BULLETIN OF THE TORREY BOTANICAL CLUB

VOL. 88, No. 3, pp. 176–187 MAY, 1961

TORREYA

Drought Effect on Radial Growth of Trees in the William L. Hutcheson Memorial Forest

MURRAY F. BUELL, HELEN F. BUELL, JOHN A. SMALL, and CARL D. MONK

Radial changes in tree trunks based on dendrometer measurements have been given considerable attention. However, the studies have taken various approaches and have employed a variety of methods. Considerable interest has centered around growth rates, annual increments, dates of growth inception and cessation, and attempts to relate these to temperature, moisture and sometimes photoperiod and phenological data. In some cases work has been limited either to intensive study of one species in one habitat or to comparisons of one species occurring in various habitats (Friesner 1941, Friesner and Walden 1946, Byram and Doolittle 1950, Daubenmire 1950, Fritts 1956 and 1958). Other studies involved a number of species, usually showing up a variety of responses of the different species in the same environment or contrasting responses in different environments (Ahlgren 1957, Cantlon 1953, Daubenmire 1946, Daubenmire and Deters, 1947, Eggler 1955, Fowells 1941, Friesner 1942, Jackson 1952, Reimer 1959). Radial growth studies have been used in forestry research where radial changes have been related to forest thinning and pruning experiments (Brown, Rose, and Spurr 1947, Stevens and Spurr 1947). Some of the radial stem changes observed in studies with the dendrometer have been somewhat clarified through the use of concurrent histological studies (Fraser 1952 and 1956, Monk 1959a) which have shown that, in the early spring, initial enlargement is the result of swelling of tissues, followed later by cambial activity. These and other studies of radial growth using dendrometers have been undertaken as specific problems of stem growth.

In 1950 dendrometer measurements were initiated not in an effort to solve any specific problems but as one of a number of types of observations on growth and periodicity in the oak forest of central New Jersey. These measurements have served to document growth phenomena of a variety of broadleaf tree species characteristic of this area. One of the most striking results of the study so far is the influence of the severe summer drought of 1957 on the radial changes of the species involved. The presentation of that phenomenon is the objective of this paper.

The trees used in the study were all located in the William L. Hutcheson Memorial Forest which is on the Piedmont Plain of central New Jersey. The topography is gently rolling. In part it is well-drained and in part the drainage is poor, having a pattern that is especially well shown by the shrub distribution (Monk 1957). The soil, derived primarily from the Triassic red shale of the Brunswick formation is comparatively shallow. The forest consists principally of white, black and red oaks (Buell 1957, Monk 1959b).

Methods. The dial gauge dendrometer as described by Daubenmire (1945) was used. Screws were set at about 4 feet from the ground on the north and the east sides of the trees. Readings were taken at weekly intervals and in the early part of the morning.

Twelve species of trees were being measured in 1957. At last two trees of each species were included and in every case where possible one of the pair occurred on low ground and one on well-drained land. Those included were: *Acer platanoides*, *A. rubrum*, *A. saccharum*, *Carya ovalis*, *Fagus grandifolia*, *Fraxinus americana*, *Quercus alba*, *Q. rubra* (on upland and lowland); *Nyssa sylvatica* (on lowland only); *Prunus avium*, *Q. coccinea*, and *Q. velutina* (on upland only).

Certain of the species reacted to the screws either by developing vertical cracks above and below the screws or by excess cambial growth in their immediate vicinity. Such effects were primarily evident on *Acer platanoides* and *Acer rubrum*. *Prunus avium* produced a gummy exudate at the location of the screws. Regardless of how such responses may effect growth, drought effects on these species were parallel with the effects on other species.

Nomenclature follows that of Grays Manual, 8th ed. (Fernald 1950).

Results. Typical growth curves of the trees show a period of fluctuation during the winter and early spring (fig. 1), followed by a more or less consistent increase in radius

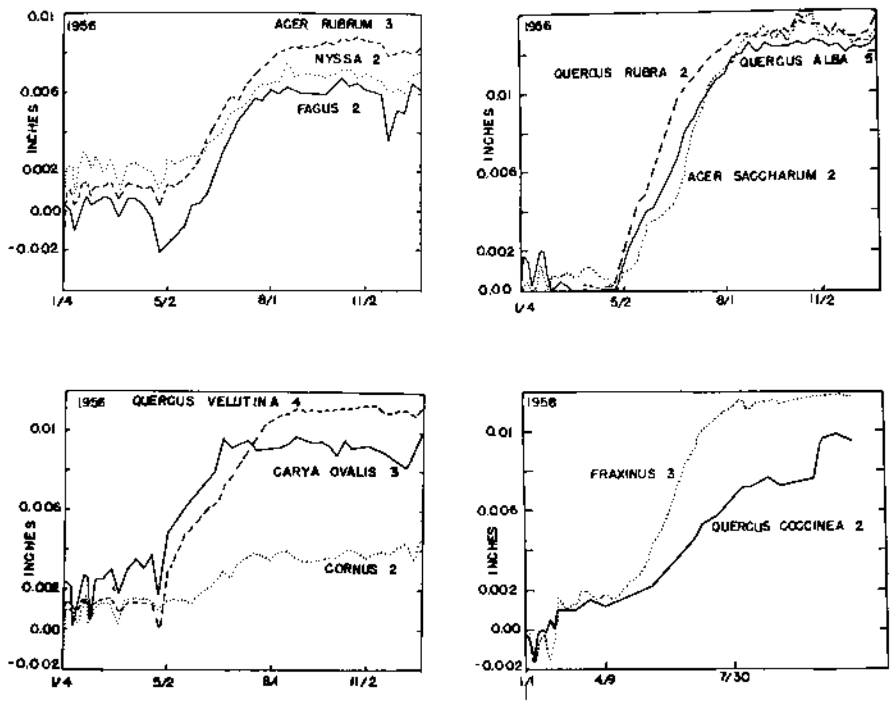

FIG. 1. Growth curves of individual trees of several species during years of normal rainfall. Numbers after species names are individual tree identifications in the growth studies in the forest. Weekly readings are plotted to produce the curves.

until about mid-summer after which there is only a gradual increase until fall, or sometimes no increase. Late summer and fall are marked by moderate radial fluctuations. By late fall the trees are commonly slightly less than the maximum previously attained, a phenomenon noticed by Byram and Doolittle (1950). The winter is a period of fluctuating tree size. The point where consistent radial expansion starts in the spring varies with the species, and the species vary from year to year. Because of the fluctuations of the curves during the winter and spring, it is especially difficult to determine for certain a starting date for annual radial increment. Actually for the purposes of this paper it is not essential to do so. It will appear from inspection of figure 2 that as a result of the drought the contraction of the stem in some species equalled or even exceeded the starting point of growth in the spring as for example *Carya ovalis.*

The summer of 1957 was one of extreme drought for this climate (Table 1). The growth curves for all species in that year are quite different from all other years (fig. 2).

TABLE 1. *Precipitation Records of the Weather Bureau Station at New Brunswick, N. J., 8 Miles East of the Study Area.*

	1950	1951	1952	1953	1954	1955	1956	1957	1958	Mean for the 9 yr. period
January	2.37	3.02	4.81	5.31	1.91	0.71	2.22	2.02	5.46	
February	3.82	4.16	2.18	2.26	1.88	2.52	5.09	2.51	4.10	
March	3.53	4.75	3.82	7.84	3.54	4.86	3.31	2.98	4.53	
April	2.19	3.21	5.84	5.46	3.64	2.45	3.23	5.66	5.97	
May	2.87	4.02	5.87	4.64	3.67	1.84	2.84	0.96	4.09	3.42
June	2.28	3.62	4.65	3.25	1.64	2.63	3.15	2.19	2.99	2.93
July	6.78	4.26	4.90	2.96	1.11	1.43	3.93	1.31	5.86	3.61
Total for May, June, July	11.93	11.90	15.42	10.85	6.42	5.90	9.92	4.46	12.94	9.97
August	4.57	2.98	7.35	2.86	7.74	13.77	4.67	3.66	3.27	
September	1.76	0.87	3.36	1.09	5.66	1.83	3.19	2.32	3.28	
October	1.42	4.99	0.63	3.88	2.83	6.80	3.50	2.03	6.26	
November	5.10	—	3.58	1.98	5.46	2.21	4.33	3.92	2.33	
December	3.42	6.67	2.74	4.24	3.32	0.17	4.12	5.71	1.67	
Annual	40.11	—	49.73	45.77	42.40	41.04	43.58	35.27	49.81	

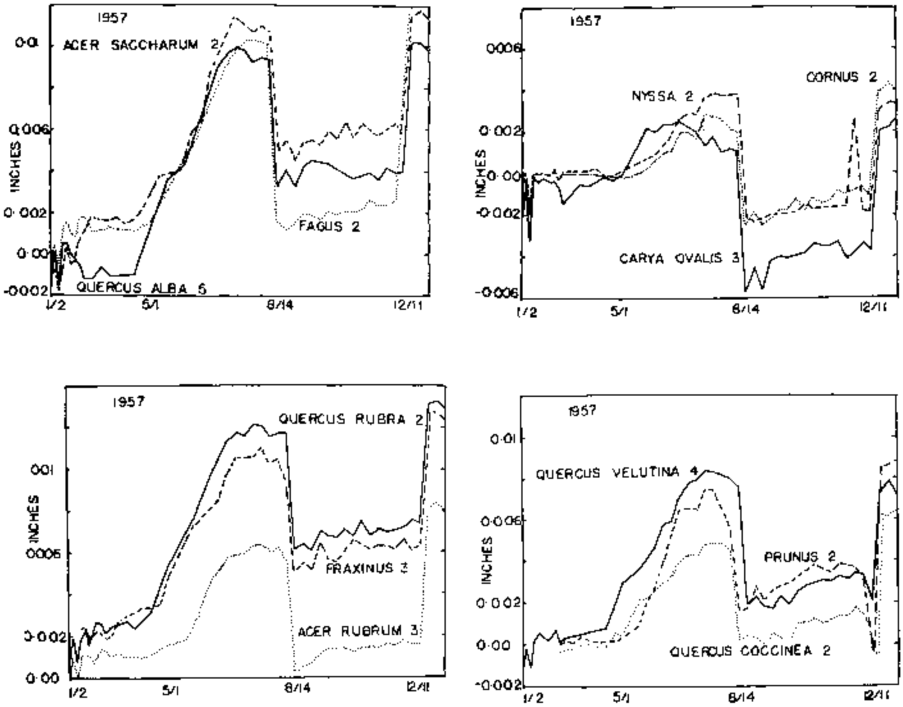

FIG. 2. Growth curves of individual trees during drought year of 1957.

The radial increment in the spring followed the usual course but the growth curves had leveled off and started to decline by mid-July. On August 7 an abrupt radial decrease of astounding magnitude occurred. The readings were taken in early morning as usual, but it takes about an hour to make the readings on all of the trees. Before the hour was up, a strong hot, dry wind began to blow through the tops of the trees. The last few trees to be read showed such a pronounced drop from the reading of the preceding week that one of the trees visited before the breeze came up was reread, and it had decreased since the earlier reading that morning. The growth curves in figure 2 are plotted from data collected by the initial reading on August 7. *Quercus coccinea* 2 and *Prunus* 2 were among the last which were read and hence show the precipitous shrinkage recorded on August 7. It first appears as the August 14 reading in the others plotted in the figure. What is especially interesting is that, following this, weekly readings were consistently low until mid-December. On December 18 the trees had returned to their previous maximum, and most of them to a size even larger than they had been before. The size attained by December 18 was maintained. In the 10 years of record, 1957 is the only year that has shown this phenomenon of pronounced shrinkage.

Discussion—The period of rapid radial expansion in spring and early summer, commonly referred to as the grand period of growth, is of especial concern in this study. It usually extends through most of May, June, and part or all of July. Since late summer moisture conditions are usually favorable for plant growth (Table 1), slowing up of growth at the end of this period may sometimes be related to photoperiod as Eggler (1955) has suggested for trees in Lousiana or to a change in the balance between growth regulators (Phillips and Wareing 1958). It is also likely that a change in water balance can often influence the termination of the grand period of growth. It certainly seems to have been the major contributing factor during the summer of 1957 when the development of an extremely unfavorable water balance resulted first in a cessation of growth, next a slight decrease in radius, and finally an abrupt and pronounced reduction in size. The remarkable recovery of the trees in December of 1957 following the drought is probably related to the complete return of normal moisture relations.

Rutgers—The State University
New Brunswick, New Jersey
and
The University of Flordia
Gainesville, Florida

Literature Cited

Ahlgren, Clifford E. 1957. Phenological observations of nineteen native tree species in northeastern Minnesota. Ecol. **38**:622–628.

Brown, C. T. Jr., R. C. Rose, and S. H. Spurr. 1947. The dial gauge dendrometer as a tool in silvicultural research. Jour. For. **45**:102–104.

Buell, M. F. 1957. The mature oak forest of Mettler's Woods. William L. Hucheson Memorial Forest Bulletin **1**:16–19.

Byram, G. M. and W. T. Doolittle. 1950. A year of growth for a shortleaf pine. Ecol. **31**:27–35.

Cantlon, John E. 1953. Vegetation and microclimates on north and south slopes of Cushetunk Mountain, New Jersey. Ecol. Monog. **23**:241–270.

Daubenmire, R. F. 1945. An improved type of precision dendrometer. Ecol. **26**:97–98.

——— 1946. Radial growth of trees at different altitudes. Bot. Gaz. **107**:462–467.

——— 1950. A comparison of season of cambial growth in different geographic races of *Pinus ponderosa*. Bot. Gaz. **112**:182–188.

——— **and M. E. Deters.** 1947. Comparative studies of growth in deciduous and evergreen trees. Bot. Gaz. **109**:1–12.

Eggler, Willis A. 1955. Radial growth in nine species of trees in southern Louisiana. Ecol. **36**:130–136.

Fernald, M. L. 1950. Gray's Manual of Botany, 8th Ed. Amer. Book Co.

Fowells, H. A. 1941. The period of seasonal growth of ponderosa pine and associated species. Jour. For. 39:601–608.

Fraser, Donald A. 1952. Initiation of cambial activity in some forest trees in Ontario. Ecol. 33:259–273.

——— 1956. Ecological studies of forest trees at Chalk River, Ontario, Canada. II. Ecological conditions and radial increment. Ecol. 37:777–789.

Friesner, R. C. 1941. A preliminary study of growth in the beech, *Fagus grandifolia*, by the dendrographic method. Butler Univ. Bot. Studies 5:85–94.

——— 1942. Dendrometer studies of five species of broad leaf trees in Indiana. Butler Univ. Bot. Studies 5:160–172.

——— **and G. Walden.** 1946. A five-year dendrometer record in two trees of *Pinus strobus*. Butler Univ. Bot. Studies 8:1–23.

Fritts, H. C. 1956. Radial growth of beech and soil moisture in a central Ohio forest during the growing season of 1952. Ohio Jour. Sci. **56**:17–28.

——— 1958. An analysis of radial growth of beech in a central Ohio forest during 1954–1955. Ecol. 39:705–720.

Jackson, L. W. R. 1952. Radial growth of forest trees in the Georgia Piedmont. Ecol. 33:336–341.

Monk, Carl D. 1957. Plant communities of Hutcheson Memorial Forest based on shrub distribution. Bull. Torrey Bot. Club. **84**:198–206.

——— 1959a. Note on radial tree growth. Bull. Torrey Bot. Club. **86**:199–201.

——— 1959b. The vegetation of the William L. Hutcheson Memorial Forest, New Jersey. Ph.D. thesis, Rutgers—The State University.

Phillips, I. D. J. and P. F. Wareing. 1958. Studies in dormancy of sycamore. I. Seasonal changes in the growth-substance content of the shoot. Jour. Exp. Bot. 9:350–364.

Reimer, Charles W. 1949. Growth correlations in five species of deciduous trees. Butler Univ. Bot. Studies 9:43–59.

Stephens, E. P. and S. H. Spurr. 1947. The immediate response of red pine to thinning and pruning. Proc. Soc. Am. Foresters. 353–369.

Drought Response in William L. Hutcheson Memorial Forest, 1957

JOHN A. SMALL

When many trees, of many species, showed brown and dry leaves on some or all of their branches by September 1, 1957 in Hutcheson Forest, it seemed an opportune time to record the effect of droughtiness on individuals, species, and on the forest as a whole.

The forest is controlled by a grid system providing sections of 100 meters on each side. A reconnaisance was made, trees were noted, the d.b.h. and the location of those trees with apparent top injury was recorded, in September-October 1957. In 1958 the reconnaisance was repeated between July 31 and September 5. At this time an estimate of the degree of injury (leafless branches) was attempted. It appeared possible to separate this injury from dead branches of earlier years. The purpose of the second survey was to: 1. determine the possibility of relocating the trees, 2. increase the accuracy of the data since the 1957 survey ran into autumn coloration as a confusing factor, 3. check upon the possibility that the trees might have escaped into early dormancy and survived, at least to some extent, the drought effects, and 4. ascertain, on the other hand, if drought injury had occurred in 1957 which was not expressed or at least not recognized in the appearance of the foliage at the time of that reconnaisance. Some further checking was done in August of 1959. An attempt was made to assemble any pertinent records of the environment of the forest during 1957 and to make pertinent comparisons.

1. All but two of the trees were relocated, out of a total of 188.

2. As was expected, the number of trees injured or killed proved to be greater when checked in 1958 than was recorded in 1957, but the increase was even more than expected. It also appeared that in some instances the injury had not been as serious as it appeared in 1957. Subsequent observation has corroborated this in some cases, but in others the apparent recovery or survival was a failure. For instance, the largest *Q. alba* in the forest (location 195 × 290) was recorded as killed in 1957. All of its leaves were brown and