

## RESEARCH REPORT

### FITZROYA CUPRESSOIDES YIELDS 1534-YEAR LONG SOUTH AMERICAN CHRONOLOGY

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#### ABSTRACT

The longest tree-ring chronologies for the Southern Hemisphere published to date go back to A.D. 1011 in central Chile; 1028 in Tasmania, Australia; 1140 in western Argentina; and 1256 on the North Island, New Zealand. For paleoclimatic and other studies longer time series would be very desirable. Here we report on the first successful crossdating and chronology development for *Fitzroya cupressoides*, a redwood-like conifer in western Argentina, which goes back to 441 and exhibits desirable statistical characteristics.

#### INTRODUCTION

*Fitzroya cupressoides* (Molina (Johnson)), common name "alerce," is a tall conifer which grows in the subantarctic forest of Argentina and Chile. The species is long-lived, a highly desirable characteristic in the development of tree-ring chronologies.

Increment core samples of *Fitzroya cupressoides* were collected from adjacent sites by Schulman in 1949, Lerman in 1962, and by a group of us under the direction of LaMarche, in 1975. In this paper we describe the characteristics of a chronology developed with these samples and compare it to *Austrocedrus chilensis* chronologies from nearby sites.

#### GROWTH CONDITIONS

According to Tortorelli (1956), *Fitzroya cupressoides* grows in very humid locales and in swamps. The species is dominant and frequently associates with *Saxegothea conspicua*, *Laurelia sempervirens* and *Drimys winteri*. The trees often attain 50 m in height and 3 m trunk diameter. The sapwood is yellow and the heartwood red-brown. Annual growth rings are clearly visible with a sharp transition from earlywood to latewood. *Fitzroya* has been observed growing outside its described habitat, associated with *Pilgerodendron uviferum* and *Austrocedrus chilensis* in peat-bogs (Boninsegna *et al.* 1981) and in a marsh associated with *Pilgerodendron* and *Nothofagus* (LaMarche *et al.* 1979).

#### SITE DESCRIPTION

The following description of the sampled site has been taken from LaMarche *et al.* 1979:

Río Cisne, Chubut, Argentina, 42°09'S, 71°33'W, 524 to 600 m altitude Río Cisne is a short river connecting Lago Cisne to Brazo Norte del Lago Menéndez in Los Alerces National park, accessible only by boat. Two subsites were sampled here. One is a steep ridge south of Río Cisne, encircled by a path, covered with a dense mature forest of *Fitzroya cupressoides* and *Nothofagus dombeyi*, with heavy underbrush largely of cane (*Chusquea* sp). The other subsite is a level, very humid dense forest of the same association of species near a swampy forest and adjacent to the shore of Lago Menéndez just south of the mouth of Río Cisne.

### METHODOLOGY

The sample collection is curated at the Laboratory of Tree-Ring Research of the University of Arizona. It consists of increment-borer samples from three different collections: nine collected by Schulman in 1949 (Schulman 1956); thirty-five taken by Lerman in 1961-62 and seventy-seven obtained by LaMarche's group in 1975. The samples collected by Schulman and by Lerman exhibit several fractures and in some cases loss of material. It was necessary to resurface them to observe the rings clearly. The annual rings of several samples collected by LaMarche's group had been previously sequenced (counted). Crossdating was done following the technique described by Stokes and Smiley (1968). There was only one absent ring of a total of 22,862 rings in the selected high-quality data set.

Rings were measured with a microcomputer-linked Bannister incremental measuring machine (Robinson and Evans 1980) and the crossdating was verified and corrected with computer program COFECHA (Holmes 1983). Crossdated series were selected for high sensitivity, high correlation with the master series (mean of all other series) and length (more than 200 years). Forty-three selected series from twenty-eight trees were used to build a chronology using computer program ARSTAN (Cook and Holmes 1984, Cook 1985). The "STNDRD" chronology derived by program ARSTAN was compared with five chronologies of *Austrocedrus chilensis* from sites near Río Cisne (LaMarche *et al.* 1979). The comparison was made through the computation of a correlation matrix for the common interval of the six chronologies from 1700 to 1974 (275 years) and through the analysis of the cospectra (coherence and phase) for the same interval, between the Río Cisne chronology and each of the other five.

### RESULTS AND DISCUSSION

The individual *Fitzroya* series show "waves" of surging and suppression (several wide rings followed by several narrow rings). This condition was observed in almost all the series studied. Frequently there are groups of microrings very difficult to measure with accuracy. Also the presence of some wedge rings makes the crossdating occasionally problematic. From 110 samples examined, only 53 were successfully crossdated, which probably indicates a great heterogeneity in the sampled site.

Some statistics obtained with program COFECHA are shown in Table 1. Particularly notable is the variability in the values of the mean sensitivity of different series (.166 to .531). Selected statistics obtained with program ARSTAN are presented in Table 2. The signal-to-noise ratio (7.64), percent of the variance explained by the first eigenvector (30.23) and the mean correlation between trees (.258) fall in the lower part of the usual range of these values in a chronology. Table 3 gives some comparative statistics between the Río Cisne chronology and four nearby chronologies of

**Table 1.** Program COFECHA statistics based on 43 ring-width series from 28 trees.

Characteristics of series	Mean value	Maximum value	Minimum value
Mean sensitivity	.275	.531	.166
Autocorrelation, original measurements	.800	.938	.477
Correlation with master series	.494	.687	.336
Length of series, years	532	1440	219

**Table 2.** Program ARSTAN chronology statistics, Rio Cisne, Chubut, Argentina [*Fitzroya cupressoides*] chronology 441 to 1974 (1534 years) 28 trees, 43 radii.

Chronology type	STNDRD	RESID (AR 5)	ARSTAN
Mean	1.000	1.000	1.006
Median	.979	1.005	.987
Mean sensitivity	.167	.197	.152
Standard deviation	.256	.172	.249
Skewness	.843	-.234	.812
Kurtosis	5.080	3.978	4.902
Autocorrelation order 1	.664	-.035	.694
Partial autocorr. order 2	.290	.021	.183
Partial autocorr. order 3	.189	.044	.127
Variance from autoregression	36.7 pct.		43.6 pct
Error variance	.016738		.012814
Ratio of error variance of chronologies (ARSTAN/STNDRD)			.766
Common interval 1630 to 1899 (270 years) 22 trees, 33 radii			
	DETRENDED	RESIDUALS	
Mean correlations	SERIES	(WHITE NOISE)	
Among all radii	.271	.250	
Between trees (Y variance)	.258	.243	
Within trees	.637	.487	
Signal-to-noise ratio	7.64	7.06	
Agreement with pop. chron.	.884	.876	
Variance in eigenvector 1	30.23 pct	27.55 pct	
Chron. common interval mean	.997	1.000	
Chron. common interval st dev	.213	.149	

*Austrocedrus chilensis*. The percentage of absent rings, chronology first-order autocorrelation, standard deviation and mean sensitivity in the *Fitzroya* chronology are within the range of values reported for *Austrocedrus*. The Rio Cisne chronology has a larger proportion of a variance in the high frequencies, a result that needs to be

**Table 3.** Comparison between Rio Cisne chronology and nearby *Austrocedrus* chronologies (LaMarche *et al.* 1979).

Chronology	Rio Cisne	El Maiten	Estancia Teresa	Laguna Terraplen	Cerro Los Leones
Mean ring width (mm)	0.42	1.24	0.53	1.37	0.56
Absent rings (percent)	0.004	0.35	0.09	0.00	0.30
Autocorrelation	0.66	0.62	0.70	0.54	0.62
Standard deviation	0.26	0.30	0.32	0.23	0.26
Mean sensitivity	0.17	0.20	0.20	0.18	0.17
Correlation between trees	0.26	0.26	0.10	0.30	0.32
Correlation with Rio Cisne chron.	1.00	0.25*	0.13	0.26*	0.08
Percent variance in frequencies: (1)					
0-12 years	73.7	67.5	69.3	61.8	62.5
13-30 years	15.6	20.3	21.2	23.8	27.8
31-50 years	10.7	12.2	9.5	14.3	9.7

Notes:

\* Values significant at the 95% level.

(1) Sum of the variances of the indicated lags in the frequency spectra, expressed as percent of the total spectral variance.

studied in more detail. Correlations between the chronologies are significant for El Maitén and Laguna Terraplén. Figure 1 is a plot for the "STNDRD" chronology computed with Program ARSTAN. It should be pointed out that the interval between the beginning (A.D. 441) and A.D. 924 is less reliable due to the low number of samples in the chronology (less than five).

### CONCLUSIONS

*Fitzroya cupressoides* can be crossdated well and used in the development of long chronologies. The Río Cisne chronology is the longest one in the Southern Hemisphere and its quality is comparable to the other chronologies developed in the same region. The presence in the samples of frequent "waves" of surging and suppression indicates that the relationship between the chronology and climate must be carefully analyzed in order to establish the quality of climatic information contained in the chronology.

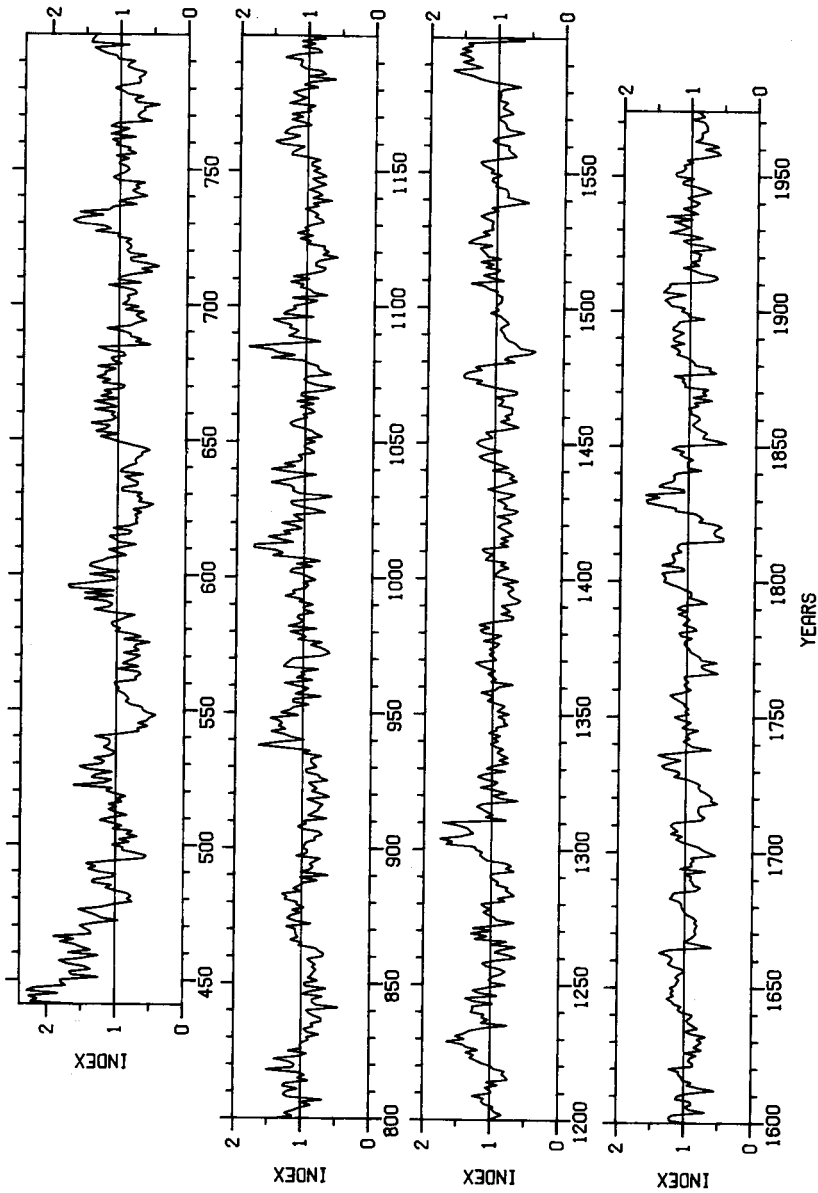


Figure 1. Chronology of ring-width indices for *Fitzroya cupressoides*, Rio Cisne, Argentina.

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