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EFFECTS OF 1925 SUMMER DROUGHT ON SOUTHERN APPALACHIAN HARDWOODS

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Meteorological Observations

A drought of extraordinary severity occurred in the Southern Appalachian region during the summer of 1925. The rainfall, as reported by the U. S. Weather Bureau Station at Asheville, North Carolina, was as follows: May, 2.15 inches; June, 1.97; July, 0.77; and August, 0.22. The normal average for the Asheville station, based on 27 years' records, is, for May, 3.49 inches; June, 3.97; July, 4.47; and August, 4.04. For the 4 months considered, the total rainfall in 1925 was thus 5.11 inches, or

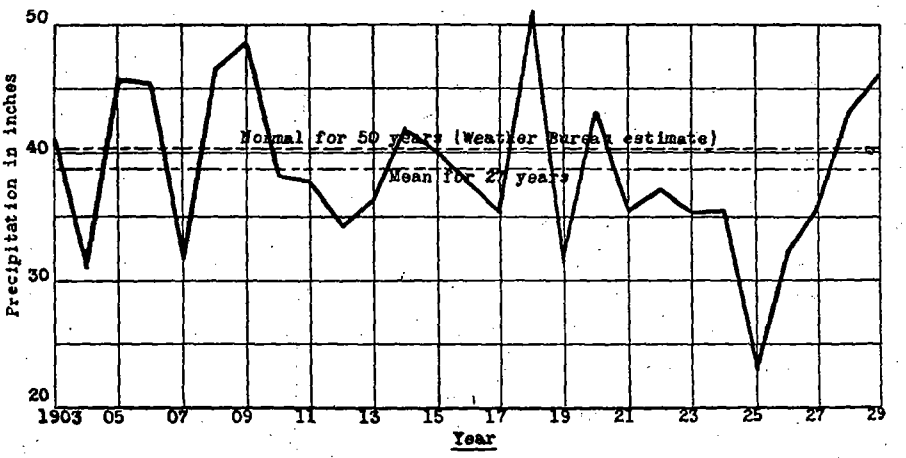

Fig. 1. Annual precipitation for the period 1903–1929, Asheville, North Carolina.

about 32 per cent of the mean normal summer rainfall of 15.97 inches. For July and August it was only 11.6 per cent of the normal average.

Annual precipitation[2] throughout the 27-year period, 1903–1929, is shown in figure 1. It is to be observed that considerable annual fluctuation from the normal occurs, precipitation ranging from a minimum of 22.79 to a maximum of 51.08 inches. Figure 2 shows the total summer precipitation,

[1] Formerly Appalachian Forest Experiment Station.

[2] These data are taken from the reports of the U. S. Weather Bureau Station at Asheville, North Carolina.

ranging from a minimum of 2.96 to a maximum of 19.27 inches, for the period 1903–1929.

BEHAVIOR OF THE FOREST

During August and September of 1925 the leaves of many trees on ridges and upper slopes of the Bent Creek Experimental Forest, 10 miles from Asheville, became wholly or partially brown, and some species fell prematurely. This forest lies at an altitude of 2,100 to 2,600 feet, and is composed chiefly

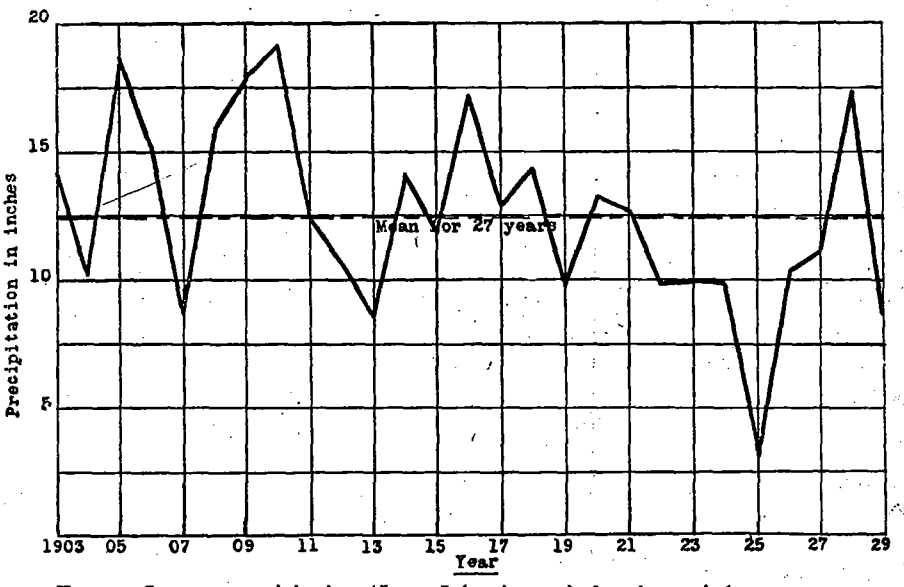

FIG. 2. Summer precipitation (June, July, August) for the period 1903–1929, Asheville, North Carolina.

of oaks, short-leaf and pitch pines (*Pinus echinata* Mill. and *P. rigida* Mill.). In September, two small areas conspicuously affected by the drought were placed under close observation. One was located on an upper west slope, the other on a middle east slope of one of the low forested mountain ridges.

Observations were made of tree conditions, topography, and soil. Individual trees were tagged and described as to bole condition, crown, vigor, dominance, and leaf injury by drought. The leaf browning and early leaf fall were more pronounced among the younger trees. The browning appeared to be particularly severe on dogwood (*Cornus florida* L.), sourwood (*Oxydendrum arboreum* (L.) DC.), and chestnut (*Castanea dentata* (Marsh.) Borkh.), while white ash (*Fraxinus americana* L.), black locust (*Robinia pseudoacacia* L.) and pignut hickory (*Hicoria glabra* (Mill.) Sweet), showed less injury from the drought. Trees with large logging or fire scars showed more severe browning of the leaves than those with sound boles. On many of the large trees, the browning was confined to the topmost branches.

SOIL MOISTURE

The soil on the area under observation was relatively shallow, being seldom more than 18 or 20 inches in depth. It is mapped by the U. S. Soil Survey as Porter's stony loam and Porter's clay loam. Over much of the area showing severe drought injury the bed rock is close to the surface, with frequent rock outcrops. The topography is steep, the degree of slope ranging from 50 to 100 per cent.

Determinations of moisture content of the soil at the time of the drought and in the year following, disclosed wide differences. In September, 1925, there was an average of from 5 to 6 per cent moisture, oven-dry basis, for the 4 inches of surface soil, and of 8 to 11 per cent at a depth of 1 foot. In the early summer of 1926 the moisture content had increased to a range of from 15 to 40 per cent oven-dry basis. In some locations where rock outcrops were abundant the shallow soil was found to have a moisture content of from 40 to 45 per cent, as compared with 5 per cent at the time of the previous sampling during drought conditions. No study was made of available moisture of the soil, but considering the amount of clay present, it is reasonable to believe that when reduced to a moisture content of 5 per cent this soil has no water available to the plant roots.

SUBSEQUENT RESULTS

The condition of the trees was again recorded in September, 1927, and in September, 1929. An insufficient number of individuals of each species was under observation to permit an analysis of the data on a statistical basis; nevertheless certain outstanding facts may be considered as significant. During the succeeding 4 years not one of the tagged trees that maintained normal foliage during the drought period showed any evidence of injury that could be attributed to the drought. About half of the trees showing definite drought injury at the time of tagging in September, 1925, completely recovered. The remainder sustained injury in the form of dead branches in the crown, or were killed by drought or by secondary causes.

BEHAVIOR OF SPECIES

Considerable differences in response to the drought were shown by the several species under observation. The leaves of the dogwood turned brown at the distal end, the rest of the leaf retaining its green color; those of the basswood, ash, and hickory were lost prematurely.

In other species—oaks, for example—the leaves that turned brown became completely so, although other leaves on the tree remained green. The leaves of the chestnut oak (*Quercus montana* Willd.) were only moderately or slightly injured; the trees were quite normal the following spring, and no permanent injury could be attributed directly to the drought. Black oak (*Q. velutina* Lam.), showed severe leaf injury during the drought period and all

of the trees of this species were dead in 1929. With few exceptions, red oak (*Q. borealis* Michx.) and scarlet oak (*Q. coccinea* Muenchh.) responded similarly to black oak. The hickory species present, mockernut (*Hicoria alba* (L.) Britt.), pignut (*H. glabra* (Mill.) Sweet), and shagbark (*H. ovata* (Mill.) Britt.), were only slightly injured during the drought, the principal response being an early shedding of the leaves. In most cases recovery among hickories was complete.

Increment borer cores of the trees that recovered completely after the drought season showed that there had been little appreciable reduction in annual diameter increment either in the drought season or during the following years. Those trees, however, which died during the 4 years succeeding the drought showed a definite reduction in diameter increment for the years in which they remained alive after the dry season.

DISCUSSION

Extensive root excavations were impracticable because of rock obstructions, but it seemed likely that root restriction due to rock outcrops or to shallow soil rock pockets was the significant factor responsible for the drought injury. A similar conclusion was reached by Meinecke [3] as a result of a study of drought injury to forest trees in the Sierra Nevada Mountains of California. On the Bent Creek area the greatest drought injury occurred in the case of trees with restricted root systems growing on shallow soil, which explains differences in reaction between individuals of the same species. This fact alone, however, would not account for the differences in behavior of various species, a phenomenon that can be properly explained only after we shall have obtained, through adequate research, an increased knowledge of root development and hydrostatic systems of various tree species.

An increased mortality among scarlet, black, and red oaks in the Southern Appalachians has been recorded for the year 1927 by Balch.[4] While he does not ascribe the increased mortality to a definite primary cause, severe late frosts in April, 1927, which completely killed the new foliage over much of the Bent Creek region, no doubt lowered the vitality of the trees. The general conclusion is that a combination of unfavorable seasonal conditions reduced the vigor of the individual trees already of low vitality due to overmaturity or competition; subsequently the shoestring fungus (*Armillaria mellea* (Vahl) Quel.), together with certain insects, particularly the two-lined chestnut borer (*Agrilus bilineatus* Web.) and certain species of *Prionus,* the long-horned beetles, or a combination of these parasites, brought about the death of the trees. During the spring of 1929 many trees of scarlet oak were wind-thrown throughout the region in the vicinity of Ashe-

[3] Meinecke, E. P. An effect of drought in the forests of the Sierra Nevada. *Phytopathology,* 15: 549–553, 1925.

[4] Balch, R. E. Dying oaks in the Southern Appalachians. *Forest Worker,* 3: No. 6, p. 13, 1927.

ville. The shoestring fungus was associated with the roots of all such windthrown trees as were examined. The prevalence of this root fungus may also be the result of irregular seasonal precipitation and the late spring frost that occurred in the 4 years preceding 1929. It is possible that these climatic conditions disturbed the natural resistance of the tree against its parasitic enemies.

As a rule, ground water follows the rock formations on mountain slopes, and rock outcrops often give rise to moist areas where the extent and vigor of the vegetative growth is out of proportion to the amount of soil present. During periods of drought this ground water is absent, and the shallow soil becomes dried down to the bed rock, causing injury to the relatively luxuriant vegetation. This injury frequently results in the death of annual plants. Herbaceous perennials die down to the ground, but their roots remain alive unless the drought is unusually severe. Small woody plants, such as alder (*Alnus* sp.), may also die to the ground but may sprout up from the roots the following year when moisture conditions become adequate.

The varied reactions observed in 1925 in the case of the tree species have already been described. It is obvious that these various adaptations, the partial or complete browning of the leaves and the premature leaf fall, result in a reduction of the transpiring area. Those species, therefore, whose individuals are able to respond in this way to drought conditions are better fitted, from this standpoint, for situations subject to occasional summer dry periods.

It is believed that during excessively dry seasons, drought injury similar to that of 1925 has occasionally occurred in the past in the Southern Appalachian Mountain region, and has constituted an important factor in determining the composition of the natural forest stands. Because of the fluctuations in annual precipitation in the region the same sort of injury is to be expected in the future. Drought conditions in the Southern Appalachians favor the occurrence of forest fires during the summer. These forest fires also have been influential in determining the nature and composition of the mountain forests.

It is frequently stated by writers on general forestry that the climate of the Southern Appalachians is favorable to the growth of a heavy deciduous forest. No attempt will be made to discuss this general statement in the present paper. Observations on the 1925 drought, however, suggest that wide fluctuation from the normal means in seasonal precipitation are of salient significance in the distribution of tree species growing in regions of irregular topography. It is suggested that the minimum of the fluctuating precipitation range must be considered in determining the site possibilities for any given tree species. If this is true, many of the tree species now present in the stands of the ridge and upper slope forest in the Southern Appalachians are relatively unproductive.

Those tree species that are injured but not killed in dry years will remain in and become a menace to the vigor of the stand, exhibiting poor form, stag-

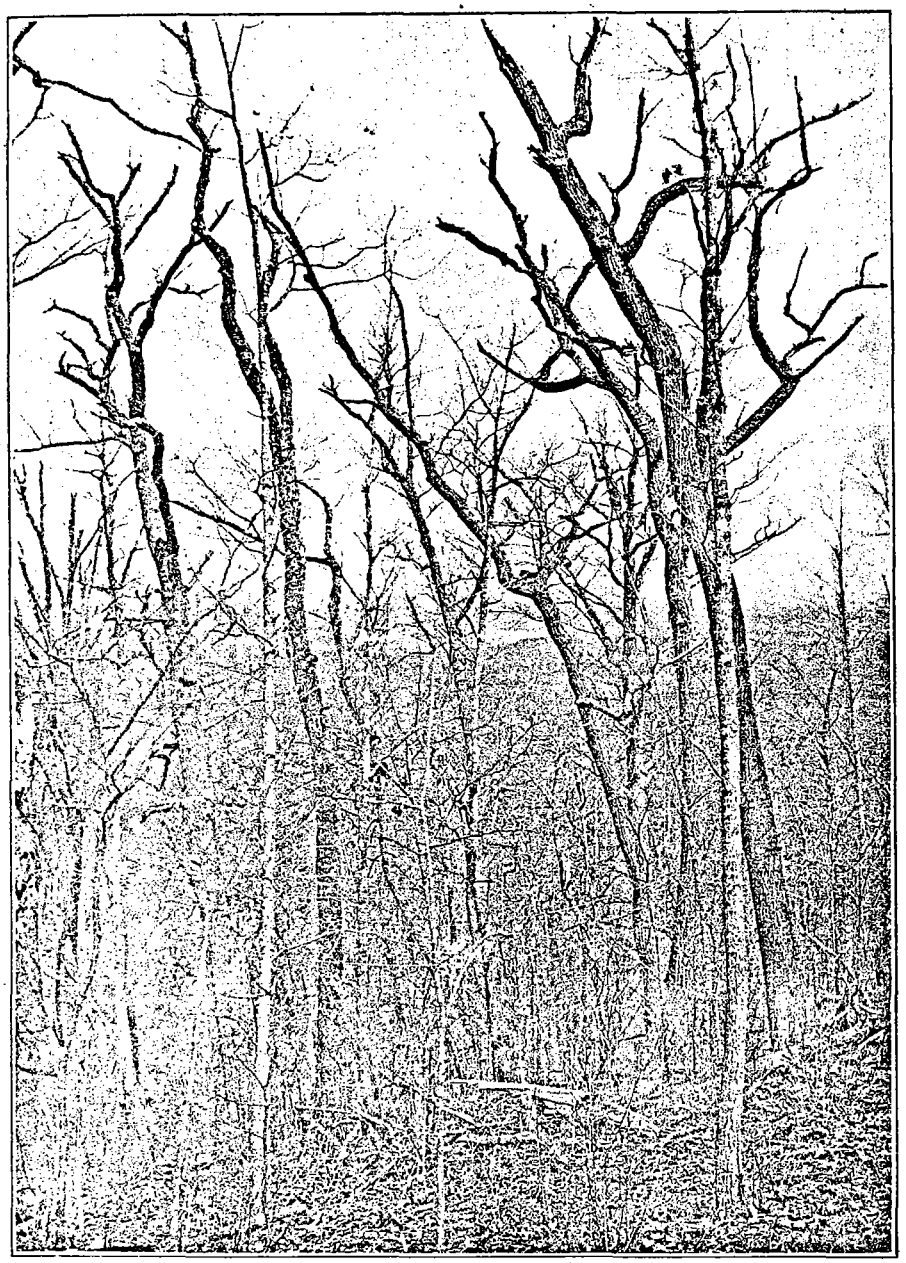

FIG. 3. Drought-injured forest on upper slope, Bent Creek Experimental Forest, near Asheville, North Carolina. Photograph by the Appalachian Forest Experiment Station, U. S. Forest Service, March 20, 1930.

headedness, and slow growth. Where fire has accompanied the drought the poor vigor of the crippled trees is even more marked. It is probable that these factors account for many of the crippled hardwoods that control the upper slopes and ridges (Fig. 3) many of these species are obviously out of their favorable habitat, and yet through their unusual persistence under unfavorable circumstances they continue to hinder the establishment of other tree species possibly more suited to the dry slope and ridge conditions.

Efficient utilization of the upper slopes and ridges in the Southern Appalachians for watershed protection is a problem of much concern. Observations on seasonal droughts have a practical application to this problem. The minimum seasonal precipitation appears to be a critical factor in determining the growth of tree species on the upper mountain slopes. Due consideration must be given to this fact in the choice of tree species to be selected in any planting program, or favored in any management plan, for the upper slopes and ridges of the Southern Appalachian Mountains.

SUMMARY

For the year 1925 the annual precipitation in the Southern Appalachian region was approximately one-half of the annual mean for 27 years. The summer precipitation (June, July, August) was less than one-fourth of the summer mean.

The precipitation deficiency expressed itself on the vegetation of the region through early browning and premature leaf fall.

Most of the trees on good sites apparently recovered completely the following year. On upper slopes and on shallow or rocky soils some tree species that had established themselves during cycles of sufficient precipitation were severely injured or killed, either directly or subsequently through secondary agencies.

Partially killed crowns, resulting in stagheaded trees, were of common occurrence on shallow soils. Black oak (*Quercus velutina* Lam.) was particularly susceptible to the drought. Chestnut oak and pine survived on areas where black oaks were completely killed.

Precipitation records indicate a considerable annual and seasonal fluctuation for the Southern Appalachian region. Drought conditions have occurred in the past and may be expected in the future. This fact should be considered in determining certain forestry practices in the Southern Appalachians, particularly in regard to planting of species on the upper slopes where drought conditions may become severe.