PHYSIOLOGICAL-GENETIC VARIATION IN PLANT SPECIES

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Introduction:

Through the years there have been many studies on the kinds of physiological adaptations plant species have made to the ecological niches that exist within their ranqe. The following citations describe the kinds of physioloqical-genetic adaptations that have been found in studies with tree species. The work of Pauley and Perry (1954), Irgens Moller *(1958),* Kriebel (1956), Olsen and Nienstaedt *(1959)* and many others reveal races adopted to grow at different latitudes and altitudes with genetic differences in photoperiod requirement serving to control the duration of seasonal growth. The work of Walker et al (1954), Habeck (1958), Vinogradov (1949), Fukarek *(1958)* reveal special adaptations to serpentine soils, limestone soils, dolomitic soils, sand-stone soils and to well-drained upland soils versus poorly drained bog soils. University of Minnesota racial studies with Jack pine reveal maritime and inland races. United Sates Forest Service planting at Placerville reveal maritime and inland races of lodge pole pine. Unpublished observations by Zobel and Perry indicate that there are maritime races of slash pine and loblolly pine. Zobel's research (1957) with loblolly pine reveals drought tolerant races of loblolly pine. Scandinavian research reveals the existence of races adapted to heavy snow and ice conditions. Wang and Perry (1960) have demonstrated genetic differences in winter, chilling requirement for red mare, paper birch, yellow birch, and hemlock. The studies of Wakeley (1954) reveal racial variation in disease resistance. Recent research by Steinhof (1961) reveals racial and individual variation in capacity to take up and use nutrients. These are only a few examples of the various kinds of physiological genetic variation that have been discovered through transplanting different geographic sources of trees to a number of controlled environments. I know of no instance where proper experimentation has failed to reveal racial adaptation to the environmental factor studied. Furthermore there seems to be a parallel pattern of physiological adaptations by diverse taxonomic groups. Although broad generalizations are dangerous, one is strongly led to make the following generalization from the existing evidence:

> That when and where a variation in an environmental factor exists within the range of a species, there also exists a corresponding and appropriate variation in physiological-genetic make-up of the species, and that species occupying the same geographic range frequently display a parallel pattern of physiological-genetic adaptations.

Until contrary evidence becomes available forest managers will find it wise to assume, the foregoing generalization is correct.

The following results of recent research provide added support for this generalized statement about racial variation.

While at the University of Florida Dr. Wang and I made a collection of a large number of geographic origins of loblolly pine and slash pine. This collection was divided into two lots, one subjected to a day-length equivalent to that of Gainesville, Florida. The Worchester county Maryland day-length was obtained through the use of floodlights which were adjusted at weekly intervals to duplicate within plus or minus 10 minus the day-length of Maryland. The plans in the two experimental plots were measured at weekly intervals through the periods of active growth for a duration of three years. From these data a clear picture of genetic variation in photoperiod requirement and duration of seasonal growth was obtained for both slash pine and loblolly pine. At the end of three years of growth it appears that about 30%-40% of the variation in growth within sources as well as between sources can be accounted for by differences in duration of seasonal growth, while the balance can be accounted for by differences in daily rate of growth. Individual plants from the some geographic provenance or the same mother tree that cease active height growth late one year also cease active growth late in succeeding years. Weather conditions may induce a shift in phenological activity for the local species population but the individuals of the population tend to retain the same rank of early or late cessation of active growth. As might be expected the plants from the northern-most latitudes show the greatest response to the photoperiod treatments in Gainesville, Florida. The supplemental floodlights more than quadrupled the growth of the Maryland source under Florida conditions. The photoperiod treatments, however, did not succeed in inducing the loblolly sources from Maryland to grow at a rate equivalent to the Florida source, Doubtless, temperature, soil, and biological and climatic differences other than day-length are of major importance in determining total growth.

As a part of the work at the University of Florida Dr. Wang and I conducted research on the photoperiod and winter chilling requirements of a number of species including hemlock yellow birch, paper birch and red maple. Northern provenances of these plants did not grow well in Florida even when they were given adequate winter chilling and photoperiod treatments This indicated that there might be genetic variation in the temperature and soil requirements of these different races. To test this hypothesis I requested a National Science Foundation Research grant to go to the California Institute of Technology where it was possible to subject different provenances of red maple and loblolly pine to controlled day and night temperature treatments. Red maple plants from northern provenances, Canada, the Lake States and New England, made their optimum growth with night temperatures between 14 and 17° C. Red maple plants from Southern provenances made their optimum growth with night temperatures in the range of 20 to 23° C. Under the controlled conditions of the Earhart Laboratory red maple plants from Vermont grew best with the day temperature between 23 and 26° C. Under the controlled conditions of the Earhart Laboratory red maple plants from Vermont grew best with the day temperature between 23 and 26° C. and were inhibited by higher temperatures. Plants from the Everglades of Florida, by contrast, continued to show increased growth with increasing day temperatures up to 30° C. This was the highest experimental treatment available in the Earhart Laboratory and it was not possible to determine the optimum growth temperature requirement for Southern source of red maple. However, genetic variation in day temperature requirements is very striking. The day and night temperature requirement of the various sources of red maple correspond well with the day and night temperatures that normally prevail in the place where the collections were made. Evidently races have evolved which are adapted to the various day and night temperatures that exist in the range of red maple. The variation in growth by single plants of the same source under the same temperature regime indicates there is genetic variation within as well as between provenances.

The parallel series of experiments with two provenances of loblolly pine reveals geographic variation in the day temperatures required for optimum growth. Plants from the high altitudes of Tennessee grew better at low temperatures than plants from the hot climates of Bastrop, Texas. On the other hand, Bastrop, Texas source outgrew the Tennessee source under the higher temperature treatments of 30º. The response by two provenances of loblolly pine to controlled night temperature treatments was not interpretable and these experiments will have to be repeated.

Red maple plants of Northern provenance tend to go dormant under treatments with night temperatures above 23° C. and below 10° C. They also grew poorly and tended to go dormant under treatments with low daylight intensity. The 16-hour photoperiod used in all experiments was theoretically sufficient to permit active growth of all sources of red maple. These observations indicate that temperature and low light intensity may counteract favorable photoperiodic conditions and bring about terminal bud formation and the onset of dormancy by red maple. The red maple from Vermont grew well in the greenhouse, but grew very poorly and set terminal buds under artificial light of 1000 ft. candles or less, The Florida source of red maple grew well under both lighting conditions. This indicates that the Florida source is more tolerant to low light intensities than the Vermont source. This laboratory observation of racial variation in tolerance supports the field observations of ecologists who suggest that Southern provenances of a species are prone to be more tolerant to competition than Northern provenances.

If one examines the species range map with all of the described physiological variations in mind, it is hard to conceive two points 50 miles apart between which plants can be transported without incurring some loss of growth. Economic considerations do not permit the development of genotypes tailored to fit every ecological niche in the range of a species. Fortunately there is a large amount of variation within geographic populations and the best progenies from one locale usually will outperform the average progenies from another locale. Therefore, genetic strains can be developed that will give superior (but not optimal) performance over a fairly large geographic provinces. The experiences from plant breeding work with corn and other agronomic crops indicates two or three genetic strains will adequately serve the needs of a fairly large state. Of course, states like North Carolina or California will require extra attention because of the diverse environments that exist within their borders.

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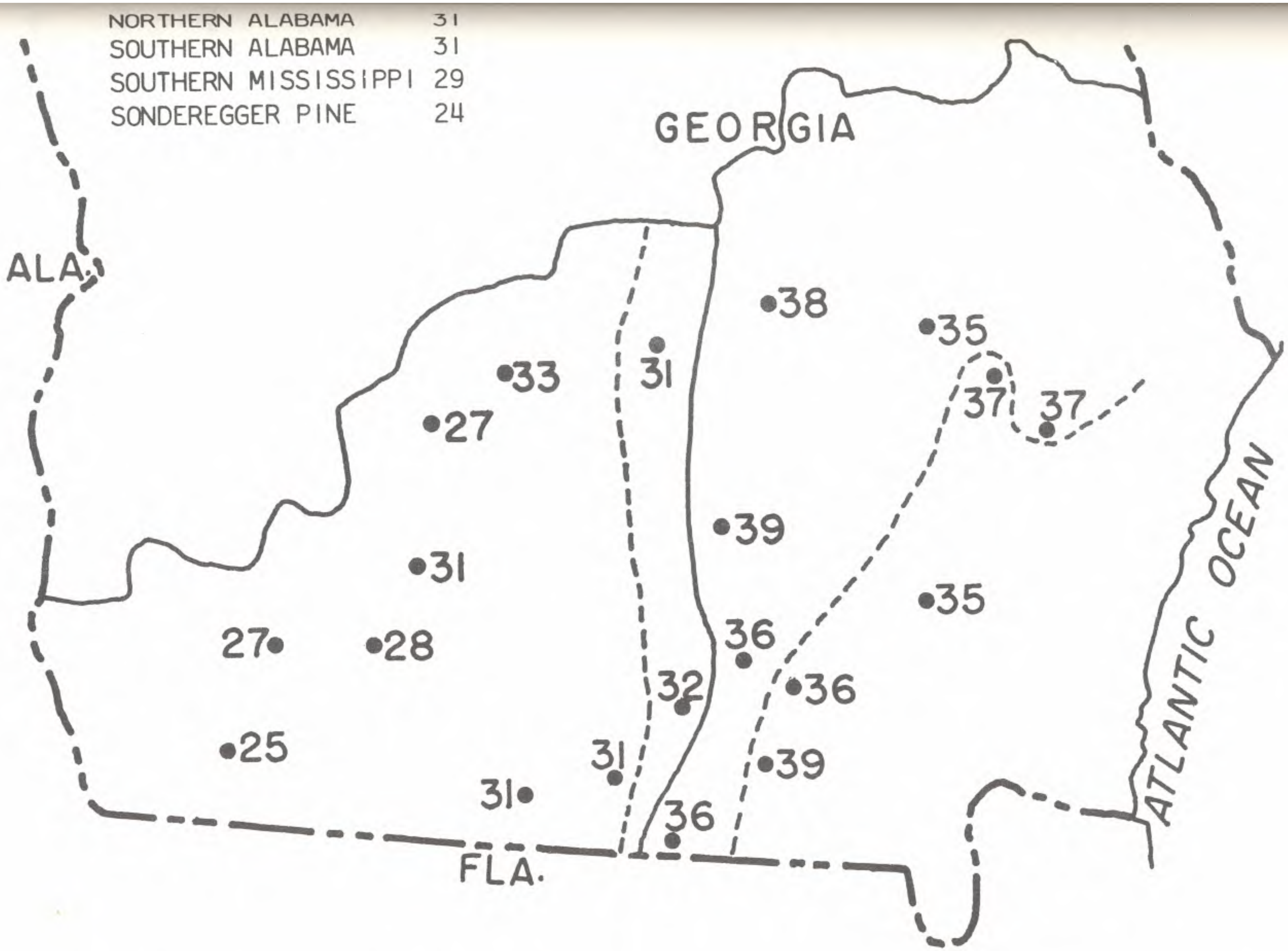

FIG. 1. NUMBER OF ROOTS PER SEEDLING FROM SAMPLED LOCATIONS. SOLID CURVED LINE DEMARKS AREA WITH HIGH VS. LOW NUMBER OF ROOTS PER PLANT, DOTTED LINES ENCLOSE LOCATIONS HAVING HIGH TOTAL ROOT LENGTH. THREE TREES WERE SAMPLED AT EACH POINT.