The 1936 Long Branch Plots at Bent Creek: The First Statistically Designed Study of the Appalachian Forest Experiment Station

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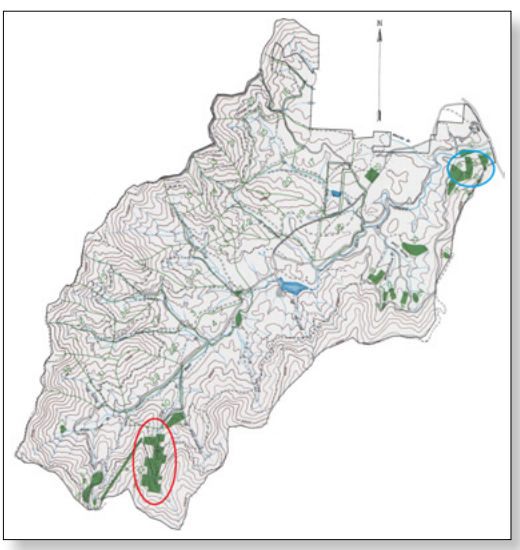
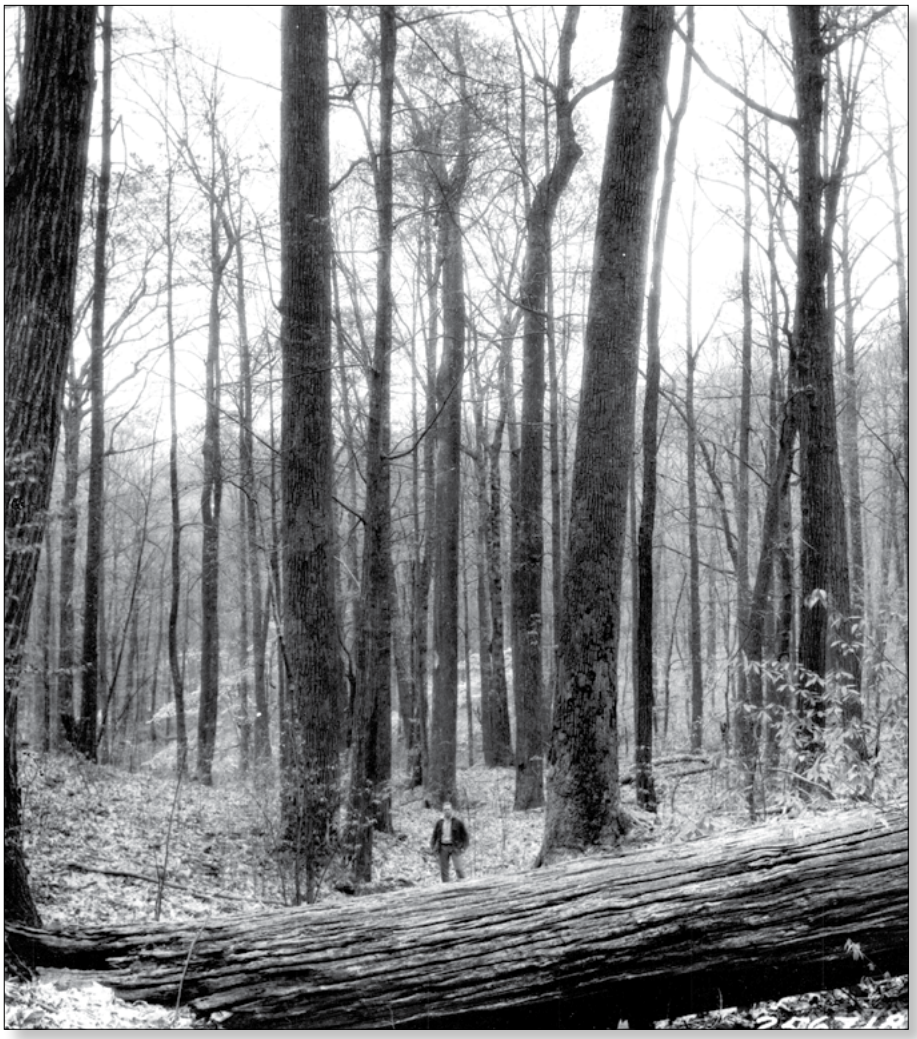
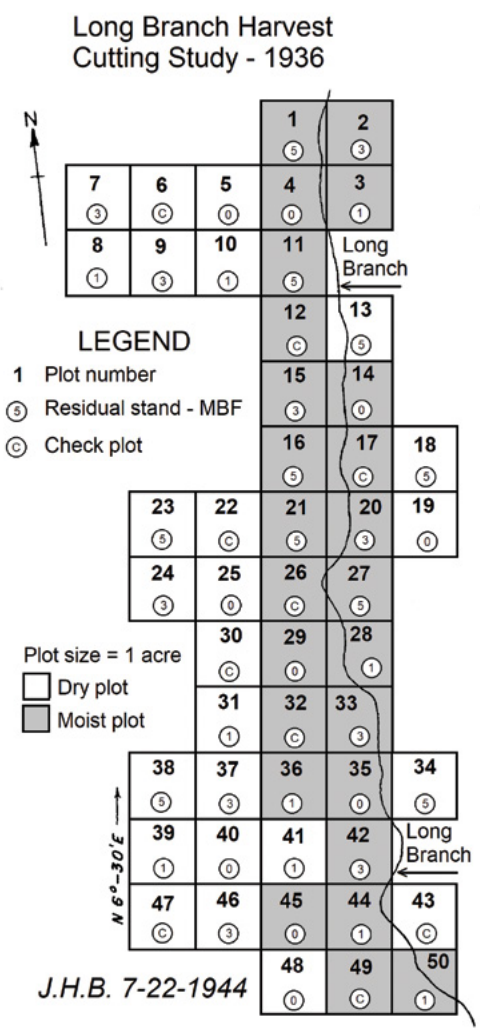
The first "designed" study conducted by the Appalachian Forest Experiment Station (AFES) marked a change from an observational to a science-based approach in the Station's research field methods. Before the 1930s, American forest researchers generally applied silvicultural treatments across large areas and compared results using anecdotal observations. The large study areas, however, usually included unrecognized site (e.g., soil differences) or stand conditions (e.g., age differences), which could influence treatment results. During this period, field methods using replicated small plots for agricultural studies had been developed in England (Fisher 1925, 1935) and were strongly recommended for improving the quality of U.S. Department of Agriculture Forest Service research (Gevorkiantz 1935, Kittredge 1924). The Long Branch study was established in 1936 on the Bent Creek Experimental Forest (BCEF) by Leonard I. Barrett, a forester with a master's degree from the University of Michigan, who likely had knowledge of Fisher's study design methods.

The reason for Barrett's Long Branch study originated 20 years earlier. In 1915, Earl Frothingham, forest examiner for the Forest Service, travelled throughout the Southern Appalachian Mountains conducting a study of cut over areas with the objective of evaluating stands for "… immediate silvicultural management" consisting of two options: either manage the present stand as potentially profitable or remove all remaining mature trees to release the existing seedlings and saplings to form a new stand (Frothingham 1917). When Frothingham was named the first director of the AFES in 1921, he outlined an initial plan of research emphasizing the restoration of degraded stands and prudent timber harvesting that maintained productivity (Asheville Citizen 1921). Two years later, he developed a working plan (Frothingham 1923) that provided a template for a series of long-term studies conducted by AFES. This working plan outlined silvicultural methods for the management of Appalachian forests and looked to determine both the growth and economic value of the residual unharvested stand of timber and the amount and composition of tree seedling reproduction. In 1930, Jesse Buell installed the first study of harvesting methods under Frothingham's working plan using the traditional approach of large, unreplicated, treated areas (Buell 1930). In a publication reporting 20-year results from this study, Wahlenberg (1953: 874) commented the treatments are "… without the design needed for statistical analysis."

Field location of Buell's 1930 unreplicated harvest study (blue circle) and Barrett's 1936 replicated harvest study (red oval) in Bent Creek Experimental Forest.







Left: This photograph was included with other records related to Barrett's Long Branch study in the Bent Creek Experimental Forest; however, the location where it was taken is unknown. The stand structure is likely representative of a portion of the old-growth stand of poorly formed sawtimber present on the study site. See footnote 1 for more information on the timber stand at the study site before the harvest treatment.

Right: Long Branch study site showing field layout of fifty, 1-acre treatment plots and visual assignment of half of the plots as either mesic or dry based on perceived soil moisture regimes. (Map based on original by J.H. Buell, July 22, 1944.)

Barrett's Long Branch study was the second harvesting study in the BCEF and used a design that permitted statistical analysis. Barrett's treatments were installed along both sides of Long Branch, a relatively high-elevation (3,000 feet) tributary stream of Bent Creek (Barrett 1936). Except for the loss of canopy American chestnuts (*Castanea dentata*) killed in the 1920s by the introduced parasitic fungus (*Cryphonectria parasitica*) and then later salvaged, this timber stand was described as "… virgin when the first silvicultural treatments were planned in 1936" (Wahlenberg 1954: 1).[1] Particularly important, the inventory records for the installation of the study include composition and diameter of trees before harvest. Wahlenberg (1954) stated,

> *Mixed with the oaks were some yellow-poplars 3 or 4 feet in d.b.h and more chestnut trees, some of them even larger. The chestnuts were nearly all infected and half of them dead from blight by 1930 and were removed for acid wood. Except for this salvage cutting the tract was virgin when the first silvicultural treatments were planned in 1936.*

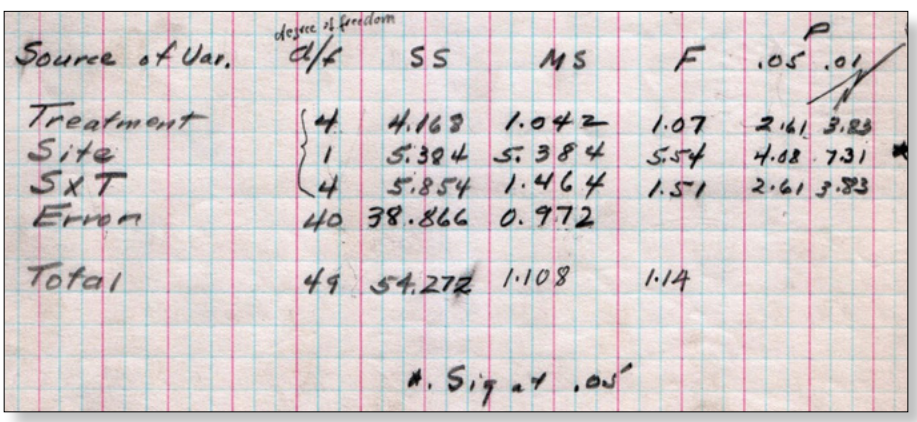
[1] Research for this article revealed that the Long Branch cove was a previously unreported and largely undisturbed old-growth stand in BCEF.

A total inventory of all trees > 4.6 inches in diameter at breast height (d.b.h.) was made on the 50-acre tract during the summer, which included the diameter of all chestnut stumps. The early history of the Long Branch property during the 1800s was described by Nesbitt (1941). Objectives of the study were to examine the effects of varying levels of harvest on growth and epicormic sprouting of the remaining uncut trees.

Unlike Buell's study, where each treatment was applied only once across a large area, Barrett's study was based on a statistical design of randomly assigned treatments and untreated controls replicated on many small plots. He tested 5 harvesting treatments replicated 10 times, resulting in fifty, 1-acre plots. Because the sample plots paralleled Long Branch, the study design recognized two classes of site quality as a natural source of variation that could influence tree growth of the harvest treatments: (1) moist sites near the stream, and (2) dry sites farther away. The harvest treatments compared the effects of five levels of merchantable tree volume (measured in board feet [BF]) remaining on each treatment plot: 0 BF; 1,000 BF; 3,000 BF; 5,000 BF; and control (no harvest). Trees smaller than 9.6 inches d.b.h. were not harvested. Because the 0 BF treatment did not harvest trees smaller than 9.6 inches d.b.h. (the minimum size for sawtimber at that time), for practical purposes, it could be described as a commercial clearcut. That type of harvest followed the first objective of Frothingham's 1923 work plan because smaller trees remained that would soon grow to sawtimber size. For comparison with a silvicultural clearcut (where all trees 1 inch and larger are cut) see the 1930 photograph taken by Margaret Stoughton of Buell's study (McNab and O'Shields 2023).

The first inventory of treatment results was made in January 1945, after 7 years of growth by the residual trees. Because Barrett had been appointed director of the Central States Forest Experiment Station in 1942 (U.S. Department of Agriculture 1942), Ernst V. Brender, a junior forester at the AFES, performed the first analysis of variance of data from a designed study (Brender 1946). His analysis indicated no differences in mean annual basal area growth among the five treatments, which ranged from 2.09 to 2.95 square feet per acre.

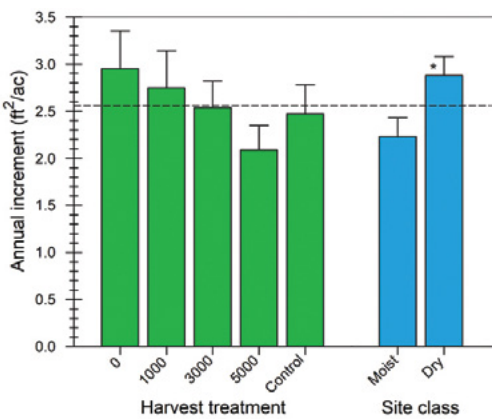
However, moisture class significantly affected mean annual basal area growth, which was greater on dry sites (2.88 square feet per acre) compared to moist sites (2.23 square feet per acre). Although Barrett's study design was appropriate in that it provided for testing the effect of site quality on tree growth, the finding of better growth on dry sites was probably contrary to expectations. Brender (1945)



Source of Var.	d/f (degree of freedom)	SS	MS	F	P .05	P .01
Treatment	4	4.168	1.042	1.07	2.61	3.83
Site	1	5.384	5.384	5.54	4.08	7.31 *
S x T	4	5.854	1.464	1.51	2.61	3.83
Error	40	38.866	0.972			
Total	49	54.272	1.108	1.14		

*. Sig at .05

Left: The original analysis of variance made by Junior Forester E.V. Brender, on January 14, 1946, using preliminary data from the first replicated study of the Appalachian Forest Experiment Station in the Long Branch drainage of Bent Creek Experimental Forest (Brender 1946). Barrett's study design tested the effects on stand growth resulting from two primary sources of variation: (1) density after the harvest treatment, and (2) site soil moisture regime; and a secondary source of variation from the interaction of harvest treatment and site. The asterisk opposite site indicates it was the only significant source of variation affecting annual growth of the residual stand. The trimmed note in the upper right corner references the *F* values of the Treatment, Site, and S x T variables required for their significance at the *P* = 0.05 and *P* = 0.01 levels and states "Obtained from tables."



Right: Mean annual basal area increment in relation to residual sawtimber volume resulting from a preliminary analysis 7 years after treatments were installed on the Long Branch study plots. The overall mean annual basal area increment across all treatments was 2.56 square feet per acre (horizontal dashed line). The mean annual basal area increment was significantly greater (*P* = 0.05, asterisk) on dry sites (2.9 square feet per acre) than on moist sites (2.2 square feet per acre). The basal area increment did not differ among the residual stand board foot volume harvest treatments. Error bars are one of the standard error from the mean.

commented (without explanation) that consideration could be given to changing the moisture classification of eight plots. Response variables of tree reproduction, volume increment, and epicormic sprouting were not analyzed until the study ended in 1952, 15 years after establishment.

Results from the Long Branch study were reported in two publications. Seven years after harvesting the Long Branch plots, Jemison and Schumacher (1948) used regression analysis to evaluate epicormic branching, which did not differ by harvest treatments, but was affected by tree species, site moisture class, and log position in the tree. Fifteen years after the harvest treatments, Wahlenberg (1956) focused on evaluation of treatments associated with sawtimber volume and value, which did not differ among harvest treatments or moisture classes. Although a hypothesis of growth response associated with moisture differences was never stated, study results for basal area increment were not provided; perhaps because they were the reverse of what was expected. New knowledge from this study included the influence of light on survival and growth of seedlings of shade-intolerant species, slow height growth of oak (*Quercus* spp.) seedlings, importance of advance reproduction, and destructive effects of browsing by white-tailed deer (*Odocoileus virginianus*) on seedlings of some species, particularly yellow-poplar (*Liriodendron tulipifera*).

“Although the Long Branch study ended after 20 years, the knowledge learned revealed the complex interactions of growth response between tree species and site quality and demonstrated the need for future well-designed silviculture studies in the Southern Appalachian Mountains.

CONCLUSIONS

In summary, Barrett’s study revealed no silvicultural treatment differences associated with harvesting that were important for forest management. However, it was pioneering from a scientific perspective to provide a method for separating differences of treatment responses among biological and environmental sources of variation. Although the Long Branch study ended after 20 years, the knowledge learned revealed the complex interactions of growth response between tree species and site quality, and demonstrated the need for future well-designed silviculture studies in the Southern Appalachian Mountains. The findings from Barrett’s study provided hypotheses for testing in a follow-up study on the Long Branch plots. The entire 50-acre study area was harvested in 1963 to evaluate the effects of silvicultural clearcutting and site quality on stand composition and development (McGee 1963).

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