DENDROCHRONOLOGY OF *AUSTROCEDRUS CHILENSIS* FROM LANIN NATIONAL PARK, SAN MARTIN DE LOS ANDES, ARGENTINA

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Introduction

Austrocedrus chilensis is a widely distributed arid site conifer of the forest-steppe transition zone in Argentina and Chile (from latitude 32°S to 43°S). *A. chilensis* has proven to be an excellent species for dendroclimatic applications (Schulman, 1956; Villalba, 1994) especially for the reconstruction of precipitation. The species can be found on a variety of site types and exposures.

We hypothesized that the best crossdating and climatic signal would be found in *A. chilensis* growing on the most extreme arid sites. We also hypothesized that mortality events mainly represent past drought episodes. We also compared the *A. chilensis* chronology developed for this study with a regional network of existing sites to assess regional growth patterns that may relate to larger scale climate variability.

Site Description

We selected two *A. chilensis* stands growing on two contrasting sites found on a west facing slope near San Martin de los Andes to test this hypothesis.

Site 1. A basaltic cliff face with thin soils, little herbaceous vegetation and no fire evidence. Dwarf *A. chilensis* trees were present and exhibited characteristic signs of old growth including strip bark, dieback, twisted and gnarled branches.

Site 2. At the base of the cliff face and on other flat areas where volcanic soils were deep, the *A. chilensis* trees were larger and abundant herbaceous vegetation covered the forest floor. These deep soil positions were relatively more mesic compared with the rocky site and included various species of *Nothofagus*. They appear to have been disturbed by logging and fire in the recent past.

Methods

Crossdating

We collected core samples of living *A. chilensis* on the rocky and deep soil sites to test the hypothesized difference in crossdating qualities and climatic response. We also collected cross-sections from dead *A. chilensis* to determine their death dates and test the hypothesis that mortality occurs most often during extended drought events.

Regional Climate Signal

Do tree-ring chronologies in northern Patagonia have a regional climate signal? Does the San Martin de los Andes chronology exhibit that signal?

For this analysis, we used two sources of data: a set of 25 tree-ring chronologies from Villalba and Veblen (1997) and two chronologies from San Martin de los Andes. We combined the two San Martin chronologies into a single composite chronology, for a total of 26 chronologies from northern Patagonia.

All chronologies were detrended and standardized with a -2/3 spline. We employed principal components analysis (PCA) to detect any modes of variation in the distribution of loadings among the chronologies. Finally, we used Varimax rotation after the initial PCA to redistribute variance more accurately.

Results

Crossdating

Figure 1a (soil) and **Figure 1b** (rock) demonstrate that ring-width index series from both sites show drought stress, but the “soil” chronology seems be more coherent, while the scatter is larger in the “rock” chronology showing more between tree variation in growth patterns. There are three possible explanations:

1) The trees on the rocky cliff are often damaged by rock fall.

2) The rock site actually includes a range of microsite conditions: some trees have very little available soil and are dwarfed, while trees on ledges grow on deeper soil and experience better growing conditions.

3) Overall, the rock site is extremely harsh, marginal for tree growth. The rock site shows a wider variation in growth than the deep soil site.

Typically the raw ring width chronology should exhibit a decrease in ring size associated with the increasing age of trees. While this is true for our rock site, the soil site shows a period of increasing ring width circa 1920 associated with a sample bias due the recruitment of young trees during this period.

In mesic western forests of South America, earthquakes result in massive recruitment result of trees on landslide sites. Within our research area, the site evidence suggests that fire is the most pervasive disturbance creating extensive even-aged stands of *Austrocedrus chilensis* (Veblen et al., 1992). The increase in young trees on the soil site may be associated with an increase in the fire regime due to European colonial settlement at the turn of the 19th century (Veblen et al., 1992). While these fires killed many of the young trees on the deeper soil, the trees on the rock site were protected.

Figure 2 shows that drought extremes appear to impact tree growth more severely on the rocky site. Notice the many times when the rocky low growth extremes exceed the severity of low growth on the soil site. The arrow indicates low tree growth and mortality of *A. chilensis* associated with a very severe dry event (c. 1955).

Regional Climate Signal

We compared the 2 factors derived from the 26 chronologies with latitude and longitude to determine the geographic pattern associated with the distribution of the PCA loadings. Loadings for the first PCA factor were centered roughly in the center of the geographic distribution (40º), near the locale for the San Martin de los Andes chronology. The first factor is therefore clearly not associated with a geographical gradient. Loadings for the second factor, however, were distributed along a latitudinal gradient. A N-S gradient from 37º to 42º south latitude causes detectable differentiation in tree rings across the observed range of *A. chilensis* (Figure 1). The highest loadings were from chronologies in the south-westernmost portion of the observed range of *Austrocedrus* near the Rio Futaleufu whereas the lowest loadings were from the north-easternmost portion of northern Patagonia near Huinigango. These results suggest that differential site responses to environmental change gradients along the north-south axis of the range of Austrocedrus are likely. Additionally, the San Martin chronology, which is located near the center of both factor distributions, cannot provide much information about extremes in gradients Austrocedrus responds to. However, the San Martin chronology exhibits the same regional signal as most of the other *Austrocedrus* chronologies. Thus, general patterns of regional climate forcings produce similar chronologies in most sites.

In conclusion, the San Martin de los Andes chronology exhibits the regional climate signal demonstrated in Villalba and Veblen (1997). Principle components analysis suggests that tree ring response to climate is consistent throughout northern Patagonia.

Discussion

Our first hypothesis was that the rock site would be more strongly affected by climate than the soil site. Drought extremes do appear to impact tree growth more severely on the rock site, as shown by the number of times that the low growth extremes from trees on the rock site exceed the severity of low growth on the deep soil site.

Our second hypothesis was that tree mortality occurs in dry years. We were able to crossdate 4 trees all of which died between 1955 and 1957. These dates correspond with one of the most severe dry periods of the last one hundred years. This is the same tree mortality event identified by Villalba and Veblen (1998).

We conclude that drought is a factor in forest dynamics of *A. chilensis* on rock and deep soil sites. However on the deep soil sites, fire is also a major factor as shown by massive regeneration of c. 1900s (and potentially in the late 18th century) in the more densely wooded sites in northern Patagonia.

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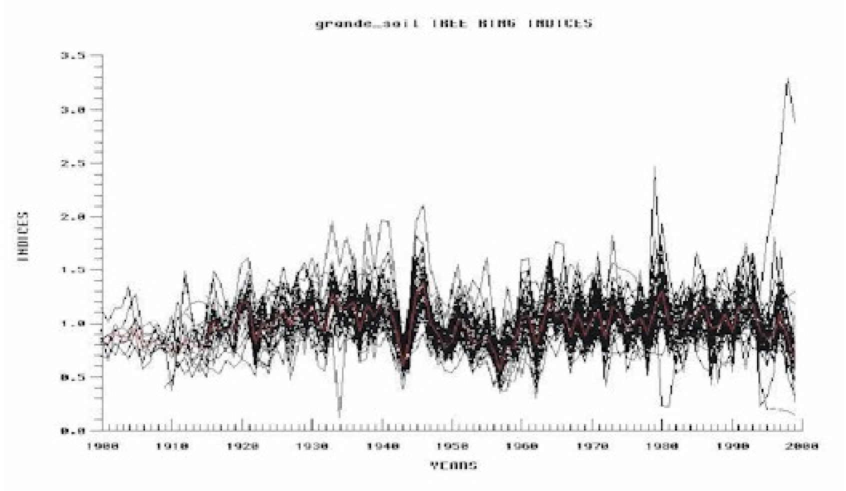

Figure 1a

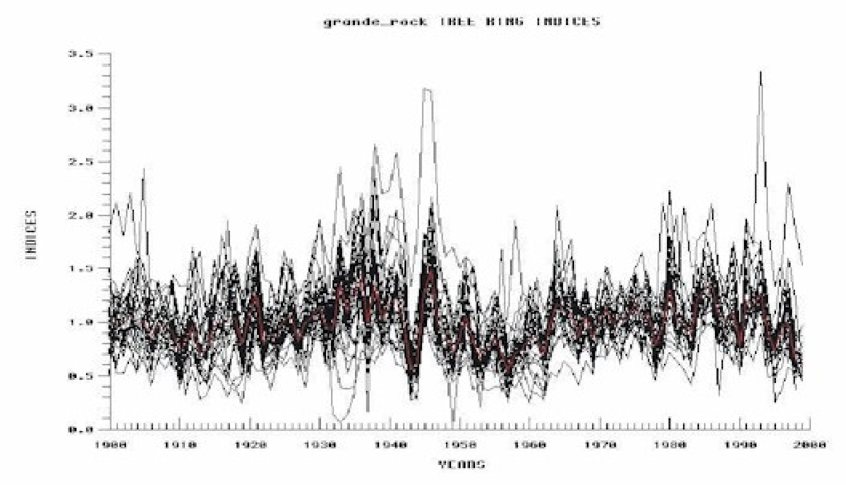

Figure 1b

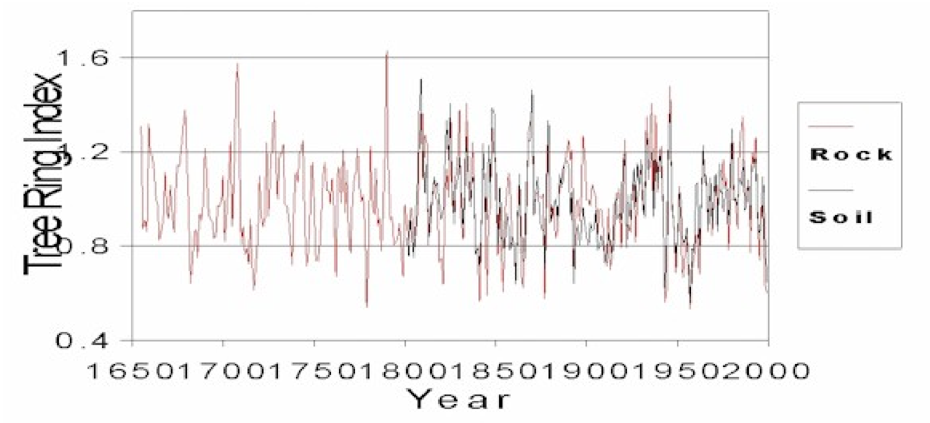

Figure 2