatures of air, soil, and plants, increased evaporation, higher soil moisture content during spring and lower during summer, etc.) acting on a larger scale during prolonged periods of abnormal weather or in a changing climate to cause mysterious declines of trees including ash, oak and maple.

Aberrant weather patterns: Moisture deficiencies were implicated as causes or contributing factors in studies of all 3 diseases. The closeness of this similarity is best illustrated by a comparison of data adapted from the separate studies of Ross, Staley and Hibben. Examination of the graphs in Figure 1 will reveal 2 general facts: 1) the majority of genera

seasons during the 1950's, including several successive years during the first half of the decade, were characterized by subnormal rainfall; 2) radial growth of white ash, scarlet oak and sugar maple was related to seasonal precipitation during the periods studied.

Not shown on the graphs are several additional facts:

— Dieback symptoms other than growth reduction in white ash became generally conspicuous during the mid-1950's and severe during the latter part of the decade. The incidence of cankers on ash increased sharply beginning in 1958 and 1959. Ross found that canker formation and dieback in individual trees occurred one year or more after a sharp reduction in growth.

— Mortality of red, black and scarlet

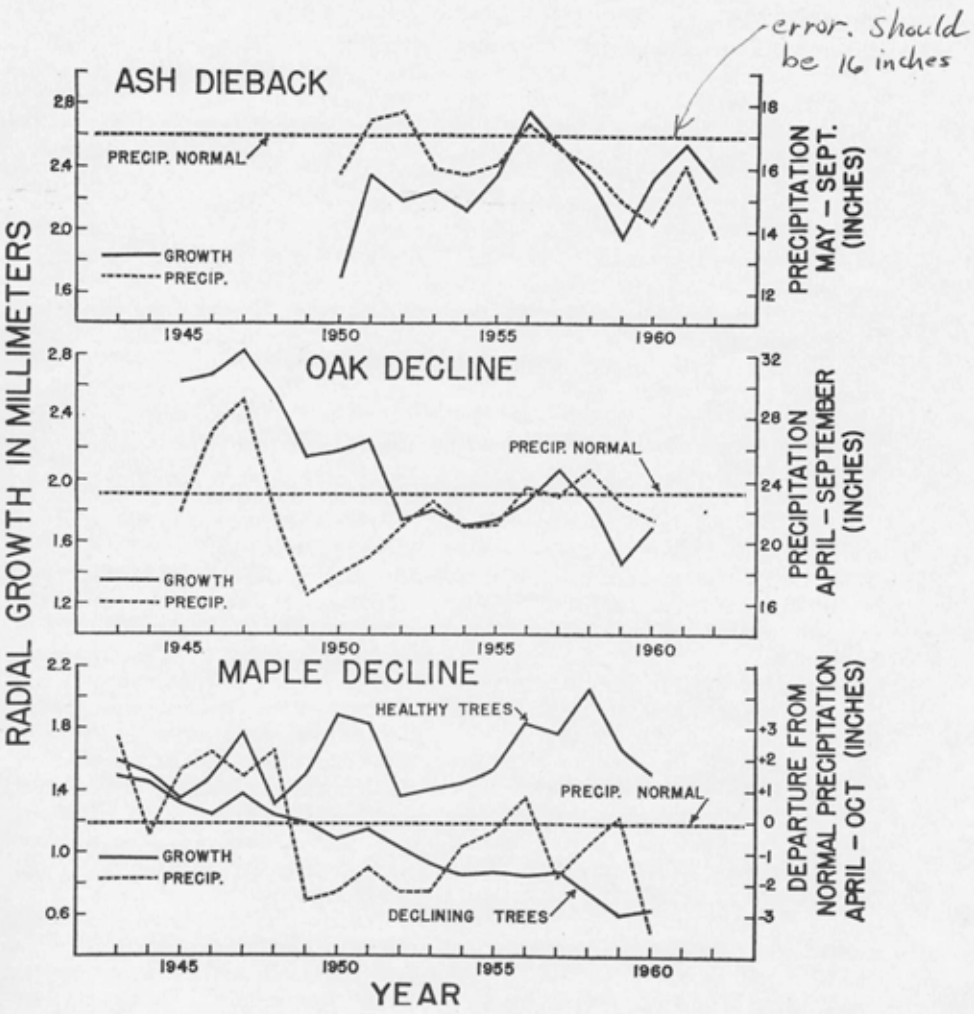

Figure 1. Relation of precipitation to radial growth of white ash, scarlet oak and sugar maple. Graphs adapted from data of Ross, Staley and Hibben, respectively. Precipitation data represent moving 2-year averages in all cases. Increment data from Ross and Staley include diseased and healthy trees.

oaks has been reported periodically since 1951, with extensive mortality occurring in 1955 and 1959 in the areas studied by Staley. Death of trees occurred 2 to 7 years after a reduction in growth.

— Symptoms of maple decline developed during the 1950's in 6 of the 7 areas studied by Hibben. Again, growth reductions preceded development of other symptoms. It can be seen from the graph that diseased maples responded less than healthy trees to fluctuations in rainfall before and especially after the onset of symptoms.

While difficult to prove, the inescapable conclusion to be drawn from the foregoing, based upon detailed evidence presented by Hibben, Ross and Staley, is that drought is a common major causal factor in the recent declines of at least 3 northeastern hardwoods.

Synthesis: Several causal factors, often interacting, are involved in the decline and mortality of white ash, oaks, maple and probably other northeastern trees. These factors are of 3 types: predisposing, inciting and contributing.

Predisposing factors are often but not necessarily edaphic. For example, Staley found that oak decline was often associated with soils having low moisture holding capacities; Hibben noted changes in local environment that follow logging operations. The net effect of predisposing factors is to reduce the ability of healthy trees to withstand injuries or attack by pests.

Inciting factors such as drought or defoliation are responsible for the first general symptoms of decline: reduction of food reserves and rate of growth. Trees in early stages of decline respond less or more slowly to favorable conditions such as adequate moisture, and their decline is accelerated by new or continuing adverse conditions. It can be seen that decline in trees is partly a matter of diminishing tolerance to adversity.

Factors contributing to decline include those mentioned above plus the activities of insects and pathogens, particularly fungi. Thus, severe insect defoliation is responsible for the initiation of oak decline, and subsequent defoliations by insects and frost, adverse soil conditions, drought, and attack by root-rotting fungi contribute to it. Similarly, Ross concluded that ash dieback is induced by drought and that the subsequent attack of canker-forming fungi accelerates the demise of the trees. It is likely that a possibly widespread virus infection of white ash would also fall in the category of factors contributing to decline.

From these comparisons it is apparent that the declines of ash, maple and oaks differ only in details of symptoms and relative emphasis of causal factors. It is likely that they are disorders of the same nature and that they are only the more conspicuous examples of a more general response of northeastern hardwoods to a concomitance of adverse factors, particularly drought, in recent years.

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