THE EFFECTS OF FLOODING ON THE TRANSPERSION AND SURVIVAL OF SOME SOUTHEASTERN FOREST TREE SPECIES

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Field observations indicate that the distribution of certain forest tree species is modified by periodic flooding of the soil. There appear to be distinct differences between species with respect to the amount of flooding which they will tolerate. Overcup oak, for example, often occurs on areas which are flooded for considerable periods of time during the year, but northern red oak usually occurs only on the better drained sites. Cypress commonly grows on flooded soil, but loblolly pine seldom occurs in such wet locations. Presumably the roots of some species are more susceptible to injury from the lack of oxygen and excess of carbon dioxide found in flooded soils, and injury to the roots usually results in decreased absorption of water and minerals and in damage to the shoots. Since very few measurements of the effect of flooding the soil on forest trees have been made, a study was planned on potted seedlings.

It was assumed that injury to the roots by flooding would be indicated by a decrease in transpiration resulting from decreased water absorption. Measurement of transpiration should therefore indicate the extent of injury to the roots caused by flooding.


All of these seedlings except cypress had been grown out-of-doors in clay pots for two years and were about 16 inches tall. The cypress was brought from the Coastal Plain about four months before the experiments were started and kept out-of-doors in clay pots until used.

Methods

The soil masses containing the root systems of the experimental plants were transferred from clay pots in which they had been growing to metal cans painted with asphaltum on the inside and white enamel on the outside. Tops of all cans were covered with two layers of oilcloth which had been cut so that the cloth might be placed around the stems of the plants. Seedlings of each species were tested in groups of six, three individuals
being flooded and three kept in soil at approximately field capacity as controls. An exception to this procedure was the last experiment in which only one species was used as a control. Previous work indicated that the principal difference in daily transpiration rate between different species of forest tree seedlings kept in soil at field capacity is largely accounted for by differences in the root and leaf surface (Parker, 6). It thus seemed sufficient in this experiment to use only one species as a control.

After a preliminary test period during which transpiration rates were measured every 24 hours, the soil of three plants of each species was saturated with tap water so that the water level stood about two inches above the soil surface. About every three days flooded containers were opened at the tops and water added to maintain the levels. Control containers were watered approximately every two days to maintain the soil at field capacity. After one month of flooding containers were drained by allowing them to lie on their sides with covers removed for a period of 12 hours. Transpiration rates were measured by successive weighings of containers at

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**Fig. 1.** Transpiration of white oak and swamp chestnut oak seedlings in flooded soil plotted as percentages of the expected rates. Spring 1948.
24-hour intervals. All plants were kept in the greenhouse and were distributed at random on a shelf under unshaded glass.

Transpiration rates are expressed as a percentage of the expected rate somewhat according to the method of Gradmann (3). The behavior of the treated and control plants is compared before flooding and a factor derived which may be applied to the control rates at any time during the experiment to find the "expected" rate of the treated plants. The expected rate is calculated, therefore, on the basis of the pre-flooding behavior and on the continued behavior of the control plants throughout the experiment. Values plotted are the average daily values of the flooded plants divided by the average expected rates for each day, times 100.

Results

The effects on transpiration of flooding seedlings of white oak and swamp chestnut oak in the spring of 1948 are shown in figure 1. Flooding resulted in a decline in transpiration which was essentially the same for both species. Recovery was also similar for both species. There was, therefore, no evidence that swamp chestnut oak tolerates flooding in closed containers better than does white oak.

Results of flooding eastern red cedar, red oak, and dogwood in the

![Fig. 2. Transpiration of red oak, red cedar, and dogwood seedlings in flooded soil plotted as percentages of the expected rates. Summer 1948.](image)
summer of 1948 are shown graphically in figure 2. There was little or no difference between red cedar and red oak in their reaction to flooding. Both species declined in transpiration at a rate similar to that of white oak and swamp chestnut oak shown in figure 1. The leaves of dogwood, how-

Fig. 3. Transpiration of red cedar, cypress, and loblolly pine seedlings in flooded soil plotted as percentages of the expected rates. Autumn 1948.

ever, showed a discoloration after two days of flooding. At the same time transpiration decreased rapidly. Leaves became a mottled reddish color on the third day after flooding, then curled and dropped off. A single bud on one dogwood opened after flooding and its leaves remained healthy
in appearance for about three weeks, but died shortly afterwards. Another set of three dogwoods was flooded in the summer of 1949, but all leaves did not die for almost three weeks after flooding. Weather was about the same in both experiments. One month after drainage oaks and cedars recovered to about 60% of the expected rate. It is probable that two months after drainage enough new roots would have developed to bring the absorption rate back to the expected level as indicated by the transpiration rate.

The effect of flooding loblolly pine, red cedar, and cypress in the autumn of 1948 is shown graphically in figure 3. Red cedar suffered most rapidly from flooding and loblolly pine suffered only slowly at first. Cypress continued at about the expected normal rate after a temporary high rate in the first two days of flooding. After drainage, transpiration of loblolly pine fell to the same level as that of red cedar. The cause of this is not clear. The decline of the transpiration of cypress was believed to be associated with the exposure of roots to air that had grown into the water layer above

![Graph](https://example.com/graph.png)

**Fig. 4.** Transpiration of red oak, swamp chestnut oak, and overcup oak seedlings in flooded soil plotted as percentages of the expected rates. Spring 1949.
the soil. These roots were growing directly upward into what was presumed to be the better aerated water at the surface.

An attempt was made to duplicate the results of the previous experi-
ments in one further experiment. This was carried out in the spring of 1949 using red cedar, loblolly pine, cypress, red oak, swamp chestnut oak, and overcup oak. Results are shown graphically in figures 4 and 5. Loblolly pine and red cedar behaved as they had in the previous experiment. The increase in transpiration rate of cypress before flooding may be related to rapid root growth after being transferred from the clay pots to the cans containing a small additional amount of new soil. At least, there was no definite decline as was observed with the other species.

All oaks behaved somewhat similarly but about four days before the end of the flooding period overcup oak seedlings began to produce a second crop of leaves, the first having appeared earlier that spring before the experiment was started. By the end of the experiment the second crop of leaves was almost fully developed, and undoubtedly this accounts in part for the increase in transpiration during the period just before and after the time of drainage.

Discussion

These results with forest tree seedlings are somewhat similar to those of Childers and White (2) obtained with young apple trees and those of Loustalot (5) with pecan seedlings. These writers found that transpiration rates were sometimes reduced in two days, although a somewhat longer time was commonly required. Heinicke (4) observed that when the soil in which one-year-old apple tree seedlings were growing was flooded in summer, leaves showed injury in about one month, but no damage resulted from flooding in the winter months.

In general the results reported here support the conclusions of Caughey (1) who found that a number of species which grow on soils flooded for long periods of time are injured as quickly by flooding as species which grow on drier sites. However, in the experiments done by the present writer, a much greater ability to withstand the flooded condition was exhibited by cypress. Overcup oak also behaved differently, but its original decline of transpiration rate was similar to that of most other species tested.

The sudden increase in transpiration rate just after flooding in a number of experiments suggests that the soil moisture was somewhat limiting to absorption even though it was near the field capacity before flooding occurred.

Summary and conclusions

A study of the effects of flooding the soil in which a number of species of forest tree seedlings were growing showed a considerable amount of similarity in reduction of transpiration rate. There were, however, certain differences exhibited between species which ordinarily grow in widely different sites.

Cypress seedlings showed an outstandingly high level of transpiration rate after flooding, although there was evidence that the roots did not grow as well in the more poorly aerated levels of the container as in the better
aerated levels. Overcup oak showed a decline similar to the other oaks in the first few days of flooding, but unlike the other oaks, produced a second crop of leaves.

Red cedar, red oak, loblolly pine, white oak, and swamp chestnut oak all showed a similar response to the flooding treatment. Leaves of dogwood seedlings died shortly after flooding in one experiment but when the experiment was repeated the leaves died only after three weeks of flooding.

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