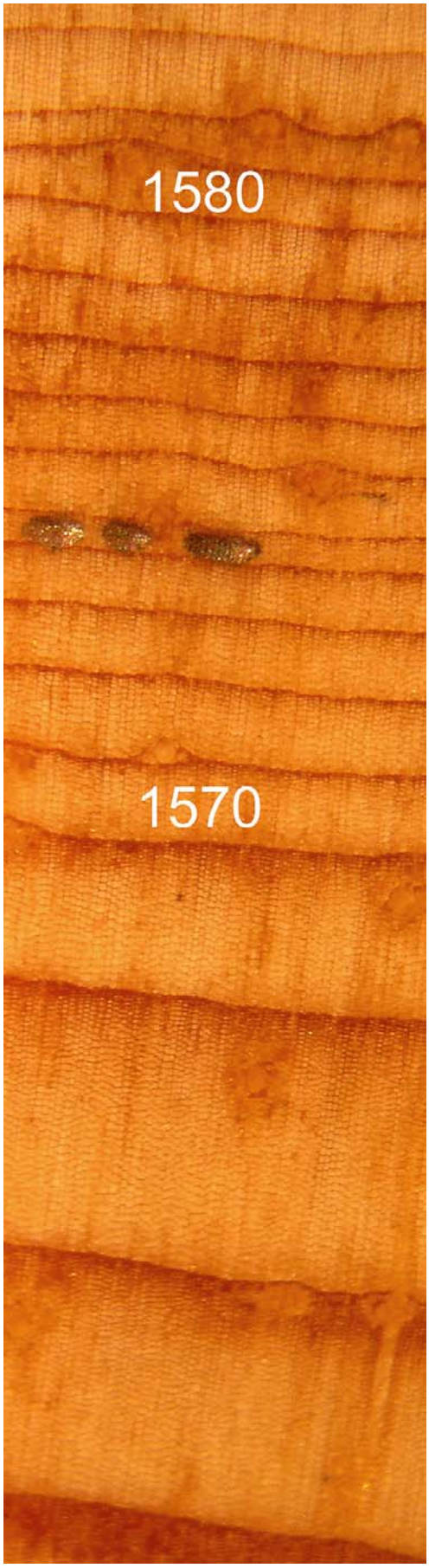

Tree-Ring Resources of the Rocky Mountain Biological Laboratory

A Dendrochronological Investigation
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Prepared for:

John Harte
Energy and Resources Group
310 Barrows Hall
University of California
Berkeley, CA 94720

Christopher Still
Geography Department
3611 Ellison Hall
UC Santa Barbara
Santa Barbara, CA 93106

John King
Lone Pine Research
2604 Westridge Drive
Bozeman, Montana
406.522.0694
lonepine@bigsky.net

Tree-ring sample LPR103. The width of the 1570 ring is 0.432 mm. Reference marks in the 1574 annual ring were used to facilitate measurement and cross-dating.

Background

During July 2004, tree-ring samples were collected in the vicinity of the Rocky Mountain Biological Laboratory (RMBL) facilities located in Gothic, Colorado. The sampling was conducted to make a preliminary assessment of the tree-ring resources of the RMBL. The collection (Table 1) consists of three live tree increment core samples from a single Douglas-fir (*Pseudotsuga menziesii*), five live tree increment core samples from an unknown number of limber pine (*Pinus flexilis*), three live tree increment core samples from an unknown number of subalpine fir (*Abies lasiocarpa* – tentative identification), and three increment core samples from an unknown tree species.

Table 1. RMBL Tree-Ring Samples. Mean sensitivity is a measure of high-frequency variation in tree-ring series (Fritts 1976).

Preliminary Sample ID	Lab ID	Species	Mean Sensitivity	Cross-Dating
Treebeard 7-25-04 inner	LPR100A	PSME	0.147	1733-2003
Treebeard 7-25-04 outer	LPR100B	PSME	0.148	1528-1732
Treebeard 7-6-04	LPR100C	PSME	0.157	1795-2003
PIFL 2 7-9-2004	LPR101	PIFL	0.193	?
PIFL 1 7-9-2004	LPR102	PIFL	0.153	?
PIFL CC Valley 7-9-2004	LPR103	PIFL	0.255	1474-1759
PIFL CC Valley 7-9-2004 Floyd	LPR104	PIFL	0.226	?
AL3 Core1 7-6-04	LPR105	ABLA	0.143	1889-2003
AL3 (?) Core 2 7-6-04	LPR106	ABLA	0.129	1881-2003
AL3 Core 2 7-6-04	LPR107	ABLA	0.121	1882-2003
?	LPR108	?	0.173	?
Virginia Basin outer ½ July 2004	LPR109	?	0.191	?
Virginia Basin inner ½ July 2004	LPR110	?	0.160	?
PIFL CC Valley 7-9-2004	LPR111	PIFL	n/a	n/a

Cross-Dating

Each increment core sample was given a unique identification number and processed using standard techniques (Stokes and Smiley 1968). Exact calendar year dating was established in seven samples by measuring each tree-ring series to the nearest 0.001 mm and subjecting the samples and measurement series to a set of dendrochronological techniques. Direct sample comparisons, skeleton plot matching (Millar et al. *in publication*, Lazear and Harlan 2001), and correlation techniques (Holmes 1983) were used to assess cross-dating quality. Cross-dating positions were confirmed by examining correlation patterns in a comparison of the RMBL samples to tree-ring chronologies archived with the International Tree-Ring Data Bank (ITRDB) [http://www.ngdc.noaa.gov/paleo/ftp-treering.html]. Of the six

ITRDB limber pine chronologies and 24 ITRDB Douglas-fir chronologies available in Colorado, two ITRDB records (Table 2) were found to maximize cross-dating verification in the RMBL samples. Sample LPR111 was not processed or analyzed because it contains only 35 complete annual growth rings, an insufficient number to verify cross-dating patterns. Low mean sensitivity, poor climate-growth relationships, environmental differences between the ITRDB sites and the RMBL site, and interspecific growth response differences are possible causes for unsuccessful cross-dating in six of the RMBL samples.

Table 2. International Tree-Ring Data Bank Chronologies.

ITRDB #	Site Name	Species	Period of Record	Location	
CO580	Land's End	PSME	1135-1999	N39° 00'	W108° 09'
CO545	Niwot Ridge	PIFL	1330-1987	N40° 03'	W105° 33'

Chronology Development

Standard tree-ring chronologies (Figure 1) were developed for: 1) the three cross-dated Douglas-fir samples, 2) the one cross-dated limber pine sample, and 3) a composite of the two ITRDB reference chronologies. A chronology was not developed for the three cross-dated subalpine fir samples due to the short length of this record. The chronologies were compiled by removing age-related trend and other nonclimatic features from the data by fitting a negative exponential curve or straight line of zero or negative slope to the measurement series. Dimensionless indices resulting from the ratio of actual to modeled growth were combined into standard chronologies (Cook and Holmes 1986).

High-frequency (inter-annual) correlations between the RMBL samples and the ITRDB composite chronology, and among the RMBL samples, were calculated after standardizing the tree-ring measurement series and chronologies with a 15 year cubic smoothing spline (50% frequency cutoff) and log transformation (Table 3).

Table 3. High-Frequency Correlation Matrix. See cross-dating results in Table 1 for time periods of comparison.

	RMBL PSME	RMBL PIFL	RMBL ABLA
RMBL PIFL	0.40		
RMBL ABLA	0.40	n/a	
ITRDB Composite	0.53	0.38	0.48

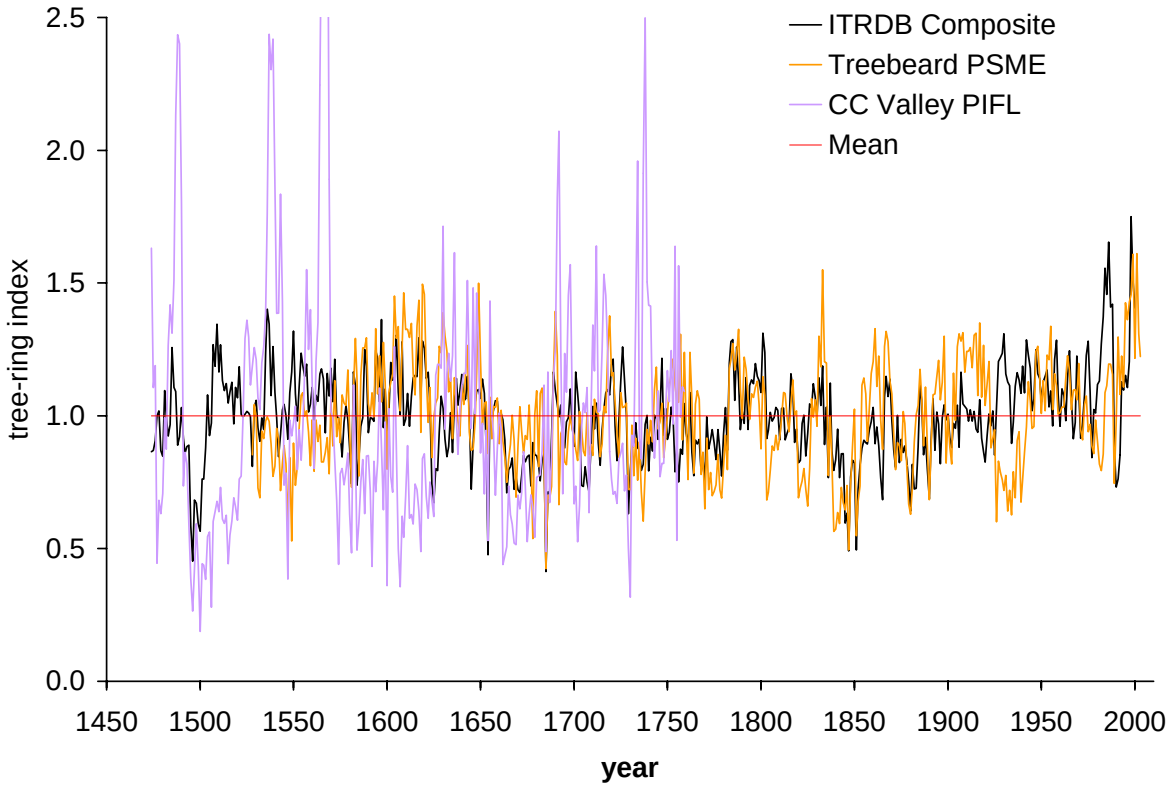

Figure 1. Standard tree-ring chronologies. The red horizontal line indicates mean growth for the period of record. ITRDB records CO580 (Douglas-fir) and CO545 (limber pine) were combined to form the ITRDB composite chronology.

Discussion

Successful cross-dating of the RMBL samples demonstrates the potential for studying forest population processes (mortality and recruitment), disturbance events (fire, avalanche, insects, etc.), archeological material (e.g., cabin timbers), and isoptopic signals. Evidence from the current set of tree-ring samples casts some doubt on the use of RMBL tree-ring measurement series to reconstruct climate. Low-frequency features in the ITRDB composite chronology are relatively synchronous with low-frequency features in the RBML Douglas-fir chronology (Figure 1). In contrast, high-frequency (inter-annual) features are only moderately correlated (Table 3) between the RMBL samples and the ITRDB composite chronology, and among the RMBL samples. Together, these factors suggest a moderate to low relationship between RMBL tree-ring patterns and climate. Climate reconstructions from tree-ring records are often only attempted when a strong climate-growth relationship has been established. Low mean sensitivity values (Table 1) can indicate a weak relationship between tree-ring patterns and climate. If the relationship is weak (i.e., climate is not highly limiting to tree growth), then it may prove difficult to develop robust climate reconstructions from the tree-ring records. In addition, the current set of tree-ring samples may not reflect particular RMBL microsite environments. For example, it is possible that trees growing in specific timberline settings are temperature sensitive

while trees growing in rocky and warm exposures at low elevation are precipitation sensitive. If such sites exist, climate reconstructions may be possible, despite the characteristics of the current RMBL tree-ring samples. It will require the analysis of at least 10-20 additional RMBL tree-ring samples to resolve the nature and strength of climate-growth relationships.

Dendrochronological research related to population processes typically involves collecting tree-ring samples from both live and dead trees, where one sample is taken per tree to maximize the number of trees sampled, and each sample is mapped to allow for a spatial/elevational examination of the timing of forest dynamics. Intensive or extensive sampling designs may be applicable. If large scale mortality events are suspected, then the focus should be on collecting and cross-dating the outermost tree-rings of deadwood remnants.

Disturbance events can be studied through the timing of tree mortality, as in the case of deadwood stem accumulations found at the bottom of avalanche chutes, or by making inferences from the timing, duration, magnitude, and spatial distribution of growth suppressions in tree-ring samples. Tree-ring records at disturbed sites are often compared to tree-ring records at non-disturbed sites to help identify disturbance characteristics. Fire scar research usually requires the collection of large cross-sections from both live and dead trees.

Investigation of archeological materials typically requires the assembly of a high-quality tree-ring chronology (comprised of 20-40 samples) to serve as reference for precisely cross-dating wood samples of unknown age. In some cases, tree-ring records archived with the ITRDB are suitable reference chronologies for cross-dating unknown samples. From the preliminary RMBL samples, it does not appear as though absent rings or false rings will create chronology development difficulties. Archeological materials sometimes require specialized techniques and equipment to extract usable tree-ring samples without unnecessary damage to the artifact.

Isotopic analyses of tree-ring samples typically requires the careful separation of individual annual growth rings. This process is facilitated by collecting at least two increment core samples from each tree, where the samples are extracted from nearly the same point on the main stem. One of the samples is processed and cross-dated using standard tree-ring techniques; the other sample is removed from potential sources of contamination, and the individual rings are excerpted under a microscope after close cross-dating comparisons to the companion sample.

In many tree-ring studies, the degree to which patterns in the recent part of the record differ from the long-term record provides the context for qualifying the results. Because of this, the longest possible tree-ring records often produce the most compelling pictures spatial and temporal change. In most cases involving conifers, the oldest deadwood on the landscape is approximately twice as old as the oldest live trees of the same species. Based on the current RMBL tree-ring samples, 1000+ year tree-ring chronologies appear likely for both Douglas-fir and limber pine. Many

limber pine sites in the western US have yielded 2000+ year chronologies, especially in dry exposure settings.

References

Cook, E. R. and R. L. Holmes, 1986. Users manual for program ARSTAN. Pages 50-65 *in* Holmes, R. L., R. K. Adams and H. C. Fritts. Tree-Ring Chronologies of Western North America: California, Eastern Oregon, and Northern Great Basin. Chronology Series 6. The University of Arizona, Laboratory of Tree-Ring Research, Tucson, Arizona.

Fritts, H. C., 1976. Tree Rings and Climate. Academic Press, New York.

Holmes, R. L., 1983. Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin, 43: 69-78.

Lazear, G. and T. Harlan, 2001. Computer Program CROSSDATE. For information regarding CROSSDATE, contact Thomas Harlan, University of Arizona, Laboratory of Tree-Ring Research, Tucson, AZ.

Millar, C. I., J. C. King, R. D. Westfall, H. A. Alden and D. L. Delany, *in publication*. Late Holocene forest dynamics, volcanism, and climate change at Whitewing Mountain and San Joaquin Ridge, Mono County, Sierra Nevada, CA, USA. *Quaternary Research.*

Stokes, M. A. & T. L. Smiley, 1968. An Introduction to Tree-Ring Dating. University of Chicago Press, Chicago.