St. Olaf College

Local Ecology Research Papers

Comparative Growth Analysis of Two Restored Thuja Occidentalis Plots

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COMPARITIVE GROWTH ANALYSIS OF TWO RESTORED *THUJA OCCIDENTALIS* PLOTS

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Abstract

Thuja occidentalis (northern white cedar) is a widely distributed North American tree that grows in two distinct habitats: dry, upland sites and wet, lowland sites. There are no apparent cellular differences between populations from either site and any difference is usually site-specific. The purpose of this study was to investigate two populations of *T. occidentalis* at St. Olaf College, Northfield, MN. As part of an ongoing restoration project, two plots of *T. occidentalis* were planted, one near a wetland and the other at a drier, upland location. Soil cores were taken and measured for percent moisture and organic material to examine between and within site differences. Cores of trees with at diameter greater than 5.0 cm were also taken to look at growth pattern differences within one plot. Apical growth was analyzed from previous records. Although differences were found in soil between the, the differences were not significant. Cores revealed within site variation in growth. Significant differences (p = 0.003) was found between heights of trees of similar age in both plots, suggesting that trees on drier sites grow more slowly. All in all, white cedars found at St. Olaf College are growing well in their restored habitat.

Introduction

Restoration attempts to create or recreate a lost or missing habitat, usually for a particular species. When doing this, we look for the best conditions that resemble the species' original habitat. Sometimes a species is successful in more than one habitat and it is not always clear as to which is the best.

Thuja occidentalis, northern white cedar, is a broadly distributed conifer in northern North America. It is a successionally advanced species (Musselman, Lester et al. 1975). Its numbers have been hurt somewhat as populations that surround wetlands disappear as the wetlands disappear, although relatively unbroken lines of white cedars can be found in marginal sites and along cliff faces (Matthes-Sears, Nash et al. 1995). White cedar is naturally found growing in two distinct habitats: dry, upland sites and wet, lowland sites. The lowland sites have a higher water table and the trees are naturally resistant to decay (Curtis 1946; Briand, Posluszny et al. 1993). The upland sites are lower in organic material and soil moisture and are naturally adapted to withstand weathering (Habeck 1958; Briand, Posluszny et al. 1993). The older and more slow growing trees are generally found on upland sites as well (Briand, Posluszny et al. 1991; Matthes-Sears, Nash et al. 1995). In general, both site types are wet in the spring, but the upland sites will dry out in late summer because the soil is well drained. Often times, these two habitats are found close together, sometimes less than a kilometer apart, meaning that they would have the same general climate conditions (Habeck 1958). In the past moisture was seen as the limiting factor in the grow of white cedars (Habeck 1958). Overall, upland sites have been seen as the less desirable habitat of the two. However, uplands sites have been shown not to be resource limited (Kelly, Cook et al. 1992). Both site types experience a wide variety of nutrient levels (Habeck 1958). Studies began to focus on the idea that white cedars do not display two distinct ecotypes (Briand, Posluszny et al. 1991).

Studies on the growth patterns of white cedars have shown that differences in growth can be attributed to site-specific rather than habitat-specific environmental factors. No differences in water tissue samples, allozyme patterns, or tree architecture were found between lowland and upland cedars found in Ontario, nor were there differences in nitrate, phosphorus, or calcium levels (Matthes-Sears and Larson 1991). Any response of seedlings, from both sites transplanted to a nursery, to added nutrients or water was physiological, not morphological. Productivity did not go up because of added water (Matthes-Sears, Nash et al. 1995). White cedar is morphologically similar within range, reguardless of habitat (Musselman, Lester et al. 1975). Most variability was found within individual sites instead of between upland and lowland sites. This was especially true for pH and organic material (Musselman, Lester et al. 1975). In general, white cedars demonstrate low genetic variability (Briand, Posluszny et al. 1991). However, there is an unusually great amount of variation in growth in white cedars when compared to other conifer species (Matthes-Sears, Nash et al. 1995).

The purpose of this study was to examine differences in growth patterns of two white cedar plots planted at St. Olaf College, Northfield, MN. The white cedars in the 1999 plot should not differ in height or diameter from the 1993 plot when the cedars were of the same age. Any differences found should be site rather than habitat specific.

Methods

Site Description

As a part of the St. Olaf College Natural Habitat Restoration program, conifers were planted in ten 1/10th hectare transects in 1993 (Site 1) and 1999 (Site 2) to establish areas similar in species composition to coniferous forests found in Northern Minnesota. The St. Olaf Natural Lands were not naturally coniferous forest, but a prairie-deciduous forest transitional area. White cedar could be found in local wetlands. The restoration thus provides education and research opportunities for students and faculty. Eight species of conifers were planted in 1993: jack pine (Pinus banksiana), red pine (*Pinus resinosa*), white pine (*Pinus strobus*), white spruce (*Picea glauca*), (*Picea glauca*), black spruce (*Picea mariana*), tamarack (*Larix laricina*), balsam fir (*Abies balsamea*) and white cedar. In 1999, only six of the species were planted, excluding tamarack and black spruce. The white cedars were planted with black spruce and tamarack near a restored wetland in 1993 and by themselves on a site uphill from the wetland in 1999.

Dendrochronology

Tree cores were taken from six random trees of more than 5 cm in diameter at 15 cm off the ground and examined for patterns in ring width and formation. These patterns were correlated with historic local climate data according to methods found on the Ohio State University dendrochronology web page (McCarthy 2000). Using Microsoft Excel, I found the residuals of the ring widths. I then found the total monthly precipitation for each month in the growing season, March – August, for each year and plotted that against the residuals in a regression graph.

Growth Measurements

To follow the growth of white cedars at St. Olaf, height and diameter measurements were taken in 1995, 1997, 1999, and 2003 for Site 1 and in 2000 and 2003 for Site 2. The data from 1995 were used for Site 1and the data from 2000 were used for Site 2 as an age comparable measure of height. I performed an ANOVA to determine the differences in height in the two sites. To compare the growth of white cedars with the other conifers in the two sites, I performed an ANOVA for each site to plot the heights.

Soil Methods

To examine differences in soil types, I took ten soil cores from five locations within Site 1 and six cores from three locations within Site 2, on two separate occasions. To determine soil moisture, the weight of soil was taken after it was collected and then again after it had been in a drying oven at 105° C for 48 hours. The difference between the weight of the wet and dry soil was divided by the weight of the dry soil and multiplied by 100 to determine the percent moisture in each sample. To determine the percent of organic material in each sample, we ran the soil through a 2 mm sieve and dried 10-20 g first at 37° C for 24 hours, then 105° C for another 24 hours, and finally at 500° C for two hours. The decrease in sample weight between the 105° and the 500° was divided by the 500° weight. The values for each site were averaged per location and these averages were compared with an ANOVA.

Results

No significant correlation was found between precipitation and ring width for the white cedars at St. Olaf College (Figure 1). There was a significant correlation between height and diameter (p-value < 0.0001), allowing for a comparison of height between sites. There was also a significant difference between the comparable heights of trees from each site (p-value = 0.003, Figure 2). White cedar appeared in the middle range of heights for all species planted at both sites (Figure 3 and Figure 4). There was no significant difference between the percent soil moisture or the organic material in both sites (soil moisture p-value = 0.25 and soil moisture = 0.3489). The average soil moisture for Site 1 was 17.188% and for Site 2 was 15.535% (Figure 5). The average percent organic material at Site 1 was 4.912% and 4.511% at Site 2 (Figure 6).

Discussion

The great variability in ring width within the site is congruent with previous studies. Widths of rings is independent of habitat and can be variable within the site (Kelly, Cook et al. 1992). Matthes-Sears, et al. found that white cedar tree rings show little response to precipitation (1995). This is associated with the fact that water is not always the limiting factor for the growth of white cedars. Other limitations include wind, competition, or loss of substrate (Matthes-Sears, Nash et al. 1995). Too much water, in addition to too little water, can also limit their growth (Matthes-Sears and Larson 1991). The behavior of the rings of white cedar is similar to that of bristlecone pine (*Pinus longaeva*) one of the oldest living organisms on Earth. Some studies have suggested that white cedars could be an eastern equivalent to bristlecone pine and could be used extensively to recreate past climate histories (Briand, Posluszny et al. 1993).

In addition to a wide variety of ring widths, white cedar also shows a wide variety of growth rates when compared to similar species or other conifers (Figure 3 and Figure 4). This variety is not specific to one habitat or even one geographic area. The white cedars at St. Olaf are growing normally and are in the middle of the height ranges of the trees around them, as would be expected. It is mildly shade tolerant, meaning that it could be expected to be taller than shade tolerant species, such as *A. balsamea,* and shorter than shade intolerant species, such as *P. strobus* (Matthes-Sears and Larson 1991).

The differences of height in the trees of comparable age are surprising. The Site 2 cedars were approximately three years old in 2000 (the year they were measured), while the Site 1 cedars were approximately four years old when they were measured in

1995 (Figure 2). This idiosyncrasy could be explained by differences in planting techniques, preexisting species, or management of the area. Local climatic conditions during the years the cedars were planted could also make a difference. Again, white cedars display such a wide variety of growth patterns, that this may not be abnormal at all (Matthes-Sears and Larson 1991). When trees of dissimilar ages were compared in Ontario, there was still no difference in their growth rates when size values were adjusted for age (Briand, Posluszny et al. 1991).

Because there was no significant difference between the percent soil moisture and organic material in the two sites, perhaps they cannot be classified as either upland or lowland (Figure 5 and Figure 6). Such sites can be called mesic. Such lands as these do not have extreme periods of rain or drought, such as the ones at St. Olaf College. Mesic sites are emerging as a new possibility to consider when restoring white cedar. Little research has been done on this and more should be done to ensure the credibility of such claims (Matthes-Sears and Larson 1991).

Within the traditional two sites, white cedar can live in many microsites. This makes it hard to quantify which of the two sites supports the growth of white cedars better (Matthes-Sears, Nash et al. 1995). "Better" is also hard to quantify, as it might mean longer living, faster growing, or larger in size. Trees grow slower, but longer in upland sites and no differences in size are seen between the two sites (Briand, Posluszny et al. 1991). When considering the proper restoration regime for white cedars, or any organisms for that matter, consideration of all its natural habitats must be taken into consideration (Habeck 1958). Deciding which site is best is not simple. Future studies could compare the white cedar sites on campus to other mesic sites or to other restored areas. Little research has focused on the early growth patterns of white cedars. We could use the trees on the St. Olaf Natural Lands as a unique opportunity to study these early growth patterns. This research could help to shed light on why white cedars display such distinct growth characteristics and habitat preferences.

Figures

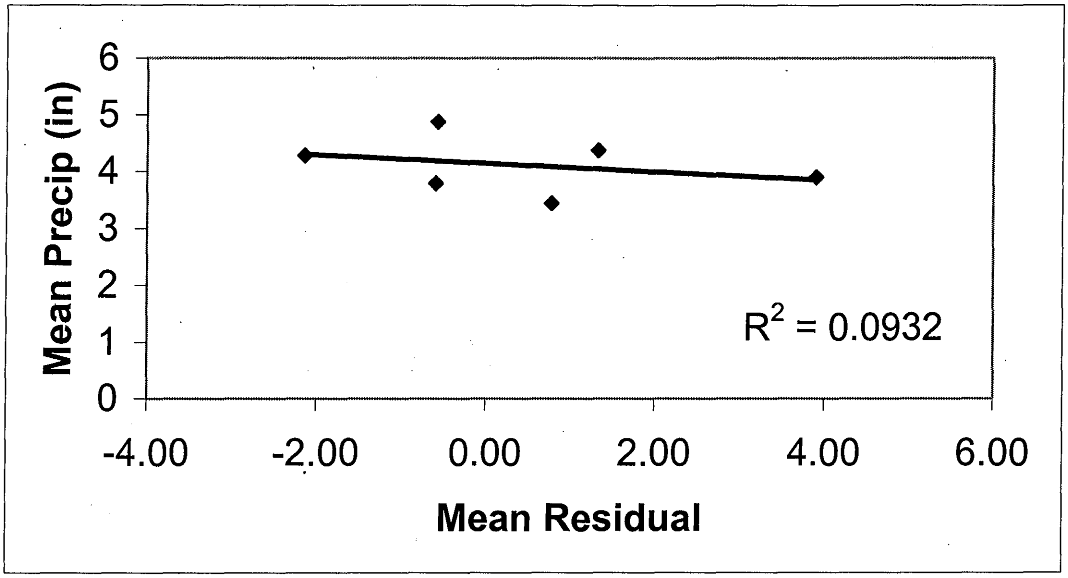

Figure 1. Mean residuals plotted against mean precipitation. There was no correlation between the two variables.

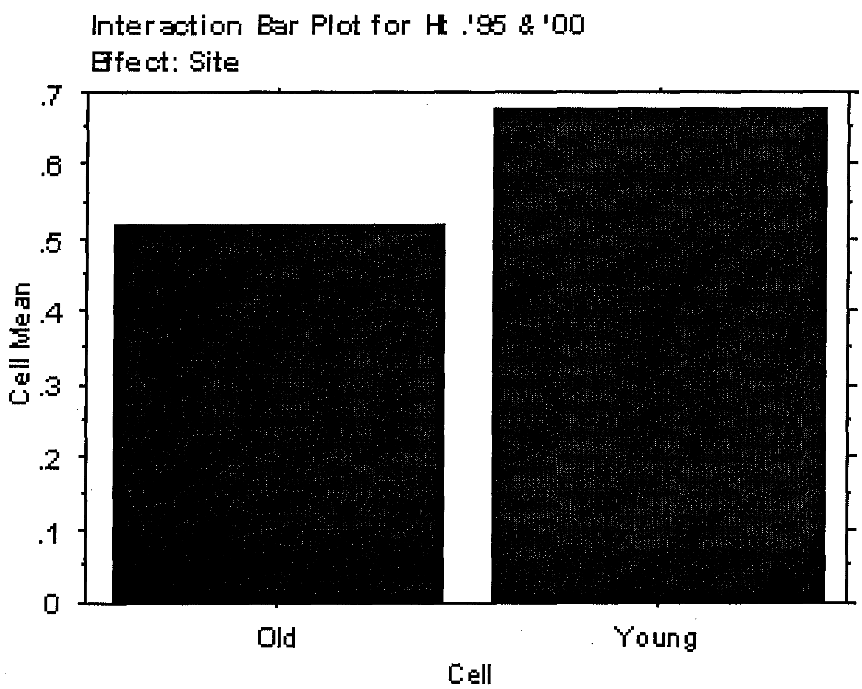

Figure 2. Difference in height between trees of comparable age in Site 1 (Old) and Site 2 (Young). There was a significant difference (p-value = 0.003) as Site 2 was taller.

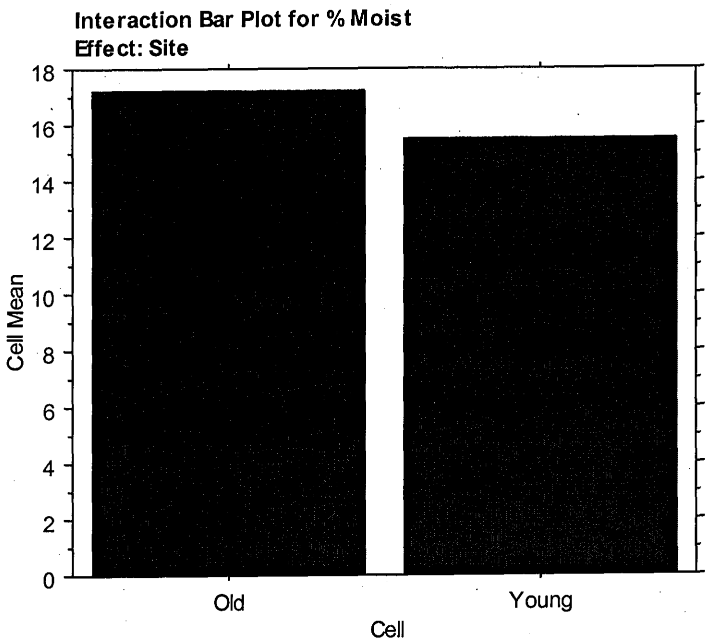

Figure 5. Difference in percent soil moisture between Site 1 (Old) and Site 2 (Young). Site 1 was higher, but not significantly so (p-value = 0.25).

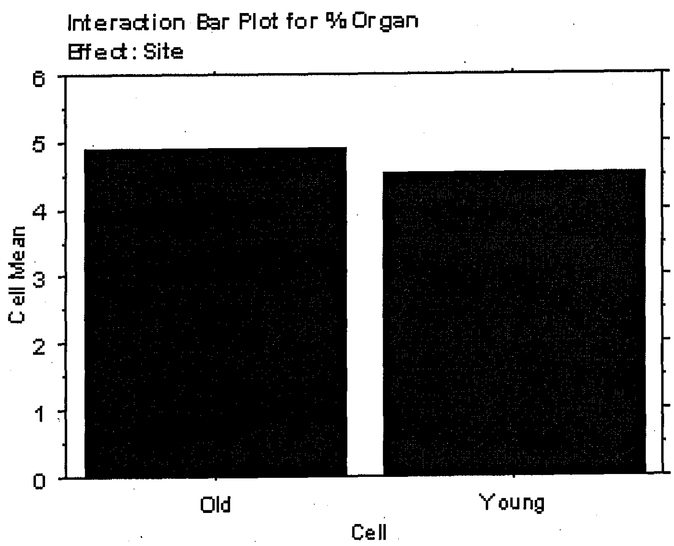

Figure 6. Difference in percent organic material between Site 1 (Old) and Site 2 (Young). Site 1 was higher, but not significantly so (p-value = 0.3489).

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