Periodicity of tree growth in Hutcheson Memorial Forest

M. F. Buell, H. F. Buell, and J. A. Small
Rutgers University

Buell, M.F., H.F. Buell, and J.A. Small (Rutgers University, New Brunswick, N.J.) Periodicity of tree growth in Hutcheson Memorial Forest. William L. Hutcheson Memorial Forest Bull. 3:24-26.1973. Weekly monitoring of diameter growth with the dial gauge dendrometer and of terminal growth of branches showed that ring porous species started cambial growth before shoot growth, and diffuse porous species the reverse. One shrub included in the data for terminal growth showed its adaptation for growth in the forest by an extended period of growth in deep shade after the canopy species had terminated their shoot growth.

Regular weekly dendrometer readings recording radial stem changes have been made on trees of the Hutcheson Memorial Forest in central New Jersey for nearly two decades. A dial gauge dendrometer (Daubenmire 1945) is used and two sets of reference screws established per tree, one on the north side and one on the east side of the tree trunk. The readings have been made regularly the first half of the morning. All species of trees of the forest except *Diospyros virginiana* have been included in the record.

The objective of the present study is to present data relating diameter growth to initiation and duration of stem elongation and to leaf fall of several of the principal tree species of the forest as well as the seasonal growth and leaf fall of the dominant shrub as related to tree activity.

In the spring of 1970 we began to monitor terminal growth of 7 of the species concurrent with the recording of the radial stem changes. The seven species were: *Acer rubrum* (red maple), *A. saccharum* (sugar maple), *Cornus florida* (flowering dogwood), *Fagus grandifolia* (beech), *Nyssa sylvatica* (black gum), *Quercus alba* (white oak), and *Q. velutina* (black oak). Two trees of each species were being monitored for radial stem changes, and the 4 weekly readings were averaged. We had noticed that new shoots and development of leaves of different species in the forest did not occur simultaneously nor at the same rate. The oaks, for example, began activity later than the red maple. We had previously made casual observations of this phenomenon. To get a more objective measurement we marked with india ink 5 twigs from each of the 7 species of trees and measured to the tip of the winter buds with a millimeter rule; we continued weekly measurements to show time of initial swelling of the bud and elongation of the new shoot until shoot growth ceased with the formation of next year's bud. Because of the inaccessibility of terminal shoots in the crowns of the forest trees used in the dendrometer measurements, the shoots used in measuring terminal growth were those of lower branches of trees which could be reached and, with the exception of *Quercus alba*, were not branches of the dendrometer trees. We recognize that this is not the desirable way of gathering the data, because of the probable variability between growth in different trees, in different parts of trees, and in different ages of trees. We do believe that our data are valid in showing an appreciable amount of between-species differences in terminal growth periodicity.

Finally we recorded rate of leaf fall. This was measured by counting the numbers of leaves missing from our sample twigs from week to week.

Included in the periodicity records are data for the overwhelmingly predominant shrub — *Viburnum acerifolium*. It seemed possible that this successful understory plant might have a growth periodicity synchronized with pre-leafing out of the forest canopy, as is true of most of the herbs.

The results of our records do in fact show a strong contrast in behavior between species. *Fagus*, *Acer*, *Nyssa*, and *Cornus* show early, rapid shoot growth that is well started before diameter growth is evident, while in the *Quercus* species the reverse is true. This is most striking in *Quercus alba*.

There are difficulties in using the dendrometer records for determining the initiation of radial growth in the spring. During the winter season there are continued pronounced diameter fluctuations influenced both by moisture and temperature changes (Small and Monk 1959). Hence, in spring these weekly fluctuations in radial measurements, although less pronounced than in winter, tend to obscure the point that marks the initial radial growth resulting from cambial activity. We made no attempt to correct for these environmental differences on stem swelling and shrinkage. The diameter growth curves (Fig. 1) are drawn using the percent of total plus readings from week to week between March 11 and November 24. The actual maximum reached by the growth curves is influenced by the amount of minus readings during this period. However, the section of the curves showing the persistent rise represents growth sufficient to counteract any depression resulting from temperature or humidity influences through that period.

Also the magnitude of the changes registered by the dendrometer as a result of environmental fluctuations differs with the species. The differences can readily be seen in the diameter growth curves (Fig. 1). Since the curves are based on the percent of all plus values in the readings, a minimum of strong environmentally induced stem contractions results in a higher point reached by the growth curve. *Fagus* and *Acer saccharum* demonstrate the least influence, and *Cornus* the greatest amount of influence, as shown by the peaks preceding the start of growth in the spring and the maximum height reached by the curve.

Hence, in *Fagus* and *Acer saccharum* the time of growth initiation is more clearly defined. The diameter fluctuations of *Nyssa*, *Acer rubrum*, *Quercus velutina*,

1973. William L. Hutcheson Memorial Forest Bulletin 3(1):24-26.

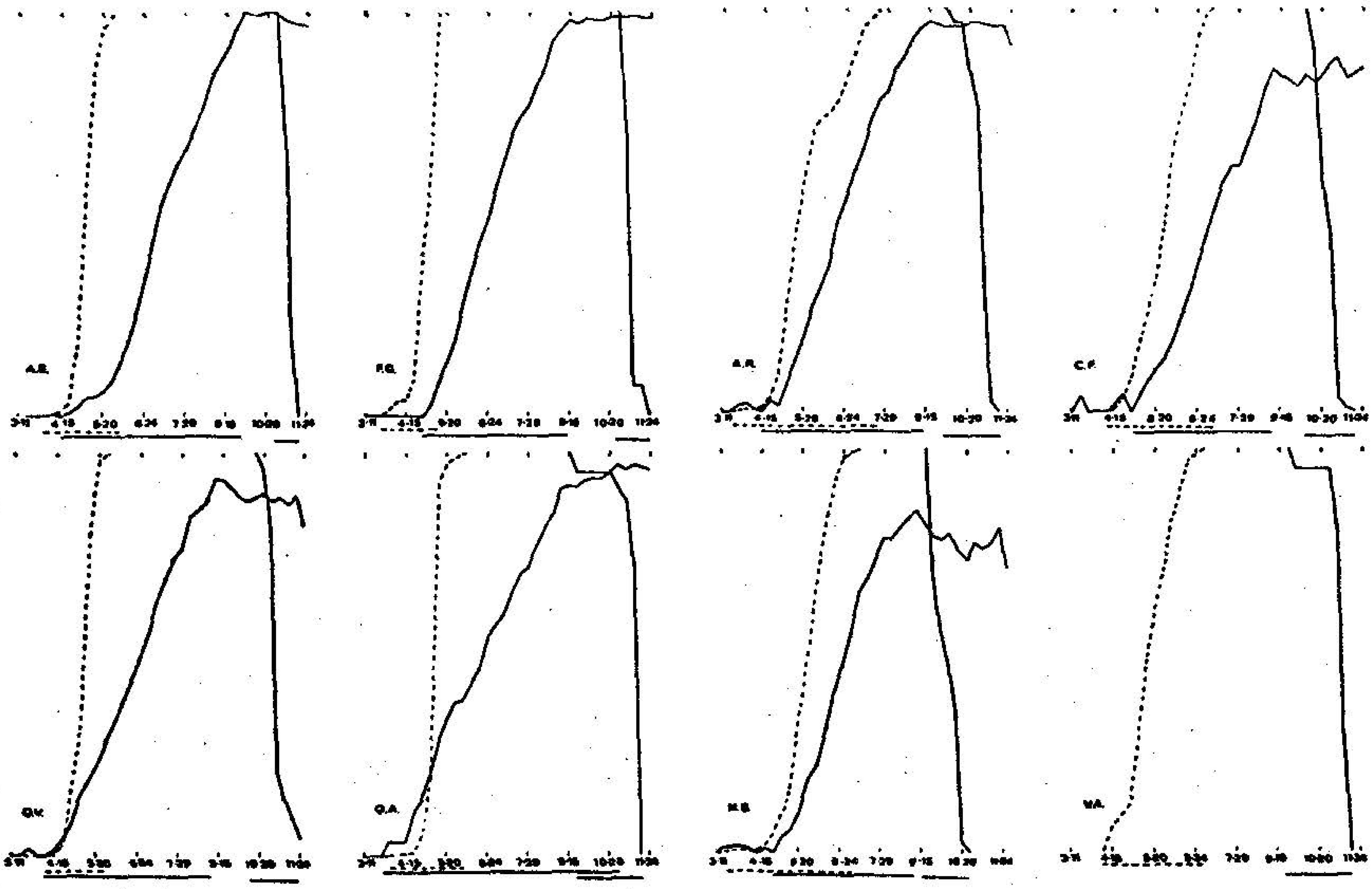

Figure 1. Curves showing shoot elongation (dashed lines), diameter growth (solid line), and leaf fall (solid line at right). All are based on percentages of each phenomenon for the season. The shoot growth is the percent growth by the week in terms of total shoot growth for the season. The diameter growth of the tree is based on the percent of all the positive dendrometer readings for the period March 11 to November 24. The leaf fall is the percent of the leaves missing from the sample branches in terms of the total on those branches at the end of the summer season. Figures across the bottom of each set of curves give the dates at each 5th weekly reading. Readings were not taken in early September, and hence the period 7-29 to 9-15 represents the same number of readings, but a 7-week interval of time. The three lines at the bottom define the duration of the stem elongation, diameter growth, and period of leaf fall.

A.S. = *Acer saccharum*, F.G. = *Fagus grandifolia*, Q.V. = *Quercus velutina*, Q.A. = *Q. alba*, A.R. = *Acer rubrum*, C.F. = *Cornus florida*, N.S. = *Nyssa sylvatica*, V.A. = *Viburnum acerifolium*.

and particularly *Cornus florida* in the spring are especially noticeable in the curves. (The spring fluctuations in diameter are shown to the extent that they return the reading to the admittedly arbitrary March 11 baseline.) The point at which the minus fluctuations do not finally return to the readings of March 11 is what we have taken as the beginning of diameter growth. For example, in *Cornus florida* that is on April 29.

In spite of this lack of precision, the data on timing of initiation of diameter growth compared with the start of shoot growth of oaks (ring porous) as compared with beech and maple are supported by observations of others. For example, Phipps (1961) in his study of tree growth in the Neotoma research area in Ohio stated that "Initiation of ring porous species was correlated with time of bud swelling, and initiation of diffuse porous species with leaf unfolding." Also Zasada and Zahner (1969) and Lodewick (1928) have reported that species with ring porous wood are characterized by having new xylem produced before new stem growth starts. They sampled cambium to detect when cambial activity began and used towers to reach the canopy of the same trees for terminal shoot measurement. Zasada and Zahner conclude that the phenomenon in ring porous wood is related to winter embolism in the vessels in ring porous wood, with consequent delay in shoot growth until the cambium can produce a new set of vessels that can supply the growing shoot with a flow of water from the roots. The earlier shoot growth of the other tree species included here is presumably related to their having diffuse porous wood that does not suffer comparable winter damage.

Shoot growth initiation is more precise, and the curves are based on percent total growth attained. Leaf fall is equally precise and is based on the percentage of leaves fallen from the sample twigs over the observation period.

The time of initiation of terminal growth as indicated by a measurable elongation of the terminal bud does vary with the species. The beech starts early and its rapid, persistent growth is especially noticeable. *Vibur-*

num acerifolium starts later. Since most of the forest herbs start their growth early and have completed their growth by the time that the canopy closes, one might reasonably expect a forest shrub to do likewise. But this is obviously not true of *Viburnum acerifolium*. This forest species is not adapted to avoid the shade of the forest by getting an early start, as most of the herbs are, but is a shade species in the true sense. It flowers in deep shade. In this regard, compare *Acer saccharum*, *Fagus*, *Quercus alba* and *Q. velutina*, all of which are dominant trees that mature their leafy branches while the *Viburnum acerifolium* below them is still growing.

Leaf fall in autumn is initiated after radial growth is completed with the exceptions of *Quercus alba*, whose cambial activity continued until the October 27 weekly reading. *Nyssa sylvatica* leaf fall began earliest of all species, the first leaves falling September 15, with its period of leaf fall extending over six weeks. However, cambial activity ceased well before leaf fall started.

What is perhaps particularly interesting is that using a rather imprecise measure of cambial growth, our results showed the same periodicity phenomena for stem diameter growth related to terminal growth in ring porous vs. diffuse porous species as has been demonstrated by previous research. The dial gauge dendrometer read at weekly intervals and subject to normal environmental changes influencing swelling and shrinkage of wood and bark does not give a very precise measure of cambial activity. Hence, the growth-periodicity relationships have to be real phenomena to have shown up as clearly as they do in these data.

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