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Recent Successional Changes in a Former Chestnut-Dominated Forest in Southwestern Virginia

ANURAG AGRAWAL* and STEVEN L. STEPHENSON

Department of Biology, University of Pennsylvania, Philadelphia, Pennsylvania 19104;
Department of Biology, Fairmont State College, Fairmont, West Virginia 26554

ABSTRACT

A former chestnut-dominated forest community on the NW-facing slope of Bald Knob on Salt Pond Mountain in southwestern Virginia has been studied previously in 1932 and 1982/83. In the present study, short-term changes in the composition of the tree (stems ≥10 cm DBH) and small tree (stems ≥2.5 cm but <10 cm DBH) strata since 1983 were assessed and growth-trend patterns in red oak (*Quercus rubra* L.) following the elimination of chestnut from the canopy by chestnut blight (*Cryphonectria parasitica* [Murr.] Barr) were examined. During the past decade, the composition of the canopy has changed very little relative to the dramatic changes of the previous 50 years. Analysis of basal area increment growth patterns of 26 red oaks at least 79 years old clearly shows a dramatic release that began in the mid-1920s.

INTRODUCTION

American chestnut (*Castanea dentata* [March.] Borkh.) was a codominant species in the upland forests of much of eastern North America prior to the introduction of the chestnut blight fungus (*Cryphonectria parasitica* [Murr.] Barr). First discovered in New York in 1904 (Merkle 1906), the chestnut blight had reached southwestern Virginia by the mid-1920s. Gravatt and Marshall (1926) reported that 80–100% of American chestnut trees in Giles County, Virginia, were infected by the blight in March 1926.

In 1932, Braun (1950) surveyed a chestnut-dominated forest on the NW-facing slope of Salt Pond Mountain in Giles County. Two areas on the slope were surveyed, one above the other. In the first area, chestnut made up 84.6% of the canopy, with northern red oak (*Quercus rubra* L.) (11.1%), white oak (*Q. alba* L.) (2.6%), red maple (*Acer rubrum* L.) (0.8%), and cucumber magnolia (*Magnolia acuminata* L.) (0.8%) also present. In the second area, chestnut (56%) was somewhat less abundant, and red oak (22%) and white oak (22%) were relatively more important as canopy species.

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* Present address: Population Biology Graduate Group, University of California at Davis, Davis, California 95616.

During the summers of 1982 and 1983, Stephenson (1986) resampled the vegetation on the same slope to determine the extent and nature of compositional changes. He reported that after 50 years of succession red oak, which made up 60.0% of all stems ≥10 cm DBH, was clearly the dominant species, and chestnut had disappeared completely from the canopy. Several species, including sugar maple (*Acer saccharum* Marshall), serviceberry (*Amelanchier arborea* [Michaux f.] Fernald), black birch (*Betula lenta* L.), black cherry (*Prunus serotina* Ehrhart), and black locust (*Robinia pseudo-acacia* L.), not recorded as canopy species in the original study, were present in the canopy.

Stephenson also reported that the mean age of 10 red oaks in the 30–39 cm size class was 51 years and suggested that trees in this size class had advanced into the canopy following the death of chestnut. However, the effect of chestnut disappearance from the canopy on preexisting codominant trees was not investigated.

The objectives of the present study were (1) to assess recent (since 1983) successional changes in a former chestnut-dominated forest community 60 years after chestnut blight and (2) to examine, using tree-ring analysis, the growth-trend patterns in individual trees that predated the blight.

STUDY AREA

The forest community investigated is in Giles County in southwestern Virginia, which is within the Ridge and Valley physiographic province of the southern Appalachian Mountains (Fenneman 1938). The study area (elevation 1,200 to 1,275 m) is adjacent to the south end of Mountain Lake (37°22′N, 80°37′W) on the NW-facing slope of Bald Knob, which forms the highest point (1,330 m) on the crest of Salt Pond Mountain. Braun (1950) included the Salt Pond Mountain area within the Ridge and Valley section of the oak-chestnut region. Major species of trees present in the region are various species of oak, with chestnut oak (*Quercus prinus* L.) and northern red oak the most important. A more complete description of the general study area is provided by Stephenson (1982, 1986).

METHODS

In the 1982/83 study, quantitative data on the tree stratum were collected from five 20 by 50 m (0.1-ha) quadrats. The specific locations of the two areas surveyed by Braun could not be determined, as her method involved "counts . . . made along an ascending band or strip" (E. L. Braun, pers. comm. to S. L. Stephenson in June 1969). However, the portion of the slope sampled encompassed the same general area that Braun had surveyed. The 0.1-ha quadrats sampled in 1982 and 1983 were relocated (as nearly as possible) and resampled in June 1993. Stems were recorded by species and DBH (diameter at breast height) in two size classes: stems ≥2.5 but <10 cm DBH (representing the small tree stratum) and stems ≥10 cm DBH (representing the tree stratum). Nomenclature follows Radford et al. (1968).

In addition, increment growth cores were collected from 10 dominant or codominant trees in and around each of the five quadrats. These were extracted (at a height of ca. 1.4 m) using a standard increment borer. Many attempts to obtain cores from the very largest white oaks and red oaks were unsuccessful because of heart rot, but 50 cores (one from each tree) ultimately were accu-

Table 1. Composition of the tree stratum based on data obtained in 1932 (Braun 1950), 1982/1983 (Stephenson 1986), and 1993. Values are absolute number (N) and relative density (RD) of sampled trees (stems ≥ 10 cm DBH for the 1982/83 and 1993 data sets)

	1932		1982/83		1993	
Species	**N**	**RD**	**N**	**RD**	**N**	**RD**
Castanea dentata	127	76.0				
Quercus rubra	24	14.4	126	57.0	111	54.7
Quercus alba	14	8.4	3	1.4	5	2.5
Acer rubrum	1	0.6	25	11.3	26	12.8
Magnolia acuminata	1	0.6	1	0.5	7	3.4
Betula lenta			12	5.4	12	5.9
Hamamelis virginiana			12	5.4	8	3.9
Acer saccharum			10	4.5	6	3.0
Amelanchier arborea			10	4.5	13	6.4
Acer pensylvanicum			7	3.2	5	2.5
Prunus serotina			4	1.8	2	1.0
Betula lutea			3	1.4	2	1.0
Ilex ambigua			3	1.4	3	1.5
Acer spicatum			2	0.9		
Robinia pseudo-acacia			2	0.9		
Carya ovata			1	0.5		
Oxydendrum arboreum					1	0.5
Rhus glabra					1	0.5
Tsuga canadensis					1	0.5
Total	167	100.0	221	100.0	203	100.0

mulated. This total included 34 red oaks, five red maples, four white oaks, and individual trees representing seven other species. In the laboratory, cores were dried, mounted on grooved boards, and sanded as described by Phipps (1985) and Schweingruber (1989). Ages were estimated by counting rings under a dissecting microscope.

Cores from trees that predated the blight were subjected to further study. Ring widths were measured to the nearest 0.01 mm with digital calipers. Missing and false rings are rare in ring-porous species such as red oak (Phipps 1985) and were not a problem in the set of cores examined in the present study. Ring width measurements were converted into basal area increment (BAI) values using AREA software (Phipps 1989). After cross-dating of cores was checked by overlaying graphs showing BAI trends for individual cores, BAI data for all cores from trees that predated the blight were combined to produce a mean BAI series for the site. To further check on the simultaneity of response among the red oaks, the BAI series for each individual core was examined for episodes of suppression and release. A release was defined as a period of five successive years of increasing BAI and a suppression as a period of five successive years of decreasing BAI (Canham 1985). The percentage of trees undergoing a release or suppression was calculated for each year.

Table 2. Composition of the small tree stratum (stems <10 cm but ≥2.5 cm DBH) based on data obtained in 1982/83 (Stephenson 1986) and 1993. Values are absolute number (N) and relative density (RD)

	1982/83		1993	
Species	**N**	**RD**	**N**	**RD**
Hamamelis virginiana	186	42.5	351	58.3
Ilex ambigua	127	29.0	106	17.6
Acer pensylvanicum	34	7.8	58	9.6
Acer saccharum	30	6.8	42	7.0
Acer rubrum	16	3.7	5	0.8
Amelanchier arborea	10	2.3	9	1.5
Castanea dentata	8	1.8	8	1.3
Betula lenta	6	1.4	8	1.3
Acer spicatum	5	1.1		
Betula lutea	5	1.1	6	1.0
Magnolia acuminata	4	0.9	3	0.5
Fraxinus americana	2	0.5		
Quercus alba	2	0.5		
Aesculus octandra	1	0.2		
Prunus serotina	1	0.2		
Quercus rubra	1	0.2	1	0.2
Oxydendrum arborea			4	0.7
Rhus glabra			1	0.2
Total	483	100.0	602	100.0

RESULTS AND DISCUSSION

Based on values of relative density calculated for all species represented in the tree and small tree strata (Tables 1 and 2), relatively little compositional change is evident when the data from the present study are compared with similar data obtained by Stephenson (1986) a decade earlier. In fact, percentage similarity indices (Mueller-Dombois and Ellenberg 1974) for the two data sets are 90.6 (where 100 = complete similarity) for the tree stratum and 81.3 for the small tree stratum. Although sixty years is too short a time for the community to have achieved any kind of compositional equilibrium with respect to what ultimately will be the "new climax" (Stephenson et al. 1993), it is quite apparent that the successional changes taking place are now much less dramatic than those of the half century preceding the 1982/83 study.

In the tree stratum, all species with a relative density ≥1.0 in 1982/83 were represented in the 1993 data set. It should be noted that several dead but still standing individuals of black locust (*Robinia pseudo-acacia* L.), which made up 0.9% of all stems in the tree stratum in 1982/83, were observed during the sampling carried out in 1993, although no living stems of this shade-intolerant pioneer species were tallied. Mountain maple (*Acer spicatum* Lam.) and shagbark hickory (*Carya ovata* [Miller] K. Koch) were the only other species present in 1982/83 but not recorded in 1993. These two species and all three of the species

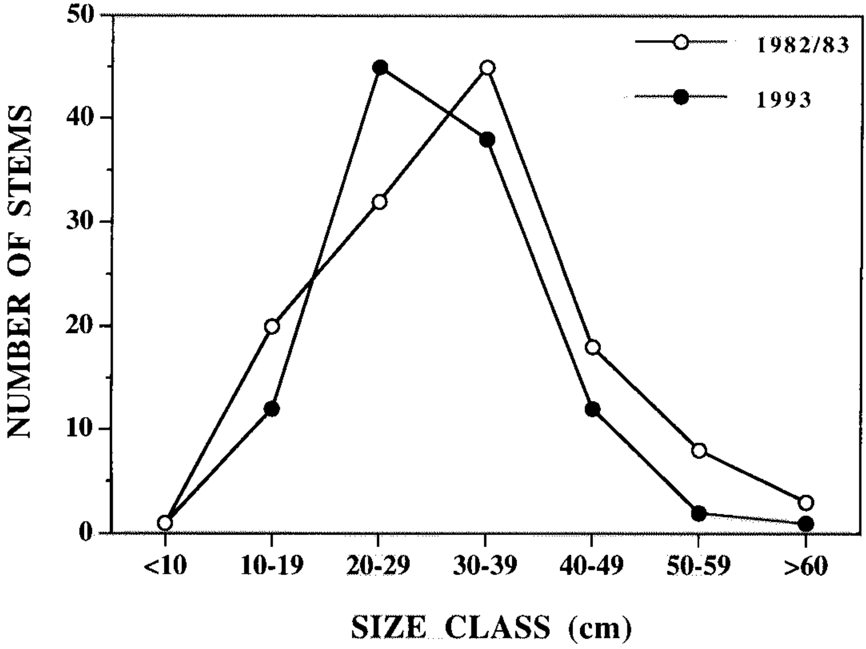

Figure 1. Size class distribution of red oak in 1982/83 (n = 127) and 1993 (n = 112).

not present in 1982/83 but recorded in 1993 are rather minor components of oak-dominated forest communities in the Mountain Lake area (Stephenson 1982). For the small tree stratum, mountain maple was the only species with a relative density ≥1.0 in 1982/83 not recorded in 1993.

The size class distributions of red oak are remarkably similar for the two data sets (Figure 1). However, the overall distribution pattern shows evidence of a shift from smaller to larger size classes over the 10-year period for stems that were in the 10–19 cm and 20–29 cm size classes in 1982/83. For example, the number of stems in the 20–29 cm size class has more than doubled since 1982/83. Such a change would be expected, as the individual trees increased in diameter with increasing age. In contrast, numbers of stems in all size classes >30 cm have decreased. In 1983, the mean age of 10 cored red oak trees in the 30–39 cm size class was 51 years. Stephenson (1986) suggested that the high number of individuals in this size class corresponded to a period of unusually high population recruitment as chestnut disappeared from the canopy 50 years earlier. If individuals in this size class do represent members of a post-blight cohort, the 1993 data indicate that the latter has recently experienced a period of increased mortality.

Both basal area and density of the tree stratum appear to have decreased slightly over the past decade. Mean values for basal area and density were 442 stems/ha and 27.1 m^2/ha in 1982/83, whereas the corresponding values for 1993

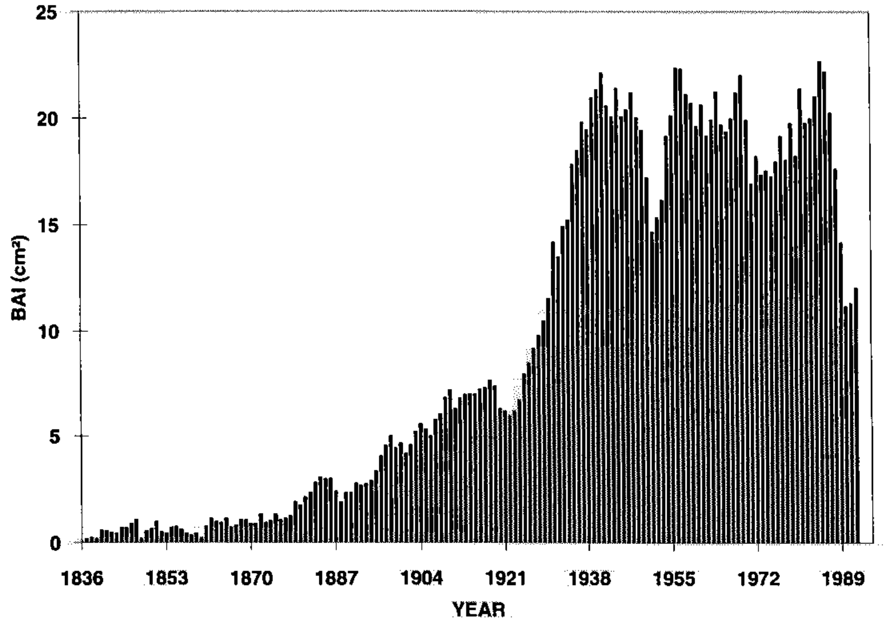

Figure 2. Mean basal area increment (BAI) of 26 red oak cores from trees ≥79 years old.

were 406 stems/ha and 25.0 m²/ha. Density in the small tree stratum has increased from 876 stems/ha to 1,204 stems/ha during the same period of time. Virtually all of this increase in density can be attributed to increases in just two species. The density of witch hazel (*Hamamelis virginiana* L.) increased from 372 to 702 stems/ha, and that of striped maple (*Acer pensylvanicum* L.) increased from 68 to 116 stems/ha.

Twenty-six of the 34 red oak trees from which cores were obtained were at least 79 years old. These 26 trees ranged in age from 79 to 157 years, with a mean age of 103 years. The mean age of the remaining eight trees was 60 years. Because pith was not reached in all cored trees and stem growth to cored height occurred over an undetermined period of time, all ages are conservative estimates.

The growth-trend pattern for the 26 red oaks ≥79 years old, based on mean two dimensional wood growth per ring per year, is shown in Figure 2. A clear and sustained increase in BAI can be seen during the mid-1920s. In addition, two other episodes of increasing ring widths occurred in the early 1950s and in the mid-1970s. Twenty-one of the 26 (81%) red oak cores showed a release between 1924 and 1927, three (12%) cores showed a release in 1951/52, and one (4%) in 1975. This suggests that the mid-1920s release was widespread, whereas the subsequent increases in BAI were more local, possibly representing the response of an individual tree to a large canopy gap.

In summary, based on the evidence presented herein, it seems apparent that there was a major, community-wide release in the 1920s, which followed a brief period of suppressed growth in the early 1920s. Presumably, the disappearance of chestnut from the canopy provided the codominant red oaks with unusually favorable conditions for growth. Analysis of the resulting growth-trend pattern indicates that the maximum ecological impact of the chestnut blight at this site occurred between 1924 and 1927.

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