Field sampling and dendrochronological techniques in mixed conifer forests: A comparative study of Ponderosa State Park and French Creek Road, central Idaho

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Summary/Abstract

Seventy trees were sampled for dendroecological analysis at two sites in the high-elevation mixed-conifer forest in west-central Idaho. The objectives of the study were (1) to compare tree growth, and responses to environmental changes and disturbances, in two sites that differ in terms of moisture availability and exposure, (2) to determine the sensitivities of three forest dominants (*Abies grandis, Pinus ponderosa, Pseudotsuga menziesii*) to environmental changes, including climatic shifts and fire, and (3) to supplement dendrochronological baseline data for the central Idaho region for future regional-scale studies. We developed and compared two chronologies from different sites for tree age, growth variation, and disturbance events. There was no linear relationship between tree diameter and measured inner year; individual trees of the same age vary considerably in diameter, and we conclude that simple diameter measurements are a poor estimator for tree age.

Introduction

Dendrochronology has proven to be an effective tool for determining tree-stand age, fire and anthropogenic disturbance history, and for reconstructing climate in different field areas. Each of these processes leaves a tree-ring signature that can be interpreted using visual and statistical crossdating techniques. Proper techniques, skills, and knowledge are necessary for sampling, characterizing, and dating of tree cores or cross-sections. However, depending on the goal of the tree-ring study, poor site selection may lead to problems with data collection and interpretations of the tree-ring patterns.

The introductory group at the 15th Annual North American Dendroecological Fieldweek (NADEF) at McCall Field Station spent the week learning proper sampling and processing techniques at two locations near Payette Lake in west-central Idaho. We sampled three 0.05-ha plots as well as a small selection of older ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) trees at our first location on French Creek Road (FCR) near the town of Riggins, Idaho. At our second location in Ponderosa State Park (PSP) in McCall, Idaho, we sampled trees that we determined to be older ponderosa pines for dating and age/size comparison analysis. Both sites are mixed conifer forests dominated by the three study species: Grand Fir (*Abies grandis* (Dougl. ex D. Don) Lindl.), Douglas-Fir (*Pseudotsuga menziesii* (Mirb.) Franco) and ponderosa pine. We processed the samples for dendroecological analysis at the McCall Field Station. In addition to learning field and laboratory techniques, we learned the theory and history behind dendroecology and its related fields during class sessions in the evening.

Literature review

Dendrochronology is defined as the study of the chronological sequence of annual growth rings in trees (Stokes and Smiley 1996). A.E. Douglass, an American astronomer, pioneered modern dendrochronology in the early 20^{th} century (Fritts 2001). Dendroecological techniques are used to determine age structure within a forest and to evaluate tree-growth patterns in response to disturbance, stand development, or climatic variation (Payette *et al.* 1990, Foster *et al.* 1996). These techniques can also help assess relationships between climate, site conditions, and tree growth to show factors that most strongly influence the growth of a plant community (Cook and Kairiukstis 1989). The process of crossdating, or linking many tree cores statistically, makes it possible to extend stand histories beyond one generation of trees or one major disturbance event by using narrow and wide ring-width patterns of living and dead trees (Foster *et al.* 1996). Crossdating consists of combined traditional techniques of skeleton plotting, a graphical technique of ring-width comparison (Stokes and Smiley 1968), and the use of a crossdating quality control program, COFECHA (Holmes 1983, Grissino-Mayer 2001). Tree-ring data have now been applied to a wide range of other applications, such as dating the Messiah Violin (Burckle and Grissino-Mayer 2003), or determining the precipitation and pollution history of a city (Ashby and Fritts 1972). Tree-ring analysis methods have been substantially improved and standardized throughout the years (Phipps 1985, Stokes and Smiley 1996, Grissino-Mayer 2001, Grissino-Mayer 2003) and catalogued so that data collected from scientists worldwide may be correlated and compared for larger-scale studies. One valuable resource for such comparisons is the International Tree Ring Data Bank, which now contains over 3,300 tree-ring chronologies from six continents (Grissino-Mayer and Fritts 1997).

The science of dendrochronology is founded on eight basic principles: uniformitarianism, identifying the limiting factors to tree growth, the aggregation of many factors at different scales to determine tree growth, ecological amplitude of tree species, site selection, cross-dating, standardization, and replication (Fritts 2001). Our study places particular emphasis on the principles of ecological amplitude, site selection, and replication.

Justification for choosing two sites

We chose two sites near Payette Lake to perform site and species comparisons, to learn about sampling techniques and the key dendrochronological principles of ecological amplitude and site selection. The comparison of these sites provided an environmental gradient, which we hypothesized would aid us in determining radial growth responses in high-elevation environments that vary in moisture availability and exposure to prevailing winds. The French Creek Road site contains trees that are not water stressed, suggested by the relatively moderate relief and the highly conductive granitic substrate. In contrast, the Ponderosa State Park site contains trees that are more climatically and environmentally stressed, suggested by the high exposure to wind, higher relief, and fractured and weathered basaltic substrate.

Goals and Objectives

The goal of the introductory field project was to learn site selection techniques, sampling techniques, and sample processing techniques. The scientific objectives of the project were to:

1. Compare radial growth responses in two high-elevation sites: climate-sensitive xeric sites and mesic sites. We hypothesized that the trees in the more exposed and drier site (PSP) would be more sensitive to long-term climatic changes and growth rates would vary considerably as a function of fluctuations in precipitation and length of the growing season. We also expected that small climatic shifts would not be obvious in tree growth as measured by ring indices in the site with lower environmental stress (FCR). These trees are more likely to show suppression and release in response to local-scale stand dynamics. Fire is a major disturbance in the region and thus, we expected to see similar responses at both sites to fire.
2. Compare the sensitivity of radial growth response in three dominant species: ponderosa pine, grand fir, and Douglas-fir. Ponderosa pine and Douglas-fir are more fire-tolerant than Grand fir, and thus we expect to see the greatest growth suppression following fire years in Grand fir. Of these three species, Grand fir is the best competitor in dry conditions and we expected the least growth suppression in this species in response to draught.
3. Increase dendrochronological baseline data in mixed conifer stands in west-central Idaho, for which the number of chronologies remains low. The closest chronology is a ponderosa pine record extending from 1550-1990 at Indian Crossing (45.1º N, 117.0º W) at Wallowa-Whitman National Forest in Oregon (Wickman *et al.*). More data from additional sites will improve the existing chronologies for the region and lead to more detailed paleoclimatic and paleo-fire reconstructions.

Species Biology

Ponderosa pine is widely distributed across western North America from southern Canada into Mexico. Ponderosa pine is most often limited by soil moisture, particularly as influenced by summer precipitation. Average annual precipitation and temperature within the distribution of ponderosa pine usually range from 125-280 mm and 5-10°C (Burns and Honkala 1990). The range of ponderosa pine is discontinuous – it is absent in a large region spanning southwestern Montana to southern Idaho. The biogeography of this species provides information about its limiting factors: a possible explanation for this discontinuous range is low summer rainfall limiting seedling establishment at all but high elevation sites, however, the growing season at these high elevation sites is often too short for establishment and growth. A dendroecological study from central Oregon showed that ponderosa pine ring-width indices effectively record major regional drought (e.g., during the 1930s) but are also sensitive to temperature changes (Pohl *et al.* 2002). Ponderosa pine can either be a late- or early-successional species. In climax forests, stands often contain many small, even-aged groups rather than a true uneven-aged structure (Burns and Honkala 1990). Ponderosa pine can live to be 600 years old. Ponderosa pine seedlings are easily killed by fires, but larger trees are quite fire-tolerant relative to competitor species such as Douglas-fir (Burns and Honkala 1990).

Douglas-fir or red fir extend from central British Columbia, Canada to the mountains of central Mexico, but have been successfully introduced worldwide. Douglas-fir is found over a wide range of climates, but does not do well on poorly-drained or compacted soils (Burns and Honkala 1990). Douglas-fir is generally a dominating species in second growth stands and can grow as extensive pure growth stands, often following large fires (Burns and Honkala 1990). Douglas-fir is particularly well adapted to fire. It exhibits rapid growth and great longevity; individuals up to 1000 years old have been documented. The corky bark on the lower parts of the tree, and the ability of the species to form adventitious roots enable Douglas-fir to out-compete other less fire adapted forest dominants (Burns and Honkala 1990). The strongest signal in a study of the climatic sensitivity of Douglas-fir tree rings in central Idaho was a negative relationship with July temperature (Biondi 2000).

Grand fir grows in stream bottoms, valleys, and mountainous areas of northwestern United States and British Columbia. Grand fir grow best in areas with a an annual precipitation of 360 to 2540 mm, average annual temperatures ranging from 6-10°C, and can live to be 300 years old (Burns and Honkala 1990). Grand fir can either be a climax or a seral species and are quite common in mixed conifer forests (Burns and Honkala 1990). In moist areas, growth rates in Grand fir are sufficiently rapid to enable the species to co-dominate forest canopies, whereas at drier sites, it is a shade tolerant understory species until canopy recruitment. Grand fir is rated medium in terms of fire resistance (Burns and Honkala 1990).

Site Description

French Creek Road

The French Creek Road site (45º 24' N 115º 59' W) is a 50-acre forest stand (elevation 4,900 ft) on French Creek Road between Riggins, Idaho and Burgdorf, Idaho with forested topography on a moderate grade (Fig. 1). The site contained all three of our target tree species.

Ponderosa State Park

Ponderosa State Park (44º 55' N 116º 05' W) is a 1,470-acre park (elevation 5,050 ft) located adjacent to the McCall Field Station outside of McCall, Idaho with topography ranging from sagebrush-dominated flats to large, steep cliffs. The park occupies a peninsula jutting into Payette Lake (Fig. 1). The land-use history of Pondersosa State Park site includes limited grazing and selective timber harvesting. These activities ended near McCall before the park was established in 1957. Land-use history since 1957 now includes recreational use for camping, mountain biking, hiking, and boating. Currently, there is a restoration effort to restore the forest's ability to be resistant and resilient to recover from both natural and human-caused disturbance (Idaho Department of Parks and Recreation 2005). The site contains all three of our target tree species. Other forest trees found in the park include lodgepole pine *(Pinus contorta)* and western larch *(Larix occidentalis)* (Idaho Parks and Recreation 2005). Instead of using plot-based sampling, we selectively chose ponderosa pine trees that appeared to be older based on growth form, location, and size. Trees at this site were on fractured basalt and poorly-conductive weathered soil with basaltic parent material.

Field Methods

Three plots were delineated randomly at the French Creek Road site. Each plot measured 0.05 hectares (r = 12.66 m). All trees in the plots with diameters at breat height (DBH) exceeding 10 cm were sampled, resulting in a total of 46 tree cores, of which 12 were Grand fir, 19 were Douglas-fir, and 15 were Ponderosa pine. We also sampled four large Ponderosa pine trees found outside the plots to aid in determining stand-age. Conversely, at our second site in the Ponderosa State Park, Ponderosa pine were selectively chosen based on a visual inspection of trees thought to be the oldest. Old age was determined based on several physical characteristics: large trunk and limb size, gnarled appearance, cropped tops, general inverted carrot shape, and/or spiked tops, and growing in marginal locations.

Three-thread Haglof increment borers with a length of 16", 18" and 20" were used at approximately 0.5m above ground-level to take either one complete core for the tree's entire diameter or two radial length cores from opposing sides of the tree. The trees were cored perpendicular to the slope with the exception of trees showing damage such as fire scars or lightning strikes. Cores were placed in protective paper and wax straws and each was labeled with site location, species name, and DBH.

Laboratory Methods

The cores were glued to wooden core mounts and the label on the protective straw was transposed to the core mount. The cores were then allowed to dry for one day followed by progressive sanding from ANSI 120-grit (105-125 µm) to ANSI 320-grit (32.5-36 µm) using a mounted belt-sander, then ANSI 600-grit (13-16 µm) sanded by hand which clarified the cellular structure of the the rings and allowed for the accurate measurement of ring widths (Orvis and Grissino-Mayer 2002).

We began the crossdating process by assigning the outermost complete ring on each core with the absolute year "2004" and marking every decade ring (1990, 1980, 1970, etc.) with a mechanical pencil. The Velmex measuring system, with a precision of 0.001mm, and a 10x40 magnification stereozoom dissecting microscope was used to identify and measure rings. These were compared to an existing master chronology for the area. Ring-width data were compiled into the program Measure J2X (*Voortech Consulting*). Data accuracy was checked through the COFECHA program (Holmes 1999, Grissino-Mayer 2001). The final data set from COFECHA was then input into ARSTAN for standardization and collation into a master chronology (Cook and Holmes 1984). We used a negative exponential curve to detrend the ring-width series. We then plotted three sets of ring-width indices: the standard curve which preserves low frequency, long-term signals in the curve, the residual curve which only preserves high-frequency local signals, and the Arstan curve which incorporates both the high- and low-frequency signals in the dataset.

Results and Discussion

Sixty-eight trees were sampled in the field, and in most cases two cores were collected from each tree. Some trees had rotten piths and were ommited from further analysis. The best quality cores were dated and skeleton plots were used to visualize ring width patterns in a sub-set of the cores. We then measured 41 cores (Appendix 1).

At both sites, fire is a significant disturbance and leads to major impacts on forest dynamics. Dendrochronological analysis from a 210-year old Ponderosa pine tree in Ponderosa State Park identified fires at 1845, 1880, 1892, 1900, and 1910. Following this, fire suppression in the park has greatly reduced the fire return interval, and possibly caused changes in forest composition involving an increase in Grand fir and Douglas-fir, grasses and shrubs, as regeneration of Ponderosa pine appears to be declining.

Relationship between tree size and age

We examined the relationship between tree diameters and the innermost date of the trees in Grand fir (n=9), Douglas-fir (n=17) and Ponderosa pine (n=9) at the French Creek Road site. In most cases, tree diameter is a poor predictor of tree age (Fig. 2a). In Douglas-fir, trees of a similar age varied in diameter by a factor of 4, and in Ponderosa pine, trees of similar size varied in age by about 50 years. Diameters in Grand fir did show a general increase with tree age, although with considerable variability. We sampled nine ponderosa pine trees at Ponderosa State Park site on the basis of growth forms that indicate old trees (Fig. 2b). These were among the oldest trees (inner dates = 1584, 1872, 1896, and 1905). These results show that when selecting trees to sample, old trees are better identified on the basis of growth form than on diametric measurements.

French Creek Road Chronology

The standardized French Creek Road chronology is shown in Figure 3. We used 22 series from 12 trees to generate a 108-year chronology. The series intercorrelation was highly significant (0.582) and the mean sensitivity of the series was adequate for analysis (0.218). These strong values indicate that growth in Douglas-fir is sensitive to both long-term environmental changes and local processes such as fire regimes. To verify the dating of the series, we entered the chronology as an undated series into COFECHA for comparison with another chronology generated by the NADEF Climate Reconstruction Group for ponderosa pine from the same site and found highly significant correlations indicating that both series crossdated well and were accurately dated.

The COFECHA output allowed us to identify problem cores that were subsequently eliminated or truncated. These included:

- FCRI024A and FCRI024B: This tree was eliminated due to extremely low correlations with the rest of the series. The rings showed marked suppression for about half the length of the cores, suggesting with-in variation.
- FCRI039B: This core was eliminated because a large branch scar truncated the record and locally affected tree-rings. (FRCI039A was retained in the chronology.)
- FCRI015: The first 20 years of growth were eliminated. This segment was poorly correlated with the rest of the series, suggesting strong juvenile growth effects.

Strong periods of suppression were seen in 1918, 1962, and 1988. The suppression periods are also present in our Ponderosa State Park chronology suggesting climatic influence rather than localized disturbances such as fire, particularly since fire suppression has been in effect in Ponderosa State Park and surrounding the town of McCall throughout the 20th century.

Ponderosa State Park Chronology

The standardized Ponderosa State Park chronology is shown in Figure 3. We used 19 series from 10 trees to generate a 399-year chronology. The series intercorrelation was highly significant (0.542) and the mean sensitivity of the series was adequate for analysis (0.253). These strong values indicate that growth in ponderosa pine is sensitive to both long-term environmental changes and local processes such as fire regimes. Suppression periods are evident from the 1700s through early 1800s in the Ponderosa State Park chronology. Standardization with multiple samples correlates with suppression periods seen at our French Creek Road site.

The problem cores that were eliminated or truncated based on the COFECHA output:

- PSPI005A: Truncated to 1855 because of an injury that caused very narrow rings and likely locally absent rings.

Suppression in Radial Growth

Thirty-six trees experienced suppression in a five year period starting in 1967 (Figure 4). We focused on the later years of the tree's life (>1967) because a fire history exists for the area. The five-year period with the greatest number of suppressed trees was between 1984 and 1987. Our data suggests that this large suppression in growth was caused by a fire. The data indicates some differences in the responses of individual species during periods of high suppression. Between 1967 and 1972, 86% of the growth suppression was in Grand fir while 14% of the suppression was observed in Douglas-fir. Conversely, between the period of 1984 and 1987, 79% of the suppression was in Douglas-fir with 21% suppression in ponderosa pine. Species-specific suppression differences could be caused by disturbances other than fire. For instance, large amounts of mistletoe were seen in Douglas-fir at the French Creek site.

Future work

Clearly, our data suggest that there is a possibility of both fire and climate influence that can be shown using our tree cores. However, confirmation of this possibility requires the use of climate and fire software in addition to additional studies of the wood.

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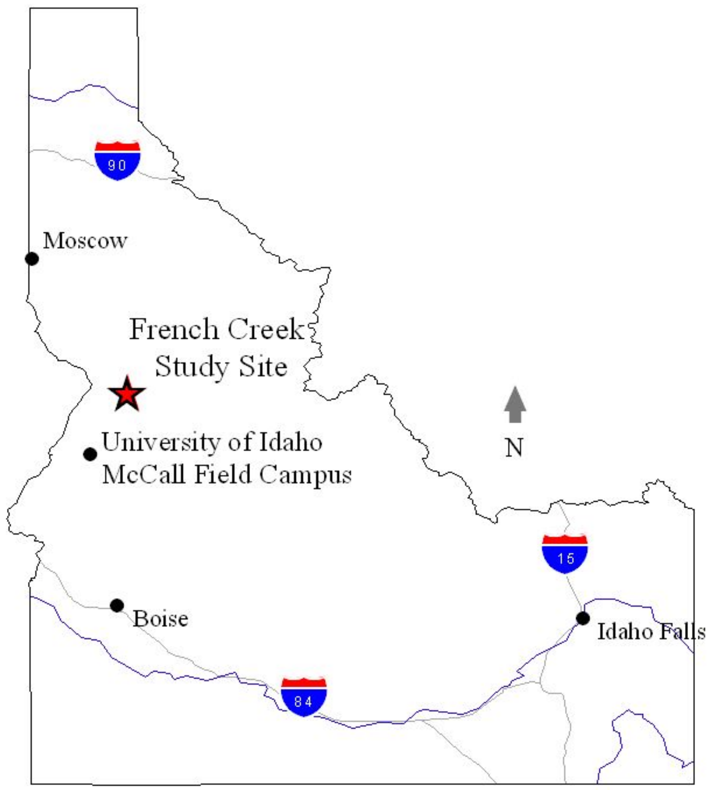


Fig. 1: Map of Idaho showing the location of study areas at French Creek and adjacent to McCall Field Campus.

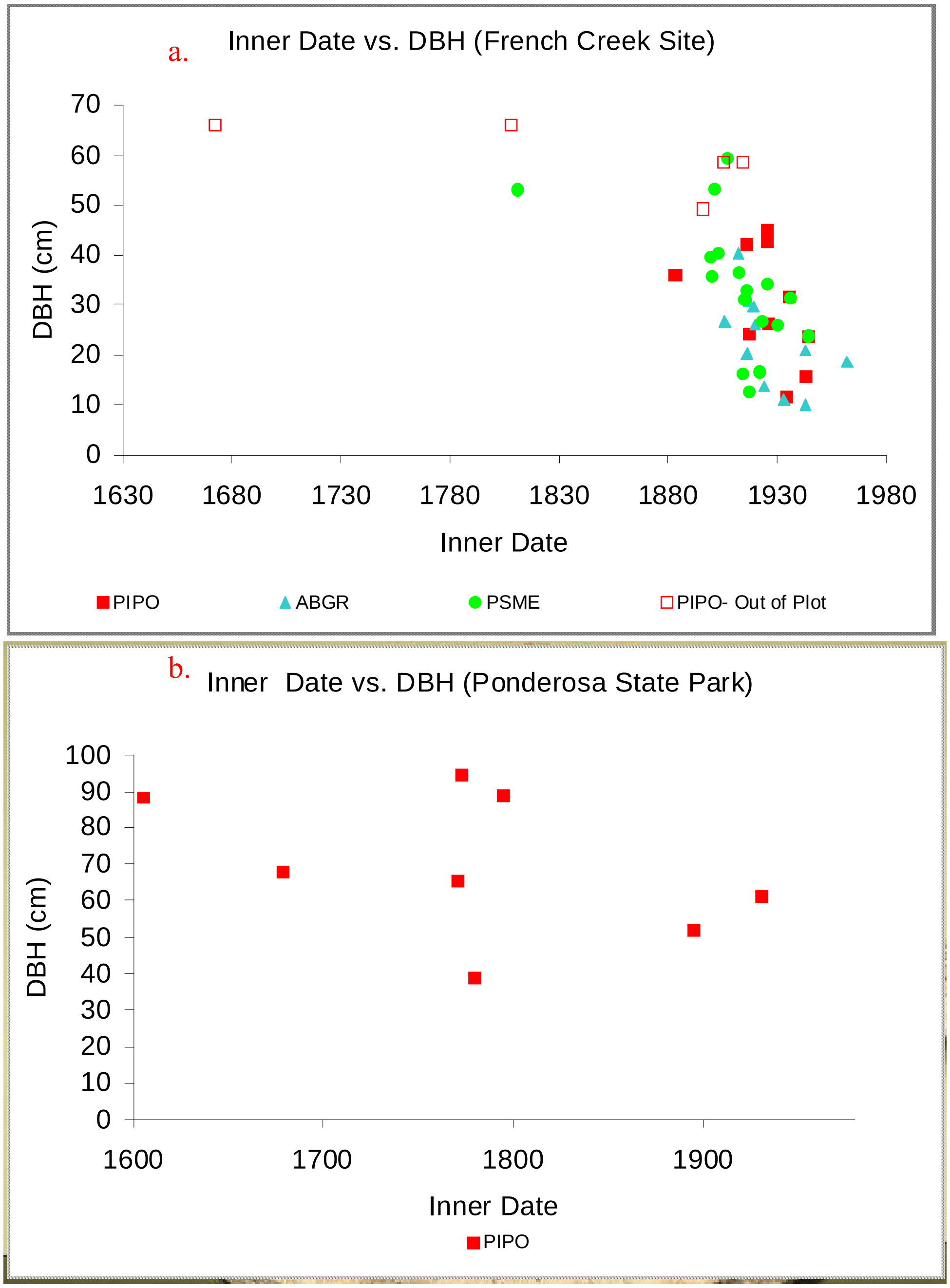
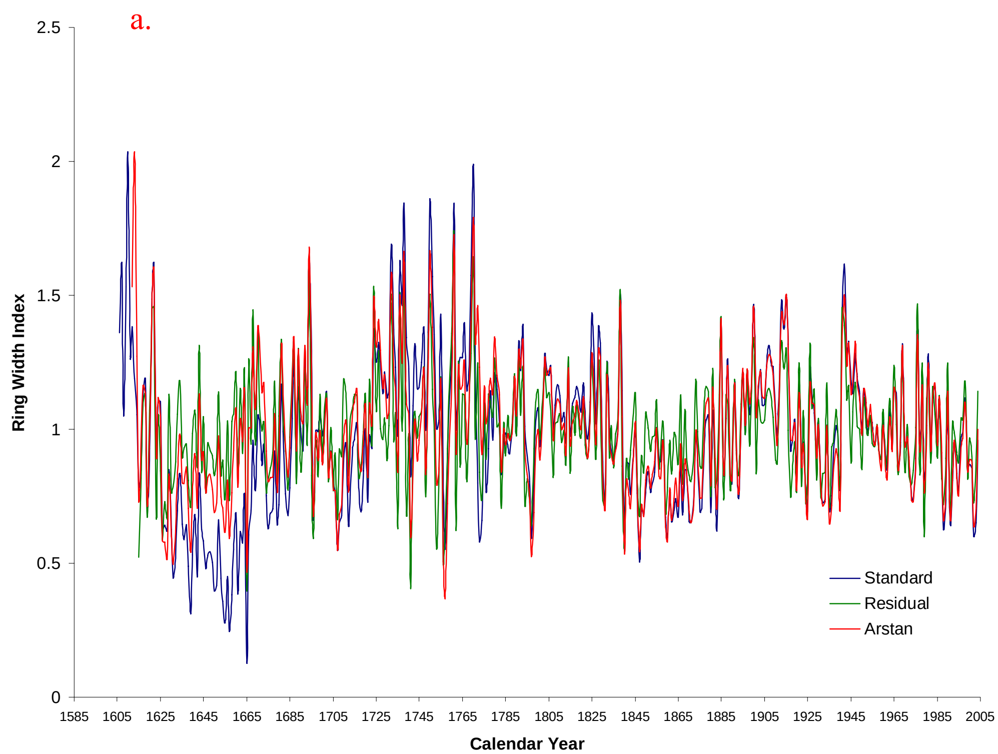


Figure 2: Scatter plot showing stem diameter age as a function of innermost measured tree-ring date for three study species (ABGR: *Grand fir*; PSME: *Douglas-fir*; PIPO: *Ponderosa pine*) at two sites (a) FC: French Creek; (b) PSP: Ponderosa State Park.



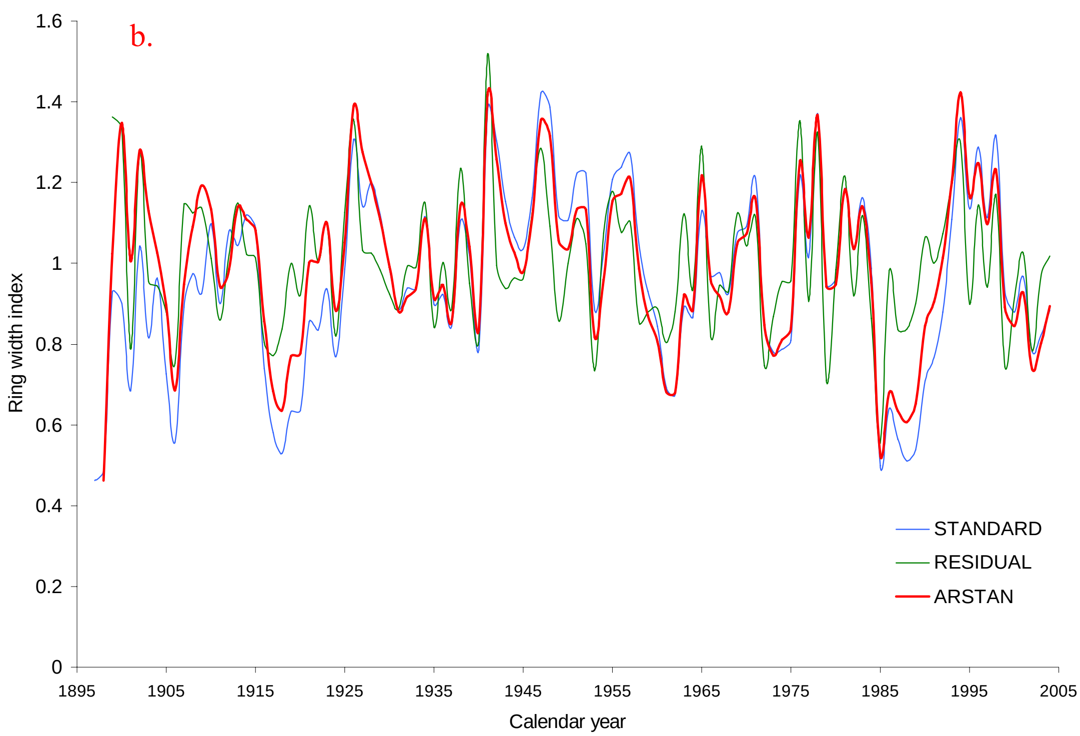


Figure 3: Ponderosa pine tree-ring chronologies for the (a) French Creek Road site and the (b) Ponderosa Pine State Park site showing three standardizations.

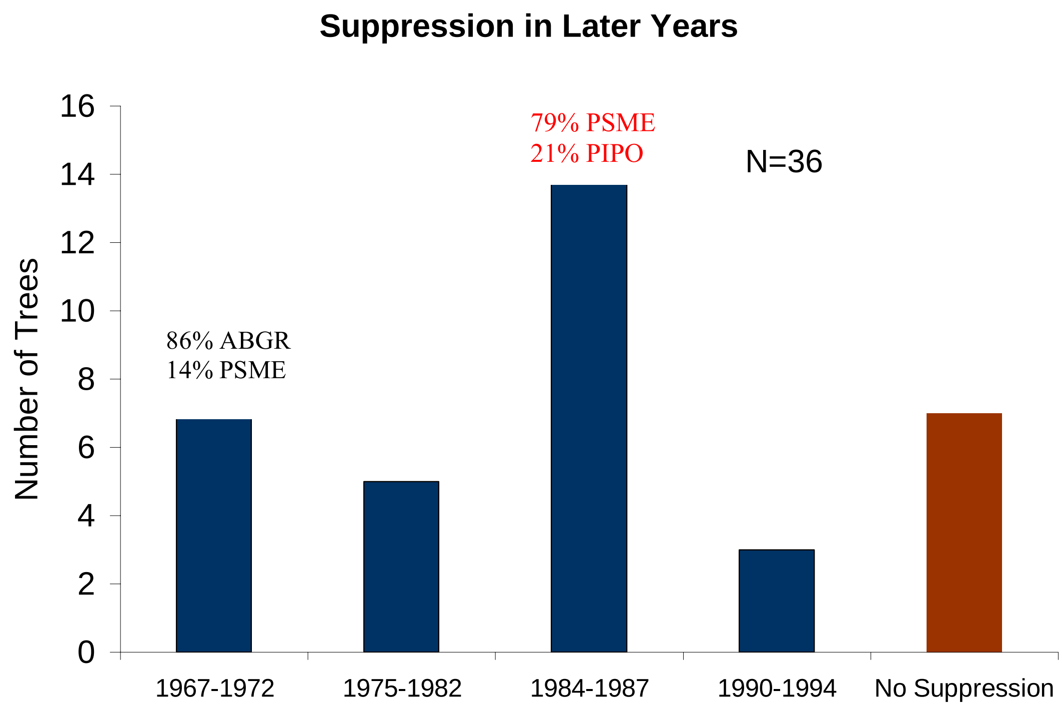


Figure 4: Number of trees at both sites with stunted tree-ring growth over a five year period beginning in 1967. ABGR: *Grand fir*; PSME: *Douglas-fir*; PIPO: *Ponderosa pine*.

Appendices

Inventory of trees sampled by Introductory Group – June 2005

Study Site	Core ID	Analyzed	Pith Code	Species	DBH (cm)	Start Date	Suppress Yr
French Creek	FCRI001A	Y	2	PIPO	11.5	1934	1982
	FCRI001B	N	2	PIPO	11.5	1952	1985
	FCRI002A	N	2	PSME	16.6	1930	1984
	FCRI002B	Y	2	PSME	16.6	1922	1984
	FCRI003A	Y	2	PIPO	31.7	1935	1985
	FCRI003B	N	2	PIPO	31.7	1938	1987
	FCRI004A	N	2	ABGR	29.6		Broken
	FCRI004B	Y	2	ABGR	29.6	1919	None
	FCRI005A	N	2	PSME	53.1	1870	1988
	FCRI005B	Y	2	PSME	53.1	1811	1985
	FCRI006A	Y	2	PIP0	15.8	1943	1985
	FCRI006B	N	2	PIPO	15.8	1936	1982
	FCRI007A	Y	2	PIPO	26.2	1926	1987
	FCRI007B	N	2	PIPO	26.2	1931	1983
	FCRI008A	Y	2	PIPO	23.7	1944	1976
	FCRI008B	N	2	PIPO	23.7	1951	1978
	FCRI009A	Y	2	PSME	31.5	1936	1985
	FCRI009B	N	3	PSME	31.5	1953	1986
	FCRI010A	Y	3	PIPO	98.1	1809	None
	FCRI010B	N	3	PIPO	98.1	1817	None
	FCRI011A	N	2	PSME	26.7	1938	1986
	FCRI011B	Y	2	PSME	26.7	1923	1985
	FCRI012A	Y	2	PSME	12.7	1917	Not measured
	FCRI012B	N	2	PSME	12.7	1930	Broken
	FCRI013A	Y	2	PIPO	24.1	1917	1990
	FCRI013A	Y	2	PSME	23.8	1944	1985
	FCRI013B	N	2	PIPO	23.8	1951	1988
	FCRI014A	Y	2	PIPO	95.3		Broken
	FCRI014B	N	3	PIPO			Not measured
	FCRI015A	N	2	PSME	31.1	1918	1985
	FCRI015B	Y	2	PSME	31.1	1915	1985
	FCRI016A	Y	2	ABGR	18.6	1962	None
	FCRI016A	Y	3	PSME	16.56	1914	1994
	FCRI016B	N	2	ABGR	18.6	1964	None
	FCRI016B	N	3	PSME	16.56	1916	1986
	FCRI017A	N	2	PIPO	45	1933	None
	FCRI017B	Y	2	PIPO	45	1925	None

FCRI018A	N	2	PIPO	42.2	1917	1986
FCRI018B	Y	2	PIPO	42.2	1916	Not measured
FCRI019A	Y	2	PIPO	42.6	1925	None
FCRI019B	N	2	PIPO	42.6	1940	None
FCRI020A	N	2	PSME	59.44	1909	1989
FCRI020B	Y	2	PSME	59.44	1907	1987
FCRI021A	Y	2	PSME	26	1930	1985
FCRI021B	N	2	PSME	26	1932	1985
FCRI022A	N	2	ABGR	26.7	1916	1985
FCRI022B	Y	1	ABGR	26.7	1906	1967
FCRI023A	N	2	PSME	53.3	1912	1991
FCRI023B	Y	2	PSME	53.3	1901	1993
FCRI024A	N	2	PSME	36.4	1929	1972
FCRI024B	Y	2	PSME	36.4	1912	1970
FCRI025A	Y	2	PSME	33.02	1916	1979
FCRI025B	N	2	PSME	33.02	1920	1985
FCRI026A	Y	2	ABGR	11	1933	Not clear
FCRI026B	N	2	ABGR	11	1933	Not clear
FCRI027A	Y	2	ABGR	20.3	1916	1972
FCRI027B	N	2	ABGR	20.3	1916	1973
FCRI028A	Y	2	PSME	39.6	1899	1966
FCRI028B	N	2	PSME	39.6	1899	1968
FCRI029A	Y	2	PSME	16.13	1914	1985
FCRI029B	N	2	PSME	16.13	1914	1985
FCRI030A	N	3	ABGR	44.3	1920	1974
FCRI030B	Y	2	ABGR	40.3	1912	1971
FCRI031A	Y	2	ABGR	26.1	1920	1971
FCRI031B	N	2	ABGR	26.1	1923	1971
FCRI032A	N	3	PSME	47.3	1905	1987
FCRI032B	Y	3	PSME	47.3	1900	1985
FCRI033A	Y	2	ABGR	13.7	1924	None

FCRI033B	N	2	ABGR	13.7	1924	None
FCRI034A	Y	2	PIPO	35.9	1883	1953
FCRI034B	N	2	PIPO	35.9	1886	1953
FCRI035A	Y	2	ABGR	20.9	1943	1975
FCRI035B	N	2	ABGR	20.9	1943	1974
FCRI036A	N	2	PSME	40.5	1911	1985
FCRI036B	Y	1	PSME	40.5	1903	1985
FCRI037A	Y	2	ABGR	10	1943	1971
FCRI037B	N	2	ABGR	10	1943	Broken
FCRI038A	Y	2	PSME	34.3	1925	None
FCRI038B	N	2	PSME	34.3	1927	None
FCRI039A	Y	2	PSME	35.6	1900	1982
FCRI039B	N	2	PSME	35.6		1984
FCRI040A	Y	2	ABGR	30.7	1917	1972
FCRI040B	N	2	ABGR	30.7	1917	1972

Pith Code: 1=pith center, 2=pith curvature, 3=did not reach pith
Suppress Year = visually estimated year that major suppression occurred

French Creek Road Study Site: COFECHA output

Seq	Series	Time	Span	1900 1949	1925 1974	1950 1999	1975 2024
1	FCRI002A	1930	2004		0.79	0.75	0.75
2	FCRI002B	1922	2004	0.68	0.72	0.72	0.7
3	FCRI011A	1938	2004		0.62	0.73	0.74
4	FCRI011B	1923	2004	0.56	0.56	0.75	0.59
5	FCRI013A	1917	2004	0.59	0.65	0.66	0.62
6	FCRI015A	1918	2004	0.68	0.78	0.8	0.82
7	FCRI015B	1915	2004	0.53	0.59	0.59	0.58
8	FCRI016A	1905	1995	0.51	0.75	0.72	
9	FCRI016B	1912	2000	0.68	0.76	0.55	0.54
10	FCRI021A	1930	2004		0.61	0.65	0.54
11	FCRI021B	1932	2004		0.66	0.74	0.76
12	FCRI025A	1916	2004	0.55	0.62	0.64	0.62
13	FCRI025B	1920	2004	0.45	0.37	0.53	0.52
14	FCRI029A	1914	2004	0.45	0.44	0.75	0.77
15	FCRI029B	1914	2004	0.31A	.29A	0.65	0.65
16	FCRI032A	1905	2004	0.61	0.45	0.51	0.53
17	FCRI032B	1900	2004	0.47	.29B	0.44	0.48
18	FCRI036A	1912	2004	0.49	0.45	0.66	0.69
19	FCRI036B	1903	2004	0.51	0.43	0.63	0.63
20	FCRI038A	1925	2004		0.61	0.54	0.55
21	FCRI038B	1927	2004		0.64	0.71	0.69
22	FCRI039A	1897	2001	0.49	0.61	0.59	0.59
Average segment correlation				0.54	0.58	0.65	0.64

Ponderosa State Park Study Site: COFECHA output

Seq	Series	Time	Span	1750 1799	1775 1824	1800 1849	1825 1874	1850 1899	1875 1924	1900 1949	1925 1974	1950 1999	1975 2024
1	PSPI004A	1892	2004						0.4	0.54	0.45	0.41	0.4
2	PSPI004B	1864	2004					0.48	0.51	0.62	0.51	0.52	0.6
3	PSPI005A	1606	2004	0.39	0.41	0.27B	0.4B	0.52	0.59	0.7	0.62	0.42	0.46
4	PSPI006A	1928	2004								0.59	0.5	0.46
5	PSPI006B	1930	2004								0.55	0.51	0.52
6	PSPI007A	1791	2004		0.4	0.33	0.52	0.61	0.67	0.65	0.49	0.46	0.47
7	PSPIOO7B	1855	2004					0.51	0.53	0.66	0.65	0.62	0.68
8	PSPI008A	1931	2004								0.44	0.59	0.69
9	PSPI008B	1934	2004								0.54	0.59	0.63
10	PSPI009A	1908	2004							0.45	0.48	0.46	0.52
11	PSPI009B	1904	2004							0.44	0.6	0.57	0.61
12	PSPI013A	1773	2003	0.5	0.5	0.59	0.68	0.77	0.64	0.67	0.66	0.54	0.58
13	PSPI013B	1772	2003	0.66	0.63	0.55	0.45	0.38	0.44	0.34	0.35	0.42	0.39
14	PSPI014A	1771	2004	0.68	0.64	0.58	0.57	0.4	0.51	0.6	0.52	0.47	0.51
15	PSPI014B	1816	2004			0.48	0.56	0.56	0.72	0.74	0.62	0.63	0.66
16	PSP1015A	1798	2001		0.54	0.56	0.52	0.57	0.71	0.71	0.6	0.51	0.53
17	PSPI015B	1798	2004		0.67	0.67	0.57	0.48	0.53	0.68	0.63	0.64	0.7
18	PSPI019A	1783	2004		0.63	0.61	0.57	0.53	0.52	0.67	0.57	0.34	0.34
19	PSPI019B	1777	2004		0.54	0.63	0.65	0.59	0.47	0.53	0.58	0.3B	0.37
Average Segment Correlation				0.56	0.55	0.53	0.55	0.53	0.56	0.6	0.55	0.5	0.53