Effects of Understory Removal in Hardwood Stands

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ABSTRACT: Control of understorey vegetation has frequently been suggested as a method of increasing overstory growth by reducing competition for soil moisture. However, past studies have given conflicting results: some show marked increases in growth rate resulting from understorey removal, while others show no effect. Results of understory removal in an oak-dominated, mixed-species hardwood stand in central Massachusetts showed no growth increase compared to control plots, even over 13 growing seasons. Most other southern New England studies found no response on a variety of glacial till soils with a wide range in soil moisture-holding capacity. Understorey removal does not appear to be a useful technique to increase growth in hardwood stands on glacial till soils in the Northeast, apparently because soil moisture is not usually limiting to tree growth on these sites. Results are compared with those from other regions in the eastern United States.

Forest stands often contain large numbers of understory trees and shrubs, particularly following thinnings that create temporary gaps in the overstory canopy. Removal of this understorey vegetation has been suggested and repeatedly tested as a means of increasing growth rates of overstory trees. Because this vegetation does not compete with overstory trees for crown space, its removal increases overstory growth only insofar as it reduces root competition for water and nutrients (Smith 1962, Dale 1975). Direct measurements of soil moisture in stands of pine (Zahner 1958) and hardwoods (Johnson and Kowner 1956) have shown that removal of understorey vegetation increases the water available to the overstory. Some studies clearly show an overstory growth response, particularly in southern pine stands (e.g., Bowser and Ferguson 1968, Grasso 1970). However, on sites where moisture is not a limiting factor to growth, a growth response would not be expected to occur even with increased water supplies. And indeed, no measurable growth increase occurred in other studies (e.g., Lotti et al. 1960, Kneilig and Stout 1960). Variation in both soil characteristics and climatic factors associated with water balance would be expected to control the range of conditions in which overstory growth response would occur. In the eastern half of the United States, climatic factors vary in a broad geographic gradient: precipitation decreases from coastal areas northward and westward, while temperature increases from north to south. Upon these gradients is superimposed a relatively fine-scale variation in soil texture and depth.

Most studies documenting response to understorey removal give results from a single site, and many give little information on site conditions of the study area. Failure to consider the diversity in responses found on a range of sites may lead to unwarranted generalizations concerning the effectiveness of treatments. It is our observation that many foresters simply assume that an overstory growth response will occur, since it is logical to assume that a reduction in competition will occur.

This study reports the 13-year growth responses to understorey removal in a mixed-species hardwood stand in Massachusetts, and compares results to those of similar studies in the eastern United States to assess the range of conditions in which treatments are likely to have effects on overstory growth rates.

STUDY SITE AND METHODS

The study site, on the Harvard Forest in central Massachusetts, lies on the northwest-facing slope of a drumlind hill at an elevation of 1100 ft. Precipitation averages 44 in/yr, evenly distributed through the year. The soil is a podzolic stony loam developed in thick glacial till, and contains a hardpan at a depth of 20 to 30 in (Lyford et al. 1960). This compacted layer impedes internal drainage and improves soil moisture conditions for the growth of many hardwood species.

The study stand was 40 years old when understory treatments were applied in 1956. It had regenerated following clearcutting of an old-field stand of white pine. A light crown thinning had been made in 1935, at stand age 20, to release selected crop trees. This thinning also favored the survival and growth of understory trees. The stand was densely stocked with a closed overstory crown canopy at the time the experiment was begun.

Within the study stand, 48 contiguous one-acre plots were laid out, each 2300 ft² in area. On a block of 24 of these plots, all understory trees and shrubs were cut in May 1956 and removed from the study area. Understory trees were delineated as all those completely overtopped by adjoining trees, plus those with tops of crowns below the mid-point of the live crowns of adjoining overstory trees. Removing these trees, and the removal of overstory trees, resulted in the total removal of all tree species present in the plots. All understory trees were cut in May 1956 and removed from the study area. Understory trees were delineated as all those completely overtopped by adjoining trees, plus those with tops of crowns below the mid-point of the live crowns of adjoining overstory trees. Removing these trees, and the removal of overstory trees, resulted in the total removal of all tree species present in the plots. The reining 24 plots left unattended to serve as controls. No overstory trees were cut in any of the 48 plots.

For all 48 plots, trees 2 in. and greater in dbh were mapped, and diameters were measured prior to treatment in 1956. Additionally, a tally was made of numbers of trees less than 2 in. dbh, but taller than 4.5 ft. Measurements were repeated in 1960, 1966, and 1989. For each measurement period, gross growth in basal area (P$^2$/3) was calculated for all trees defined as "overstory" at the beginning of the experiment.

RESULTS

Stand conditions at the beginning of the experiment are given in Table 1. The overstory was dominated by northern red oak and paper birch, with these species comprising 80% of basal area. Red maple and white ash were also important overstory species, with 13 other species occurring in small numbers. Little difference existed between the treated and control plots in initial composition or density. The control plot had slightly greater average basal area (0.03), not significantly at $P = 0.65$ and somewhat less northern red oak and more paper birch. Important understory species included white pine, red maple, white ash, black birch, and paper birch. The understory comprised about 25% of...
These studies indicate that a wide range of silicified till soils in southern New England, soil moisture is ample enough. succeeding precipitation does not provide necessary competition to tree trunks, except during severe droughts. Observations by Walters (1978) and Karrin and Lyford (1969) provide evidence of the kind of site that does not have serious soil moisture variation even in less extreme climatic conditions. Walters found a significant overstory growth response in a small, well-drained maple stand in Vermont following removal of a dense undergrowth overstory. This site contained numerous outcrops and ledges, and soil depth averaged less than 1 m deep. The soil was described as a shallow, coarse-textured, very rocky loam with low available soil moisture capacity. Karrin and Lyford found that during a dry year at Black Forest (growth-year precipitation consistently 15% of average), one undergrowth mortality occurred, but primarily on ridgtops and steep, west-facing, upper slopes with very shallow soils and considerable amounts of exposed bedrock. This was the same period in which understory treatments had no effects on growth on nearby east-facing slopes. This was as described above (Karrin and Stout 1969), and their results are of the same magnitude, but there is no evidence that these sites are not considered timberland sites in any case. The studies described above all concern overstory growth and understory growth in glacial outwash sands and gravelly soils, and understory growth and understory treatments may provide important competition to overstory growth on these, just as in the examples of the shallow till soils. However, studies are lacking for these kinds of sites in the Northeast, and reliable predictions cannot be made. Overstories on outwash and gravelly soils high proportions of pine, so growth responses would be affected by different species' sensitivities to moisture shortage as well as by soil differences.

Other Regions

A study by Dale (1975) extends the range of observations across the Central States to areas of lower precipitation. A series of five experiments in presettlement forests in Indiana, Michigan, and Wisconsin while oak showed that understory removals produced no overstory growth effects. An exception to the forest stands of the region (eastern Kentucky and Ohio), whereas basal area growth increases occurred on 2 of 3 sites in Missouri and Iowa. Dale attributed the geographical trend to lower average precipitation at the more western sites. Detailed site descriptions were not given, but site index data (97-75 ft at 50 years) indicate that all were of average site quality. Further support for this geographical trend is given by a series of studies on growth of loblolly pine and shortleaf pine stands with hardwood understories. Studies from Missouri (Rogers and Brinkman 1965) and Arkansas (Bower and Fergusson; 1969; Grano, 1970) showed 20% to 33% increases in basal area growth for stands where understories were removed. Similar studies in areas of higher precipitation on the Atlantic and Gulf coastal plains (Lottt et al. 1960, Russell 1961) showed no response. This pattern is not without exception; Langdon and Troubleshooting (1974) reported a 20% increase in growth of loblolly pine following understory removals on 15% of the land in South Carolina. Exclosures at these sites are primarily due to variations in local site characteristics.

Tree Quality Considerations

During the 15-year duration of the present study, Stark et al. (1973) developed on overstory trees in either the control or treated plots. However, the study was substantially continued, after reducing overstory density in the treated plots, residual oak stands showed parallelly following this treatment. In other Harvard Forest studies where the understory was deliberately left in place during overstory thinning, the incidence of residual stems was higher, and the basal area growth decreased. This appeared to be much lower. Thus, while understory trees have less or no negative effect on growth of overstory stems may markedly increase stem quality.