FROM THE BRONX TO BIRMINGHAM:

IMPACT OF CHESTNUT BLIGHT AND MANAGEMENT PRACTICES ON FOREST HEALTH RISKS IN THE SOUTHERN APPALACHIAN MOUNTAINS

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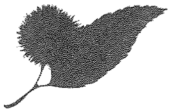


Southern Appalachian forest landscapes evoke images of the primeval forest in many people today. Indeed, most vegetation components in these forests have been present in varying mixtures and distributions for at least 58 million years (Dclcourt and Dclcourt 198 1). However, the only thing constant about these landscapes has been change. Advancing and retreating ice sheets, drought, flood, wind, and fire all served to shape forest composition and structure. Irrepressible as these forces are, people have been perhaps the most important change agents since arriving in the region at least 9,000 years ago (DeVivo 1991, Hudson and Tesscr 1993). In this context, the types and sequence of human-influenced disturbances since the middle of the 19th century have resulted in Southern Appalachian forests that bear little resemblance in terms of composition and structure to any that have existed in the past. These disturbances include the widespread use of fire, first by native people and then by European settlers; land clearing and agriculture followed by abandonment of marginally productive lands; widespread and sometimes abusive logging to supply fuel and building materials to a growing nation; industrialization and concurrent urbanization; and the implementation of aggressive fire suppression.

Perhaps the most profound ecological disturbance of all occurred with the introduction to North America and spread of *Cryphonectria parasitica* (Murrill) Barr, the fungus pathogen that causes chestnut blight. It caused unequaled impacts in eastern hardwood forests generally, and the Southern Appalachians specifically, that are still manifest today. American chestnut (*Castanea dentata* [Marsh.] Borkh.) was the most important hardwood tree in Southern Appalachian forests. Estimates of composition at large regional scales ranged from 25 to 50 percent (Ashe 1911, Buttrick 1925). Originating in Asia, the chestnut blight pathogen was first detected in the Bronx, New York in 1904. The pathogen spread rapidly, since native chestnuts lacked co-evolved disease resistance. By 1940, chestnut blight had killed SO to 99 percent of the American chestnuts throughout its botanical range. The tree persists today as sprout growth from residual root systems but usually attains diameters of only a few inches and rarely flowers before succumbing again.

The history of past disturbances, especially repeated light ground fire followed by nearly complete fire suppression, set the stage for the new forest that succeeded the blight-killed chestnut forest. Native people and European settlers alike had used this type of fire regime to reduce rank understory vegetation and promote browse for game. Aggressive sprouters like American chestnut and the oaks have a relative advantage over other tree species under this fire regime, and built up large reproduction reserves in the understory. As chestnuts died and aggressive fire suppression was implemented, newly available growing space was quickly occupied by these species already positioned in the mid- and understory. While chestnut replacement was variable, oak species (*Quercus prinus* L., *Q. rubra* L. and *Q. velutina* Lam., in particular) typically increased (Korstian and Stickel 1927).

These changes occurred over a very short time span on millions of acres in the Southern Appalachian Mountains. State-federal cooperative fire control programs, public land acquisition to form national forests and parks, and lower rates of harvest compared to previous levels resulted in oak forests which have aged relatively free of disturbance for 70 to 90 years. These forests are contrasted with those found around the time of European settlement in Table 1. Current characteristics make them vulnerable to a stress-mediated disease known as oak decline, which is affecting landscapes throughout the Southern Appalachians. The disease is both an indicator of and a contributor to compromised ecosystem health.

Table 1. Comparison of Southern Appalachian forest composition: structure, disturbance characteristics, and values perspective; pre-1900 vs. current.

PRE-1900	CURRENT
Composition American Chestnut	Composition Oak
Relatively Young and More Complex Age Structure	Cohorts 80-100 Years Old
Sparse Understory	Dense Understory
Widely Spaced, Large Diameter Overstory	Dense, Small Diameter Overstory
High Disturbance (Fire, Farming, Logging)	Low Disturbance (Fire Suppression)
Small, Dispersed Human Population	Large, Urbanized Human Population
Forest Utilization Perspective	Ecosystem Protection Perspective

Chestnut blight stem infection: Previous land use practices and the death of millions of American chestnuts during the chestnut blight epidemic opened the forest canopy to oaks and other species positioned to exploit newly available growing space.

Oak Decline Biology, Incidence, and Effects

Oak decline is a disease ofcomplex etiology affecting physiologically mature trees. It involves interactions between long-term predisposing factors, such as climate, soil characteristics, landform, advanced physiologic age, or tree species composition; short term inciting stress such as that caused by drought or spring insect defoliation; and contributing organisms of secondary action such as armillaria root disease (caused by *Armillaria mellea* [Vahl. Ex Fr.] and perhaps other *Armillaria* spp.), and the two-lined chestnut borer (*Agrilus bilineatus Weber*). The temporal sequence of these three groups of factors is important in the ultimate expression of oak decline.

Predisposing factors such as climate and site productivity determine the onset of physiologic maturity in oak (Hyink and Zedaker 1987). Inciting stress factors such as extended drought or spring defoliation by insects or late spring frost alter carbohydrate chemistry in the roots of physiologically mature trees. This change stimulates *A. mellea*, a ubiquitous saprophyte in oak forests, to become an aggressive pathogen. The tree's root system is reduced by root disease, which further compromises the water relations of the still-robust crown (Wargo 1974). Twigs and branches in the upper crown die back progressively over a period of years in an effort to accommodate the impaired root system. The two-lined chestnut borer is attracted to stressed oaks and, together with root disease, kills them (Wargo 1977). Most oaks killed by decline exhibit dieback evidence that can be dated back 2 to 5 years. Analysis of radial growth increment has revealed differences between neighboring healthy and decline-killed oaks of the same species and age class that date back decades earlier (Tainter and others 1990).

The pattern of oak decline on the landscape varies with initial stand species composition, stand age structure, decline severity, mortality incidence, and the duration of decline before inciting stress is eased. Patches ofmortality can range from a few trees in stands with diverse species composition and age structure, to several hundred acres on landscapes with a more uniform composition of physiologically mature red oaks defoliated repeatedly by the non-native gypsy moth (*Lymantria dispar* (L.)).

Widespread oak decline incidence during the mid 1980's in the southeastern U.S. reflects the coincidence of physiologic maturity of oak cohorts on a regional scale that developed after chestnut blight, fire control, and extended regional drought. Inventories have estimated oak forest types cover about 17.4 million acres in the Southern Appalachian Mountains in parts of six states (SAMAB 1996). About 54 percent of this area was classified as vulnerable to oak decline damage with oak decline incidence estimated on 1.7 million acres. National forests had a disproportionately high oak decline incidence compared with other ownerships (Table 2).

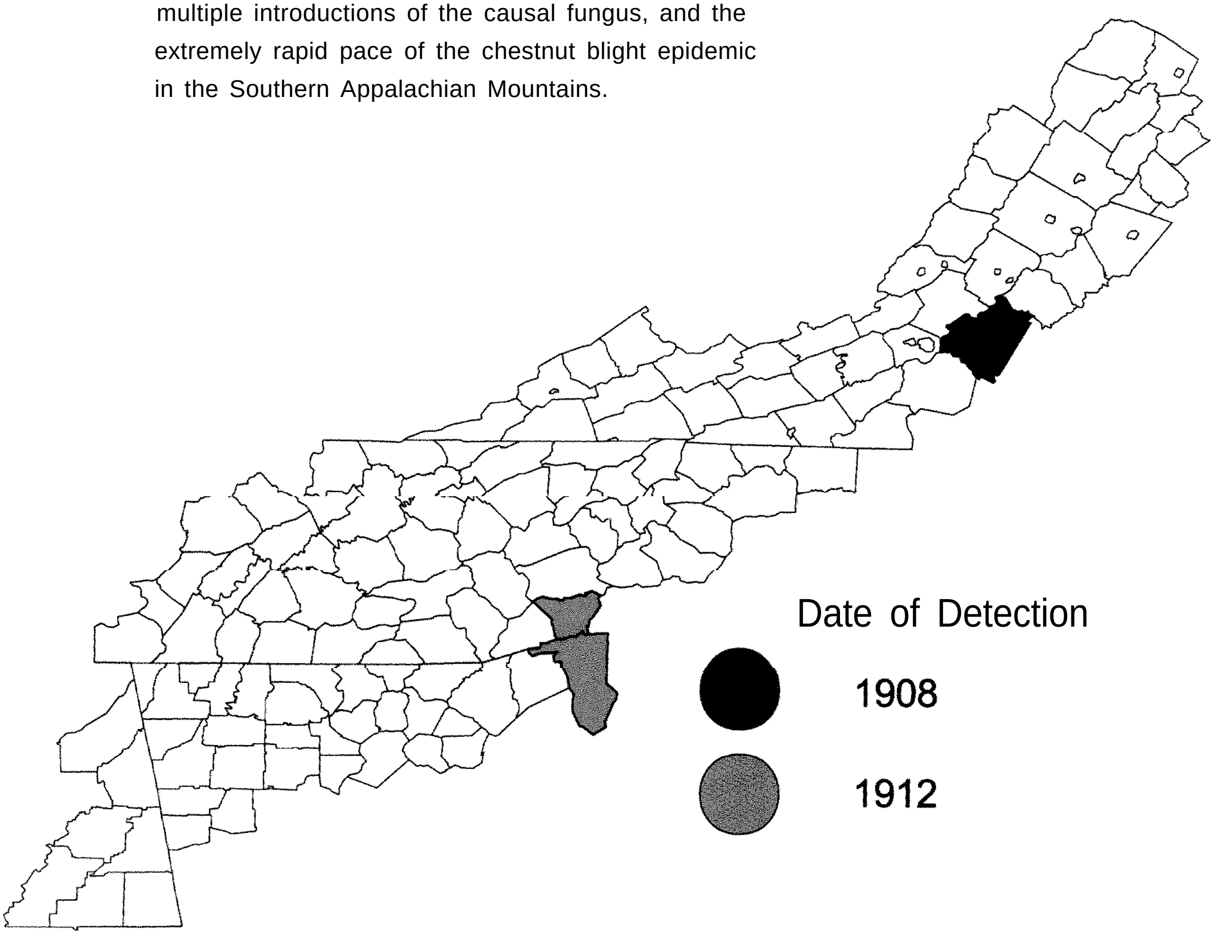
Table 2. Area and incidence of oak decline in the Southern Appalachian Assessment Area, by ownership class (SAMAB 1996).

	Host Type	Vulnerable		Affected		
Owner	Acres	Acres	% Host	Acres	% Vulnerable	% Host
National Forest	3,197,356	2,233,916	70	552,223	25	17
Other Public	419,387	249,986	60	58,453	23	14
Private	13,831,492	7,009,361	51	1,105,133	16	8
Total	17,448,235	9,493,263	54	1,715,809	18	10

Oak and others (1988) interpreted the habitat impacts of oak decline to include both detrimental and beneficial changes, depending on the wildlife species of interest. Structural changes included creation of small to large canopy openings, reduced canopy density, short-term stimulation of understory species, potential increases in cover type diversity, and increased denning and cavity nesting sites. Long-term shifts in tree species composition can occur where competitive oak reproduction is absent or in short supply. The new forest now taking shape has fewer oaks, lower oak diversity, and more shade-tolerant species that are less valued by wildlife. Mast production potential was estimated to be 41% lower than

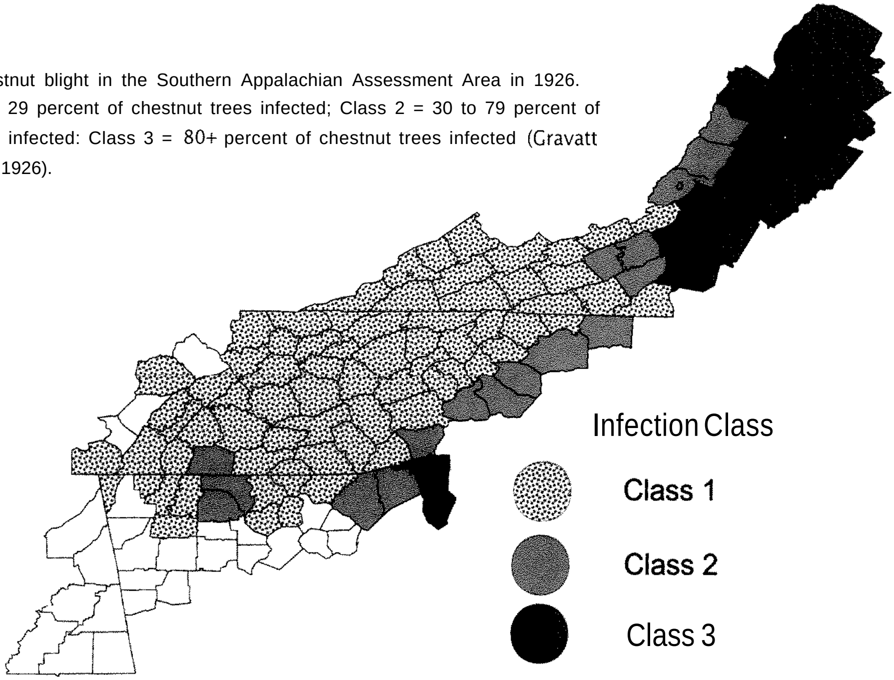
MAPS

This series of maps demonstrates the likelihood of multiple introductions of the causal fungus, and the extremely rapid pace of the chestnut blight epidemic in the Southern Appalachian Mountains.

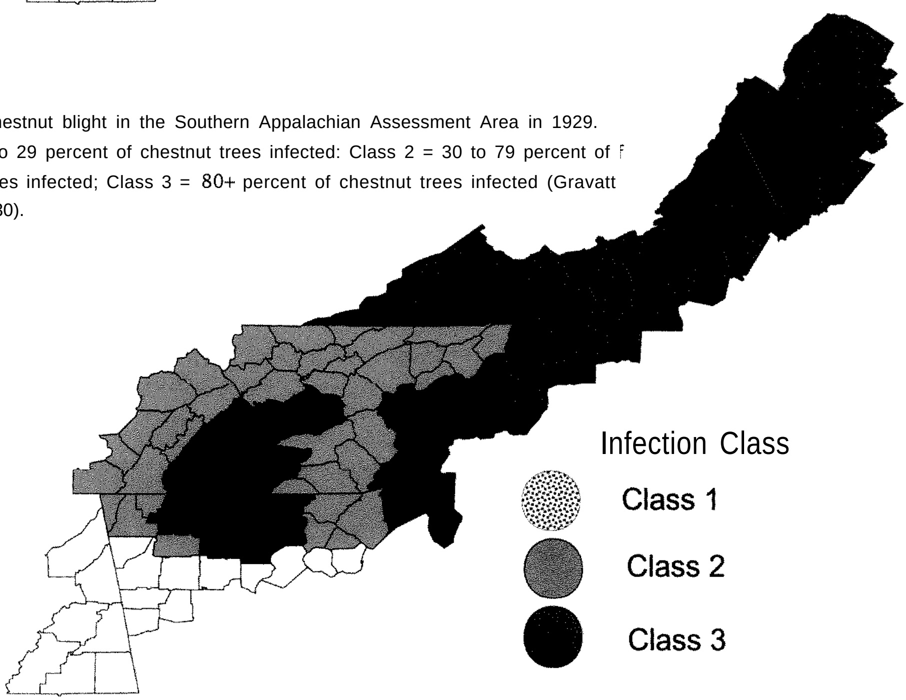


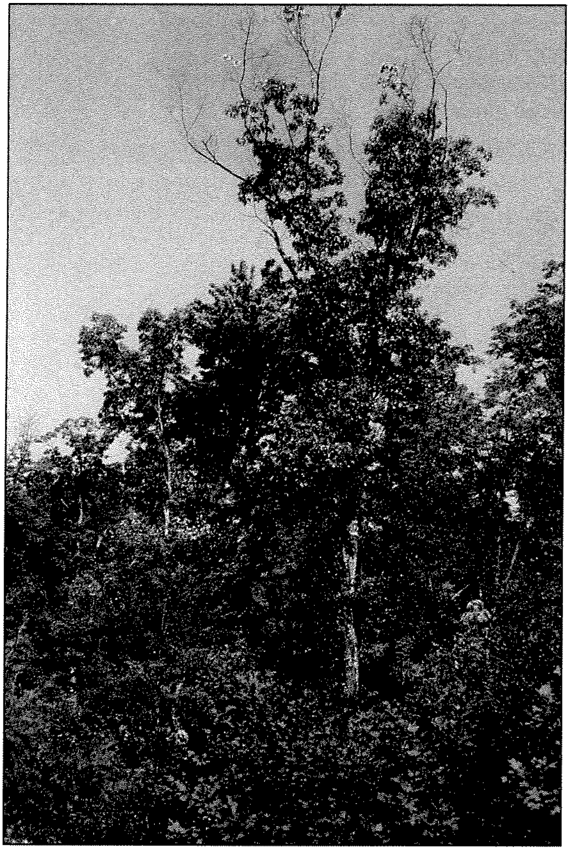
Date of first detection of chestnut blight in the Southern Appalachian Assessment Area. Bedford Co. VA, 1908; Henderson Co., NC and Greenville Co., SC, 1912 (Gravatt 1925).

Status of chestnut blight in the Southern Appalachian Assessment Area in 1926. Class 1 = 1 to 29 percent of chestnut trees infected; Class 2 = 30 to 79 percent of chestnut trees infected: Class 3 = 80+ percent of chestnut trees infected (Gravatt and Marshall 1926).



Status of chestnut blight in the Southern Appalachian Assessment Area in 1929. Class 1 = 1 to 29 percent of chestnut trees infected: Class 2 = 30 to 79 percent of chestnut trees infected; Class 3 = 80+ percent of chestnut trees infected (Gravatt and Gill 1930).



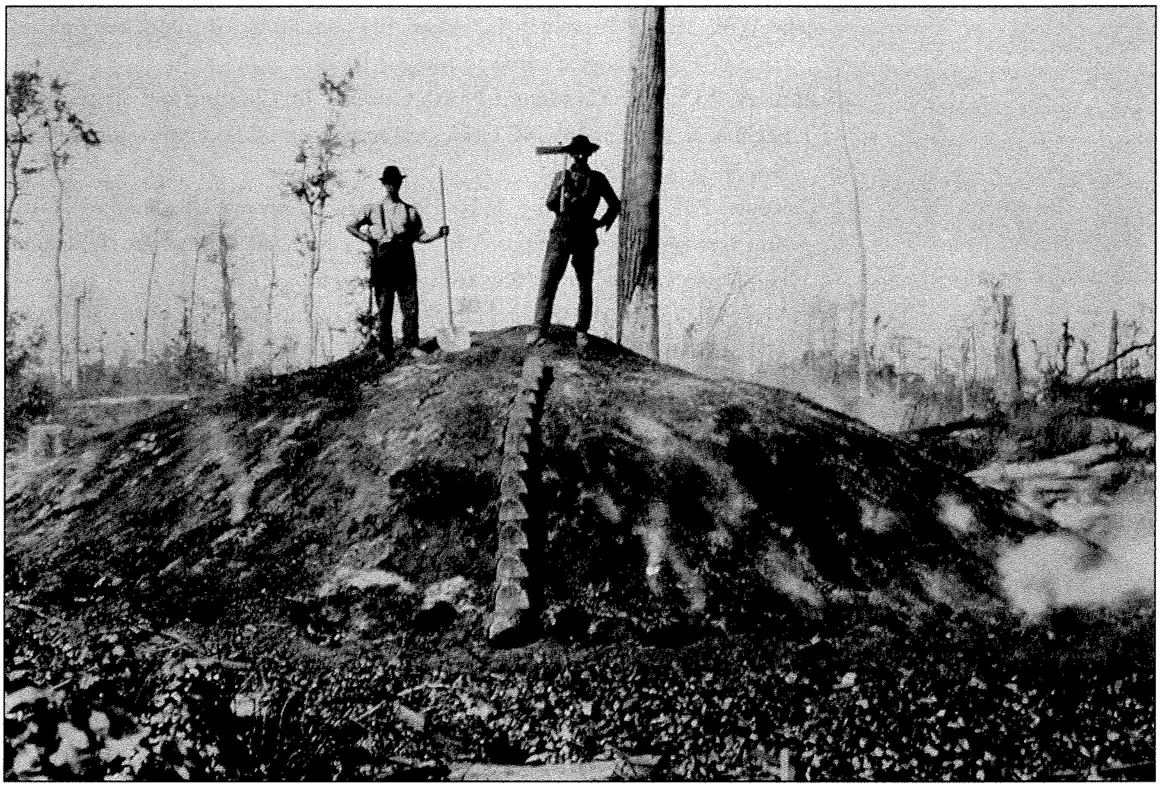


Oak decline is the progressive dieback of the crown of physiologically mature oaks occurring over many years. It often ends in the death of susceptible trees.

if decline were absent, and projected to be 58% lower within 5 years. These projected reductions would persist for a long time because residual oaks are themselves prone to future decline episodes, and competitive oak reproduction for replacement of dead overstory oaks is lacking due to the absence of stand disturbance of the type necessary to recruit oak seedlings into larger size classes. The lack of oak replacement has consequences for wildlife species that depend on acorns for food, especially in view of the fact that chestnuts, once a mainstay, are no longer available.

The elimination of American chestnut as a canopy species has elevated oaks to an unprecedented position as the most dominant tree species group in Southern Appalachian landscapes. To the extent that healthy forest ecosystems have the full array of native biotic resources, and diverse seral stages and stand structures that provide habitat for native species and essential ecosystem processes (Kolb and others 1994), Southern Appalachian forest ecosystems cannot be considered healthy until American chestnut can be re-introduced as a functioning component of that ecosystem. Multiple lines of American chestnut adapted to the broad former geographic range possessing durable resistance to chestnut blight will be needed to achieve that goal.

As daunting as the science of resistance breeding and the management of hypovirulence have been, I believe the social obstacles to reintroduc-



Today's Southern Appalachian upland hardwood forests reflect past land use practices such as frequent fire, farming, and logging as well as the aftermath of the chestnut blight epidemic. The remnant forest in the background of this area logged for charcoal production gave rise to a forest far different than any that has ever existed in terms of composition and structure. (Photo used with permission of the West Virginia Agricultural and Forestry Experiment Station.)

tion will be even more so. Early silvicultural research indicates a chestnut regeneration strategy similar to the oaks. The low disturbance regimes prevailing in hardwood forest management for nearly a century arc inadequate to provide the conditions necessary for successful chestnut establishment arid proliferation. Forest openings will have to be created across the landscape and maintained, which will entail increased harvesting, use of selective herbicides, and perhaps the judicious reintroduction of prescribed fire at some point in stand development. All of these practices arc presently unpopular among the general public, whose support is essential to success.

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