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Root Competition in a Low-elevation Grand Fir Forest in Montana: a Trenching Experiment

Abstract

Plots were trenched in an old-growth bottomland grand fir, *Abies grandis*, forest in western Montana. Cover and density of herbaceous species increased throughout the first five years in the trenched plots as contrasted with untrenched control plots. The release of the undergrowth by trenching demonstrates the importance of root competition, presumably for moisture and nutrients, in suppressing the undergrowth in these forests.

Introduction

Shady forest floors that are nearly barren of plants are common in the mesic coniferous forests of the Pacific Northwest. One's first impression, that light is limiting the undergrowth (herb and shrub layers), may be misleading. Trenching experiments in eastern North America (Toumey and Keinholz 1931, Korstian and Coile 1938) and Europe (Fricke 1904, Fabricius 1927) suggest that root competition may be more strongly limiting than light under dense canopies. These experiments release undergrowth from root competition by trees. A trench is dug around a plot, severing all roots, then the trenches are refilled. Soil moisture and nutrients (nitrate and ammonium, Vitousek 1977) in the plot increase because of reduced uptake by surrounding trees, and the effect of this treatment on the undergrowth is observed for several years. These experiments have shown that root competition inhibits the undergrowth.

I established trenched plots at two locations in western Montana to see if similar results would be obtained in closed-canopy bottomland conifer forests. On these sites a high water table could possibly ameliorate the water stress on the forest floor by providing an abundant supply for trees and perhaps shrubs and herbs.

Methods

Two pairs of similar control and treatment plots (2 x 2 m) were selected at a moist bottomland site with suppressed undergrowth at the University of Montana Biological Station (47°52'35"N, 114°01'50"W) on Flathead Lake. The stand was on soil developed from sandy and gravelly alluvium. The site was dominated by grand fir (*Abies grandis*), with occasional western larch (*Larix occidentalis*) and douglas fir (*Pseudotsuga menziesii*); nomenclature follows Hitchcock and Cronquist (1973). The shrub, herb, and bryoid layers were species poor and low in cover. Beadlily (*Clintonia uniflora*) and Hooker fairy-bell (*Disporum hookeri*) were the most prominent undergrowth species. No plots were beneath canopy gaps and all were similar in species composition and total cover at the outset. Plots were nearly level and contained no trees. Control (untrenched) and trenched plots were close to one another (>3 m and <15 m apart).

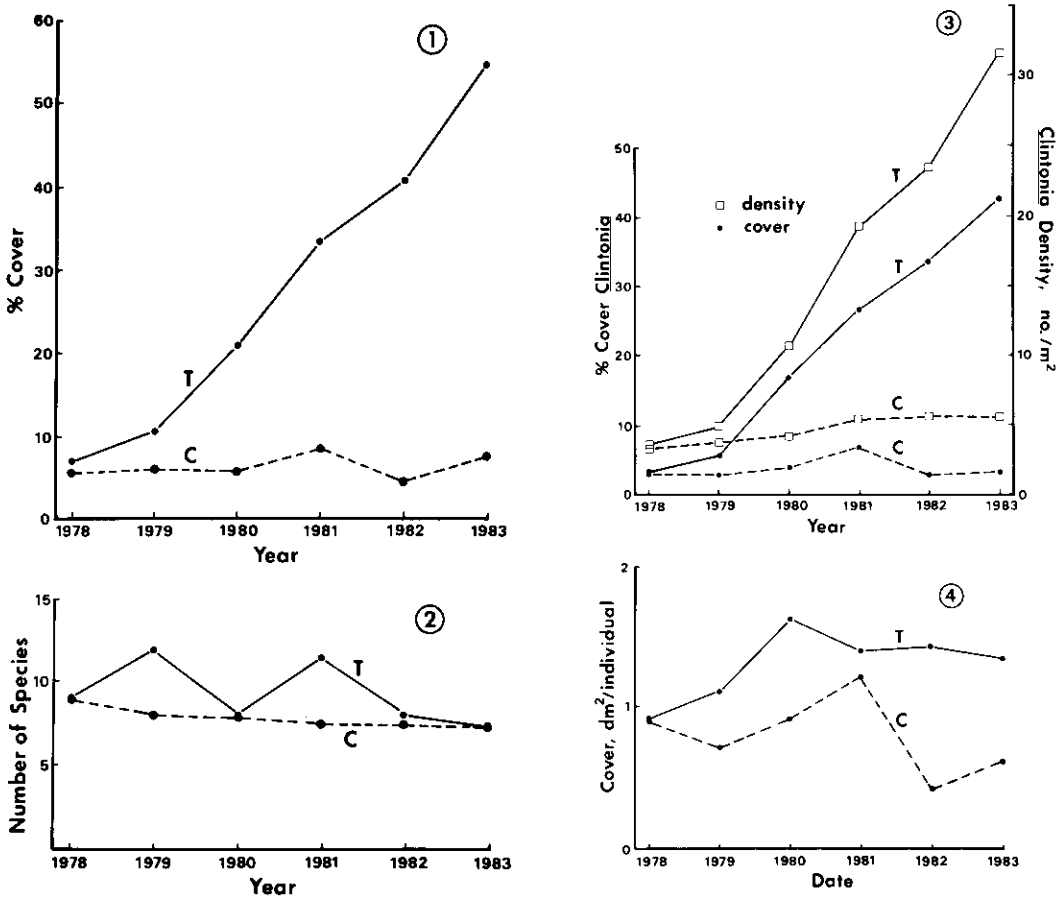
Trenches were dug in July, 1978 to a depth of 0.5 m on the perimeter of the plots. This severed most roots entering or leaving the plot, as most roots were in the top 0.3 m of soil. The plot sides of the trenches were lined with 4 mil polyethylene, then the trenches were filled. While trenches were being dug, soil was piled on plastic sheets adjacent to the plots. Corners were permanently marked with 0.5 m sections of 1 cm steel rods.

Cover of each plant species was recorded in midsummer (between 9 July and 4 August) by visual estimation in each 1 x 1 m quarter of each plot. Density was also recorded for those species whose individuals are relatively distinct. Data were collected each year from 1978 through 1983.

Results and Discussion

Overall Response

Total plant cover increased from 7 percent (1978) to 55 percent (1983) in the trenched plots, while cover in untrenched control plots remained relatively constant at about 6 percent for the five-year period (Figure 1). The response to trenching was similar in both Flathead Lake plots.



Figures 1-4. Changes in trenched (T) and control (C) plots at Flathead Lake from 1978 through 1983. 1. Total percent cover. 2. Plant species richness. 3. Cover and density of *Clintonia uniflora*. 4. Average cover of individual ramets of *Clintonia uniflora*.

The number of species showed little overall change on both trenched and control plots at both sites. However, trenched plots at Flathead Lake showed greater fluctuations from year to year than did control plots (Figure 2). These fluctuations (net loss or gain of 3-4 species per year) resulted mainly from fluctuations in seedling establishment and survival: seedlings observed in one year were commonly absent the next.

Components of Response

Changes in overall cover and density on the plots can be broken down into several aspects of population dynamics: (a) changes in the size of individuals resulting from growth and environmental fluctuations, (b) recruitment of new individuals, and (c) mortality. Each aspect is considered below. Since changes in the abundance of *Clintonia uniflora* accounted for most of the increase in cover on trenched plots, it is the focus of the following analysis of population dynamics.

Changes in size of individual ramets. The increase in cover of the most abundant species, *Clintonia uniflora* (Figure 3), was partly due to the production of more above-ground leaf area from existing ramets. Average cover of individual ramets on trenched plots rose from 0.9 dm^2 in

1978 to a peak of 1.6 dm^2 in 1980, then declined to 1.3 dm^2 by 1983 (Figure 4). The drop in average size after 1980 may reflect the increase in density of small first- and second-year *Clintonia* ramets. By contrast, average cover of individual *Clintonia* ramets on control plots fluctuated between 0.7 and 1.2 dm^2, then fell to near 0.5 dm^2 in 1982 and 1983 (Figure 4). These fluctuations apparently were caused by changes in the leaf area of individual ramets, assuming that mortality and recruitment of ramets were negligible.

Recruitment. In the first year after trenching, density of *Clintonia* ramets at Flathead Lake was nearly unchanged. Since then, density increased at a fairly constant rate of 5-8 ramets/m^2/yr (Figure 3), a rapid increase considering the low starting densities of < 10 ramets/m^2. Density of *Clintonia* remained nearly constant in the control plots.

Mortality. Because individuals were not marked and followed, mortality can only be inferred from fluctuations in density. Fluctuations in numbers, and hence probably mortality, of the major herbaceous species were small in both control and trenched plots. There were, however, pronounced fluctuations in shrub and tree seedlings in both control and treatment plots. First-year seedlings of Rocky Mountain maple (*Acer glabrum*), serviceberry (*Amelanchier alnifolia*), *Abies grandis,* and *Pseudotsuga menziesii* were frequently found, although very few of these survived a second year. Leaves on the shrub seedlings were often partly eaten, suggesting that herbivory may account for much of their mortality.

This experiment shows that root competition, presumably for water and nutrients, can limit the development of herbs beneath a full coniferous canopy, even on moist alluvial bottomlands. While this experiment suggests an important role of root competition in limiting the undergrowth, it does not imply that light, allelopathy, or other factors are not important.

Acknowledgments

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