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# The Effect of Precipitation and Temperature on Annualr Ring Growth in Four Species of Quercus

Arnold Kleine
*Butler University*

Johne E. Potzger
*Butler University*

Ray C. Friesner
*Butler University*

# THE EFFECT OF PRECIPITATION AND TEMPERATURE ON ANNULAR-RING GROWTH IN FOUR SPECIES OF QUERCUS

*By* ARNOLD KLEINE, JOHN E. POTZGER *and* RAY C. FRIESNER

Of all the factors affecting growth in trees, precipitation and temperature appear to be the most readily measurable, though there is by no means a general agreement among workers as to the exact way in which the relationship is expressed. Pearson (5) found that spring precipitation (April and May) is the most obvious controlling factor in annual height growth in *Pinus ponderosa* saplings. Stewart (7), however, in comparing widths of annular rings of an oak stump with precipitation records taken at Rochester, New York, twenty-five miles farther north, found that there was a greater correspondence between precipitation for June and July and the ring width than for the entire year. Robbins (6), at Columbia, Missouri, measured the growth rings of sixteen oak stumps, and found that the mean monthly temperature of May and June varies inversely with annual increase in tree width. He also found there is a close relation between the total rainfall of March through June and the annular ring width. Diller (2), working on Fagus, found that yearly variations in the width of annular rings are correlated inversely with the average temperature for the month of June; also that yearly variations are correlated directly in certain woodlands with the total precipitation for the month of June.

Robbins (6) states that an abnormally large or small annual precipitation shows its effect on the ring width the following year, and that the dry spring of a given year shows its effect in growth during the same year. Diller found that, in most cases, drought years show their effects on growth the following year, probably due to an accumulated deficiency in soil moisture, whereas wet years show an increase in growth the same year. Lodewich (4), while investigating the relationship between certain climatic factors and diameter growth in longleaf pine in western Florida, found no effect of temperature on wood production, but a marked reduction or increase in precipitation was accompanied in most cases by corresponding variations in ring width.

Robbins (6) states that the sums of the mean temperature for certain months have been found to vary inversely with growth, while Diller

(2), working with Fagus, found that the mean temperature of the month of June exhibits the same inverse relation.

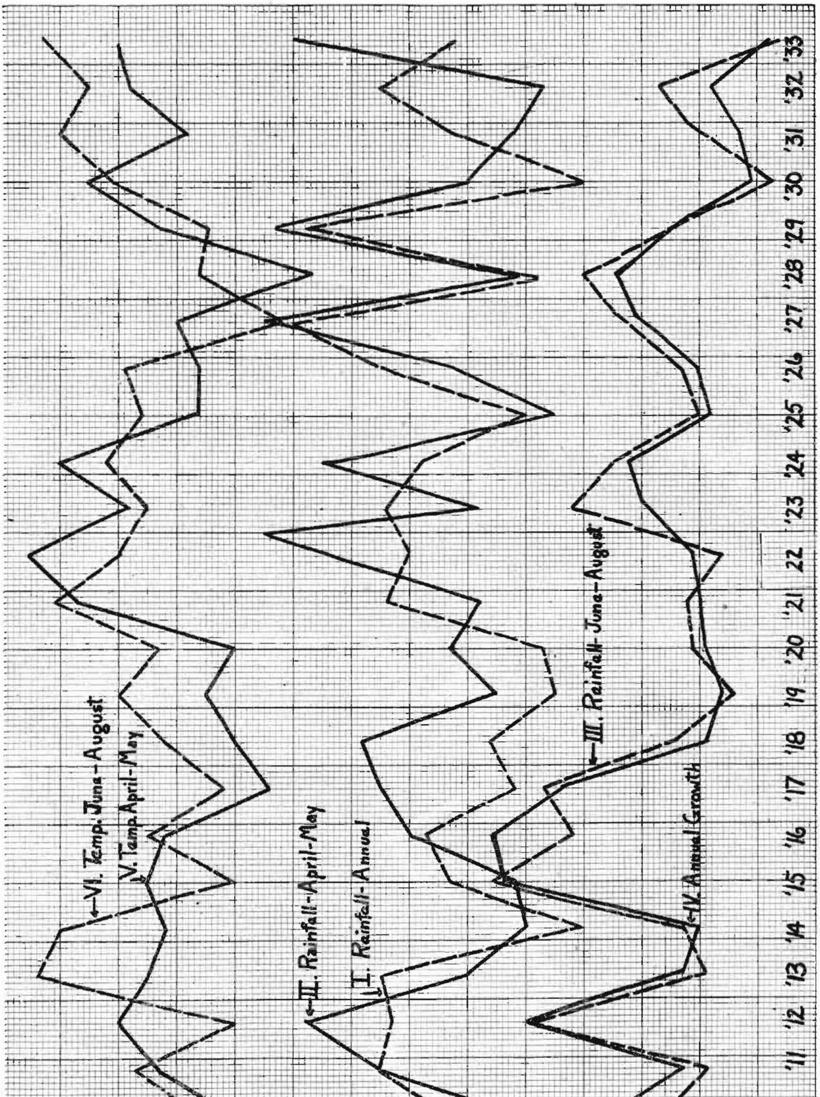
Douglass (3) suggests the possibility of a correlation between sun spots and ring development. Burns (1), in his study of the relation of rainfall and width of annual rings in a Vermont forest, goes so far as to say that there can be no direct correlation between rainfall and diameter growth, because the width of rings at any one point is not an index to total increment, and soil moisture is not a measure of rainfall nor of food supply.

## METHODS AND MATERIALS

The present investigations were made from 11 trees of *Quercus alba*, 17 trees of *Q. montana*, 16 trees of *Q. velutina* and 9 of *Q. borealis maxima*. All specimens were taken from the knobs area of Bartholomew and Brown counties in Indiana, from stumps left by lumbering operations carried on from July to September, 1934. Sections were brought to the laboratory and measurements were made with a binocular microscope suspended over the section. The annular ring widths of eight equidistant radii were taken on each of the 53 sections measured. During the measuring, medullary rays were followed instead of geometrical radii. In this manner the width of the annular growth was taken in a direction eliminating the error of oblique measurement. When a radius was completed, a number tag was placed at the end of the radius. This allowed for a recheck to be made at any desirable time. Annular ring measurements were taken of the years 1909-1933 inclusive, a growth period of twenty-five years. The measurement of eight radii per section aided in eliminating the errors of unequal growth along different radii in the same tree.

## OBSERVATIONS AND RESULTS

The most outstanding feature at first noticed in the data is the large amount of ring growth in 1912. Then for the years 1913 and 1914 there is a great decrease in annular growth, and in 1915, 1916 and 1917 there is an enormous amount of growth again. This may readily be observed in Curve IV. Since all 53 trees possessed this same characteristic growth between 1912-1917, it is of vital importance to know the relation that precipitation and temperature have during this same time. Rainfall and temperature data were taken from the U. S. Weather



VI. Temp. June-August
V. Temp. April-May
II. Rainfall-April-May
I. Rainfall-Annual
III. Rainfall-June-August
IV. Annual Growth
'09 '10 '11 '12 '13 '14 '15 '16 '17 '18 '19 '20 '21 22 '23 '24 '25 '26 '27 '28 '29 '30 '31 '32 '33

Bureau stationed at Columbus, Indiana, which is ten miles east of the area from which the tree sections were taken. The average monthly precipitation for the summer (Curve III) months of June, July and August shows almost identically the same curve as the ring growth. Also in Curves II and IV it is observed that there is little correlation between the average ring growth and the average monthly precipitation for the spring months of April and May or the total annual precipitation shown in Curve I.

In making a comparison of the ring growth for the other nineteen years (the years 1909-1933, excluding 1912-1917, inclusive), it is found that the same results are obtained as with the period 1912-1917. It almost invariably happens that when there is an increase in precipitation during the months of June, July and August for a certain year, there is an increase in the annular growth for the same year. This correlation follows so closely that when the precipitation curve for a particular year goes above or below the average line (Curves III and IV), the annular growth curve generally crosses the average line at the same time.

In a general way, both the average monthly precipitation curve for spring and the total annual precipitatiou curve correspond with the curve for annular growth. During the years 1914, 1919, 1920, 1925 and 1930 there was the least total annoal precipitation. Both the spring and summer precipitations are low during these years, and, as a result, all of these years have a small amount of annular growth. Thus these results do not seem to agree with those of Diller (2), who held that drought years show their effect the following year. From the results of the present investigation, it appears that whether low total annual precipitation is reflected in the growth of the following year depends upon when during the year the drought actually occurred.

In 1919 and 1928 there was a comparatively low annual precipitation, but in both of these years there was a relatively high summer precipitation, and, as a result, there was a corresponding large amount of ring growth. The years 1913, 1927 and 1929 have the highest annual precipitation of the period of years concerned in this investigation, but the growth is not appreciably accelerated, since the average summer precipitation is not heavy during these years.

In making a comparison of the annual ring widths with temperature, it is evident from Curves IV, V and VI that the best correlation occurs between diameter growth and temperature during the months of June, July and August. However, this relationship is different from the precipitation relationship in that the temperatures are correlated inversely with the ring growth. The higher the temperatures of the summer months, the lower the growth, and *vice versa.* In making a comparison of the relation of summer temperature and summer precipitation to annular growth, it appears that there is not such a definite correlation between the summer temperature and the ring growth as between the summer precipitation and the ring growth. However, the summer temperature is correlated inversely more to the ring width than the spring or annual precipitation is correlated directly to the ring width. There is very little if any correlation between the average monthly temperature of April and May and the annular ring growth. In 1931 and 1932 there is a relatively high summer rainfall, but it was very hot during these two years and as a result small amount of growth occurred.

## DISCUSSION

The characteristic growth during the period of 1912-1917, inclusive, was so obvious in all trees studied that when the measurements of a section were taken for this period, it could easily be distinguished just what year was being measured. In several instances mistakes were made in measuring; that is, measurements of a certain year were being recorded for the year ahead or the year behind. However, when measurements came to the years 1912-1917, the mistake was readily perceived and a recheck was immediately started. As a result, it is certain that no error is involved in the data from the standpoint of measurements being recorded for the wrong years.

The question might be asked as to why the particular summer months of June, July and August, rather than any others, should show this relation. Diller (2) holds that June is the important month from the standpoint of precipitation, while other workers have designated other combinations of months. When a comparison is made between the June precipitation and the ring growth, a correlation is found, but it does not correspond nearly so well to the ring growth as do the months of June, July and August. The same is true when June and July are combined, but the correlation is a little closer here than when the month of June alone is used. The inverse relation between growth and temperature probably may be explained by assuming that increased temperature increases the transpiration, and when soil moisture is near the critical point it results in the same effect as a lower water supply. As mentioned above, in 1931 and 1932 there was a relatively high summer precipitation, but it was also very hot during these summers and a small amount of growth results even though rainfall was higher. Thus, high temperature, due to its effect upon transpiration, may partially nullify the beneficial effect of a high rainfall. In this connection, attention should be called to the physiography of the area from whicb the wood sections were taken. All were taken from the Knobs area in which run-off is always high and soil moisture is always near the critical point during summer months. Observations made weekly during the summer of 1934 showed that soil moisture was below the wilting coefficient for six of the thirteen weeks during June, July and August. It is quite likely that in an area where run-off is not so high and where soil moisture is not so near the critical point. the relation between rainfall and growth will be different from that found in this study. It is, therefore, considered that rainfall-growth relations will always be conditioned by the peculiar circumstances pertaining in the particular area under consideration. When there is present low precipitation or low moisture supply, together with high temperature, the limited growth is due to the close relationship which exists between turgidity and growth.

It is known, of course, that precipitation and temperature are not the only factors that have an effect on the growth of trees. Such factors as intensity and duration of light available, mineral salts, and other edaphic factors would enter in. These factors, however, are not so variable from year to year and hence probably do not play so much of a role in the yearly variations in ring development as do precipitation and temperature.

## SUMMARY AND CONCLUSIONS

1. Widths of annual rings for 1909-1933 are found to correlate directly with average monthly precipitation during June, July and August.

2. Widths of annual rings for 1909-1933 are found to correlate inversely with the average monthly temperature of June, July and August.

3. The curve for the average monthly precipitation follows the curve of annual ring growtb much more closely than does the curve of the average monthly temperature for June, July and August, thus showing that precipitation plays the primary role of limiting factor in annual ring growth.

4. The average monthly spring temperature of April and May has little if any correlation to the annual ring growth.

5. Average monthly precipitation for April and May shows only a slight correlation to annual growth.

6. To some extent, high temperature has the same effect as low precipitation, because of its effect on the increase of transpiration.

7. A low total annual precipitation causes a decrease in annual ring growth only when spring and summer precipitation is low. Thus, drought years in the area here studied show their effects on growth the same year of the drought.

8. The optimum condition for growth is a cool temperature with a high precipitation during June, July and August.

## LITERATURE CITED


1. BURNS, GEORGE P. Studies in tolerance of New England forest trees IX. Rainfall and widths of annual rings in Vermont forests. Univ. Vermont Agri. Exp. Sta. Bull. 298. 1929.
2. DILLER, O. D. The relation of temperature and precipitation to the growth of beech in northern Indiana. Ecology 16 (1):72-81. 1935.
3. DOUGLASS, A. E. Climatic cycles in tree growth. Carn. Inst. Wash. Publ. 289. 1928.
4. LODEWICH, J. ELTON. Effect of certain climatic factors on the diameter growth of longleaf pine in western Florida. Jour. Agri. Res. 41:349-363. 1930.
5. PEARSON, G. A. Relation between spring precipitation and height growth of western yellow pine saplings in Arizona. Jour. Forestry 16:677-689. 1918.
6. ROBBINS, WILLIAM J. Precipitation and growths of oaks at Columbia, Missouri. Univ. Missouri Agri. Exp. Sta. Res. Bull. 44. 1921.
7. STEWART, M. N. Relation of precipitation to tree growth. U. S. Mo. Wealth Rev. 16:1278. 1913.