FEASIBILITY AND APPLICATION OF DENDROCHRONOLOGY IN OREGON UTILIZING DOUGLAS FIR: A CASE STUDY IN SOUTHWESTERN OREGON

BY
STUART EMERSON CHILVERS

A TERMINAL PROJECT

Presented to the Interdisciplinary Studies Program: Historic Preservation
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Science

June 2014

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TERMINAL PROJECT APPROVAL PAGE

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Student: Stuart Chilvers

Title: Feasibility and Application of Dendrochronology in Oregon Utilizing Douglas Fir: A Case Study in Southwestern Oregon.

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TERMINAL PROJECT ABSTRACT

Stuart Chilvers

Master of Science

Interdisciplinary Studies Program: Historic Preservation

June 2014

Title: Feasibility and Application of Dendrochronology in Oregon Utilizing Douglas Fir: A Case Study in Southwestern Oregon

The focus of this study is the Martin Powers Barn, located near Cave Junction, Oregon. The goal of this paper was to determine and verify dates of construction and modification of the barn, to construct a new long-term reference chronology for the Cave Junction area, to evaluate the validity of using Douglas fir for dendrochronology and to identify the criteria for the tree-ring dating of historic structures within the Pacific Northwest.

Seventeen specimens were collected from the barn and seven proved to be of sufficient quality to obtain a date and four of the dated samples had an outermost ring from which a cut date could be obtained. The results were quality-checked and refined with the computer program COFECHA and corrected with EDRM.

This study indicates cut dates for the hewn frame of c.1895 and cut dates for interior walls c.1931. This study shows that dendrochronology is a valid technique for the dating of wooden structures in Western Oregon constructed of Douglas fir and can potentially be utilized elsewhere in the region as well.

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DEDICATION

I would like to dedicate this paper to the memory of my mother, Elizabeth Chilvers, a great lover of history, who set me upon the course of economic deprivation but intellectual fulfillment by introducing me at an early age to archaeology and cultural anthropology through many bedtime stories and visits to cultural sites to stoke my imagination about our past. I would also like to dedicate it to my father John Chilvers, sister Jody Chilvers, brother in law Chuck Forbes, and Jean Lee who gave me all their love, support and the occasional tasty meal to help me through my moments of doubt. Lastly, to all my comrades in the Historic Preservation program including my friend Emily Vance who provided me the adage of a great man: Vocatus est, ac solutio problematis vitae causa.

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1. INTRODUCTION

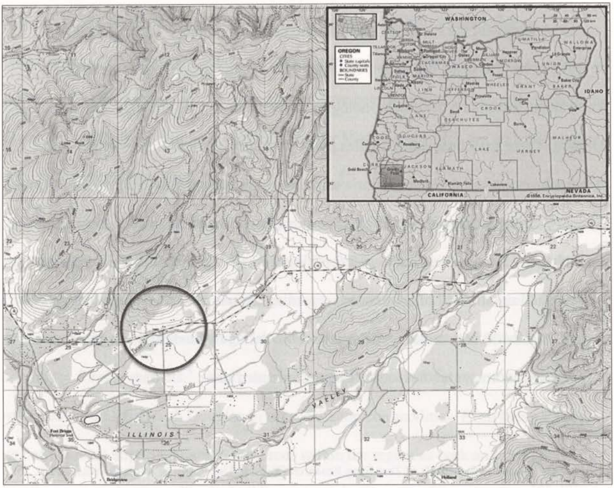

Figure 1 Location of the Martin Powers Barn (circled) (USGS, Holland 7.5", 1996 Series; Encyclopedia Britannica, 1998)

This paper presents a dendrochronology suitability study on wood taken from the Martin Powers Barn, which is constructed of Douglas fir (*Pseudotsuga menziesii*) and located west of Cave Junction, Oregon. The purpose of this study was to determine if diagnostic features are present in Western Oregon Douglas fir that can be used to determine the felling dates of the wood in the structure utilizing dendrochronology. The exploration of this topic will provide researchers with much needed data regarding the validity of dates of construction for the structure, validity of the use of dendrochronology in Oregon, and validity of dating Douglas fir.

A review of the literature pertaining to dendrochronology in Oregon did not reveal any records of its use to date historic buildings in Oregon and to the author's knowledge, there is no dendrochronological research to date on standing structures in Oregon. There have been many studies in the past that have investigated the use of dendrochronological dating of historic structures in the Eastern and Southwestern United States, Europe, and elsewhere.[1] Yet an examination of the existing body of work reveals that it has not been utilized in Oregon for this purpose.[2] It is therefore the purpose of this paper to address the lack of information regarding the use of dendrochronology in the Pacific Northwest and to discover if it is a viable dating methodology for this region with its unique environmental characteristics and endemic flora.

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1 James H. Speer, Fundamentals of Tree Ring Research (Tucson: University of Arizona Press, 2010), 152, 161, 167.

2 Pamela K. Paullin, Boring to the core: the archaeology, history, and dendrochronology of a railroad logging camp, Ladee Flat, Clackamas County, Oregon. (Thesis, Oregon State University, 2007).

Shari M. Silverman, Sadin, Paul and Compas, Lynn, Archaeological Data Recovery for Site 45LE456, Cowlitz River Hydroelectric Project, FERC License Number 2016, Lewis County, Washington, (Seattle. Human Research Associates January 15, 2013).

The thesis by Pamela K. Paullin, "Boring to the core: the archaeology, history, and dendrochronology of a railroad logging camp, Ladee Flat, Clackamas County, Oregon" used dendrochronology to relatively date the locations of housing sites through the dating of the ages of the trees in the clearings, but not to directly date the structures themselves.

There is also a archaeological report for a corduroy road adjacent to the Cowlitz River in Washington State. This report produced a date but the methods to obtain it are not clear and the samples were small fragments of cedar and reaction wood was present in the samples that may have affected the quality of the results. However, there was agreement between the samples.

Through the analysis of the Powers Barn, the study will determine if dendrochronology can be successfully applied to the dating of a structure in less stressed sites where the trees have near ideal growing conditions such as those found in the Cave Junction area. Numerous dendrochronological studies concerning paleoclimate reconstruction, fire history, earthquake occurrence and other related undertakings exist in in the region.[3] However, most of these studies have been confined to locations high in the Cascades and to dry locations east of the Cascade Mountains, which are generally better suited for dendrochronology.[4]

The use of Douglas fir in this region is of particular interest for this paper. One of the first sawmills in Fort Vancouver was built in 1828 on the Washington side of the Columbia River and used this resource as an exportable commodity to lands as far away as China. In the 1830s the mills at Fort Vancouver produced some 900,000 board feet per annum for foreign markets.[5] Since that beginning the forests of the region have continued to be heavily utilized, with Douglas fir one of the top commodities. Even today it is still one of the most important natural resources within the region as both an export and locally consumed commodity for building materials. The use of Douglas fir as a building material was and still is ubiquitous throughout the Pacific Northwest due to its

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3 See, J.K. Agee, Fire History Along an Elevational Gradient in the Siskiyou Mountains, Oregon. Northwest Science, 1991: 65(4), 188-199.

See Also, G.C Jacoby, D.E. Bunker, B.E. Benson, 1997. Tree-ring evidence for an A.D. 1700 Cascadia earthquake in Washington and northern Oregon. Geology, 25(11), 999-1002.

4 For a database of dendrochronology sampling locations and chronologies consult http://www.ncdc.noaa.gov/

5 Robert Carlton Clark, History of the Willamette Valley Oregon, Chicago: (S.J. Clarke Publishing Company, 1927), 443.

abundance, strength, and natural durability that makes it suitable for a wide number of applications.

Studies have confirmed that Douglas fir is suitable and preferred tree species for dendrochronological study, in particular when grown in stressed sites such as high elevation or dry sites like those found in the American Southwest.[6] However, in Oregon and elsewhere in the Pacific Northwest, the suitability of trees grown in less stressed sites for dendrochronological dating is virtually unknown. Douglas fir grown in sites at low elevation is generally less useful for climate reconstruction studies as compared to trees growing at the very edge of their range, and therefore has received limited attention.

The reasons behind the lack of use of dendrochronology by the historical preservation community in Oregon likely have to do with the limited timespan in which settlement in the region occurred in comparison to the rest of the country. Other reasons possibly include the lack of established tree-ring dating labs, the lack of familiarity with the technique within the professional historic preservation community, the low sensitivity of the tree species in response to environmental conditions, the relative rarity of established chronologies, and most importantly the presence of extensive historical records on which many researchers depend upon to establish timelines. It is this last factor that perhaps contributes the most to the absence of dendrochronology to date houses in this region.

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6 Arthur E. Douglass, Precision of Ring Dating in Tree-Ring Chronologies. (Tucson: University of Arizona Press, 1946) 7.

As shown by examples from the eastern states, the written record does not always provide a full and accurate account of all details regarding construction or alteration of a building. When dates are in dispute, dendrochronological dating has proven vital to establishing and verifying the dates of both historic and prehistoric sites throughout the world. Written accounts do not tell the whole story of the settlement of Oregon, or elsewhere in the Pacific Northwest, and information gaps could be filled with the aid of dendrochronology.

One area that is often overlooked when conducting studies on historic buildings is the problem posed by outbuildings and other satellite structures. These buildings are often not as well documented as the main structures and tend not to utilize as many manufactured goods that can be used to date the main house as they are often made of found materials that are located on a farmstead. These can include rough-hewn timbers, hand split shake and other items created by thrifty farmers. Often, when lacking historic records the date will be assigned solely on the basis of construction techniques used or material culture present. It is the premise of this paper that it is important to test the theory that dendrochronology can play a vital role in establishing the dates of these often neglected structures, since outbuildings can be just as important to the story of a property as the main residence.

The subject of this study, the Martin Powers Barn, could be one of the more significant structures in the Illinois River Valley, but is wanting of the attention that it deserves due to its unknown historical provenance. Additionally, in the case of the Powers Barn, the lack of attention and recognition of its potential significance could lead to its loss due to insufficient funding for its preservation. Dendrochronology could prove invaluable for establishing the significance of the barn by determining its construction date and through comparison to other structures in the area it could aid in determining which buildings are in need of priority preservation funding.

Conceptual Framework

Dendrochronology is the science of examining growth patterns in tree-rings to discover the datable characteristics therein. It originated in the American Southwest focusing on long-lived conifers, but it has since been applied to the dating of deciduous trees with its application spanning the temperate zones of both the northern and southern hemispheres. The primary limitation of the method is that it can be applied only to geographic regions where trees have definite growing seasons and produce a well-defined growth ring, thus including most temperate tree species, but excluding many tropical species. Trees in the northern hemisphere develop a layer of new wood each year, which is composed of porous and lighter earlywood formed during spring of the growth year, and a thicker and darker latewood which forms during the later part of the growing season – typically in summer. The combination of the two constitutes one full year growth.

It is within the variation of the rings due to certain limiting factors, such as precipitation and the temperature that the plant receives, that datable attributes within the growth of the plant emerge. Simplistically, narrow rings correspond to dry years and thick rings to wet years (although other stand level occurrences such as insect infestation, ice or wind storms, or fires can affect growth to varying degrees as well). The variations in growing conditions that the plant experiences can produce extremely narrow or wide rings, which are called indicator or pointer rings, and are the rings most useful for visual dating in dendrochronology. Upon examination of the specimens, patterns begin to emerge through time and these patterns can be matched to other specimens both in living trees and in dead because the limiting factors of growth are not just affecting one tree but a wide area. Through the careful observation of these patterns we are able to reconstruct a reference chronology for the region through which we can date other specimens in a process called crossdating.

Much of the current body of work in Oregon concentrates on the reconstruction of past climatic conditions and fire regimes and existing chronologies have been primarily developed on higher elevations locations on public lands.[7] The Willamette Valley and other areas close to sea level in Oregon have been entirely ignored in dendrochronological studies. Given the opportunity, the application of dendrochronology has great potential to aid in the dating of buildings and other structures utilizing wood as their building medium in these locations, if found applicable to the environmental conditions found there.

Dendrochronology Overview

Dendrochronology is a method of absolute dating with a well-proven history of accurately determining dates and aiding in the development of chronologies for past

7 See The NOAA website on climate (http://www.ncdc.noaa.gov/) that contains a searchable database of dendrochronology studies.

events. Dendrochronology is made possible by the fact that in most trees growing in temperate climate, the annual growth rings visible in cross-section, exhibit characteristic patterns.[8] These are caused by the seasonal growth patterns present in woody plants in the northern hemisphere where the plants cycle through periods of biological activity in warm seasons and periods of dormancy in the winter seasons. It is through the observation and measurement of the variations in the rings that dating is made possible. Examples of the constructive use of dendrochronology include the dating of mass land movements, fire regimes, reconstruction of rainfall records, dating of works of art and the focus of this paper, which is the dating of buildings. Dendrochronology and its sub-discipline of dendroarchaeology have been applied to dating of historic wooden structures since the creation of the technique in the early 20th century when its creator A.E. Douglas utilized it in the 1920s to date Native American buildings in American Southwest.

There were many individuals in the past, including Leonardo da Vinci, that noticed that trees grew in response to their environmental conditions, but it was an astronomer in the early 1900s that fully developed the technique to quantify and cross-reference specimens. [9] Andrew Ellicott Douglas intended to find the link between cosmic events such as sunspots, and changes in the patterns of growth in trees. The result of his study was not what he intended, but instead he linked regional environmental trends in the American Southwest to tree-ring growth in Ponderosa Pine (*Pinus ponderosa*). It was

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8 Marvin A. Stokes, and Terah L. Smiley. An Introduction to Tree-Ring Dating. (Chicago: University of Chicago Press, 1968) 3.

9 James H. Speer, Fundamentals of Tree Ring Research (Tucson: University of Arizona Press, 2010), 37.

from that discovery that he developed the basic techniques and methodologies behind dendrochronology. It is his pioneering work that is the basis for the continued success of dendrochronological dating and which has been proven to be an accurate and reliable method for obtaining the felling dates for timber utilized in the construction of buildings, and other items made of wood from temperate zones around the world.

After further refinement and development, Douglas utilized his methods to develop tree ring dating for archaeological sites. Douglas used dendrochronology to date prehistoric structures at 45 prehistoric archaeological sites throughout the southwest and proved the technique was valuable for relative dating.[10] He was able to tell the relative date of one section of a pueblo to another, but as he had not yet developed a long-term reference chronology that extended to the present day he was unable to place them in exact temporal provenance. Therefore, this first foray into dating in the 1910-20s was to date the structures relative only to each other. It was not until 1929 that Douglas developed a chronology for the region that could be used to provide absolute dates for archaeological wood specimens.[11] Others have since taken his lessons and developed long running reference chronologies dating back thousands of years.[12]

Since the 1970s there has been a refinement in the methods and technology used in dendrochronology and others have expanded upon Douglas's work with great success to provide invaluable data and accurate dates on structures in areas with temperate

10 James H. Speer, Fundamentals of Tree Ring Research (Tucson: University of Arizona Press, 2010), 152.

11 M.G.L. Baillie, Tree-Ring Dating and Archaeology. (Chicago: University of Chicago Press, 1982), 35.

12 Baillie, M. G. L. A Slice Through Time: Dendrochronology and Precision Dating. London: Batsford, 1995), 18.

climates. These regions have primarily included Europe and Eastern North America with some forays into more exotic terrain.[13] Douglas's work focused on areas with high growth stresses on trees that would produce narrow rings, called pointer years or key years, which visually stand out from the rest of the rings and are observable to the human eye. A greater amount of sensitivity and variability is desirable in the specimens, which relates to the amount of environmental stress that the tree is undergoing and which in turn leads to strong dating.

Since the use of computers became the norm in the 1970s for the analysis and comparison of ring widths, they have opened up a number of new possibilities and regions for data analysis. Since regions with adequate rainfall do not experience periods of abundance and drought like they do in Arizona, there is an apparent lack of tree ring patterns discernible to the eyes of even experienced dendrochronologists. Modern computer software coupled with accurate tree ring measurements allows determination of growth patterns, crossdating and its validation to determine if and at what confidence level series can be dated. These techniques have now made possible the analysis of wood from the stands that were previously considered complacent (e.g. eastern hardwood forests or European oaks) or species like oak that are difficult to visually crossdate. Yet even with today's computer technology not everything can be dated. M.G.L. Baillie said it best in his book "Tree-Ring Dating and Archaeology" regarding the difficulties of dating,

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13 For a worldwide perspective on the use of dendrochronology and issues in dating see: R. Wimmer, , and R. E. Vetter. Tree-Ring Analysis: Biological, Methodological, and Environmental Aspects. (Wallingford, Oxon, UK: CABI Pub, 1999).

> *It is very easy to make the results of dendrochronological analysis seem excessively tidy. This is usually the result of attempting to present the results in too logical fashion. The fact of the matter is dendrochronological research is not all that logical in itself, it is only logical with hindsight. Consider the following, the closest analogy to tree-ring chronology building is a jigsaw. The pieces (assuming that they exist at all, which is not certain at the outset) are scattered around as living trees, stumps, timbers in buildings and buried, either as archaeological material or as naturally preserved timbers, in bogs, river or lake beds. The pieces are accumulated not one by one but as groups of timbers, in no particular order, in the hope that some of some will be of use. The next stage is actually fitting the pieces together, construction of the chronology. Here the art of dendrochronology becomes apparent.*[14]

When the conditions are right for it to work, dendrochronology has provided some key insights in establishing facts about historic dates that were in dispute. The most famous use of dendrochronology being utilized successfully in the United States, besides Douglas's pioneering research, has been successful dating of some of the earliest houses in New England constructed by the Pilgrims and their descendants. Upon the completion of the dendrochronological studies on these dwellings, it was found that some dates contradicted the established building chronologies that were dogma and forced a reevaluation of dates for many historic sites.[15] However, despite these successes, the use

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14 M. G. L. Baillie, Tree-Ring Dating and Archaeology (Chicago: University Of Chicago Press, 1989), 23.

15 Gregory D. Huber, 2006. "Abbott Lowell Cummings' Prescience and Dates for First Period Houses of Massachusetts Bay Colony Using Dendrochronology". (Material Culture. 38, no. 2: 39-52).

of dendrochronology in the Pacific Northwest has been extremely limited and literature review finds few examples of its use and no attempt to date a standing structure presently.

Hugh A. Beard, Peter J. Egan, and Herman John Heikkenen Final Report: The Years of Construction for the Geddy House and the Peyton Randolph House (Phase I and II) As Derived by the Key-Year Dendrochronology Technique. (American Institute of Dendrochronology, Inc ,1983).

2. METHODS

Figure 2 The Martin Powers Barn and setting in early 2014

Introduction

Initially, three historic structures were identified as potential research sites for inclusion in a multiple case study, including two historic timber frame barns and a covered bridge. However, due to time constraints related to obtaining timely permission to access and sample the structures, the study was narrowed down to a single structure and three sampling locations for the development of a reference chronology. The site selected was the Martin Powers Barn located in Cave Junction in Josephine County, Oregon.

Site Selection

The Martin Powers Barn is timber-framed barn purportedly built in c. 1887 according to available literature.[16] The barn is currently endangered due to natural

16 Oregon Inventory of Historic Properties, Historic Resource Survey Form: Martin Powers Barn. Salem: Oregon State Historic Preservation Office, 1984.

weathering and neglect, yet still retains considerable integrity in its materials and setting. The barn is publicly owned by the Oregon Department of Transportation (ODOT), which granted the access to the structure for this study.

Sample locations on the structure, site location, and methodology are vital to determining the feasibility and utility for this study. In AE Douglas's book "Precision of Ring Dating in Tree-ring Chronologies", he outlined three essentials in attaining precision. They include the classification of trees to get the right kinds of trees, proper surfacing of specimens to get the facts about the individual rings, and crossdating or the comparison between ring groups in different trees to correct ring errors and determine climatic effects.[17] Finding the right kind of trees was of critical importance for the success of this project and it was hypothesized that the old-growth forests in the adjacent Siskiyou National Forest could provide the right trees of correct species and age. Due to human activity such as logging, burning and grazing, finding trees of sufficient age is difficult closer to the Willamette Valley and other population centers.

Primary reasons that the Powers Barn was selected included public ownership, access to stands of old growth Douglas fir for the development of a reference chronology, and the type of construction. This last aspect was of great importance for the ease of sampling and the types of samples available. The Powers Barn is constructed of an exposed timber frame constructed of hewn Douglas fir logs. Since this type of construction occasionally leaves traces of the wane from which a precise cut date could

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17 Arthur E. Douglass, Precision of Ring Dating in Tree-Ring Chronologies. (Tucson: University of Arizona Press, 1946) 5.

be obtained, it is ideal for this type of study. Another factor that makes this type of construction useful for dendrochronology is that the source of the frame is likely to be local to the area and not imported, as may be the case with sawn timbers, lending credibility to the reference chronology established for this study.

Martin Powers Barn Overview

The Martin Power's Barn, which is currently owned by the Oregon Department of Transportation (ODOT), is a small hewn frame barn located approximately six miles east of Cave Junction, Oregon on the Caves Highway (Highway 46, which terminates at Oregon Caves National Monument), and the junction of Smith Sawyer Road. Interviews with the previous landowners indicate that the barn was built around 1887. The barn's interior has been modified over is existence with the addition of a new section of roof, an interior partition of vertical boards flanking the central aisle and the installation of mows and hayracks on either side of the central aisle.

According to interviews with Effie Smith, who is a relative of one of the previous owners of the property, the barn was built around 1887.[18] There is little evidence in the structure that indicates that it was constructed that early other than a few square nails and the timber frame construction. The greater majority of materials point to a construction date of sometime towards the end of the 19th century. The most likely date based on the construction materials is the early to mid-1890s as the majority of the nails on the

18 Oregon Inventory of Historic Properties, Historic Resource Survey Form: Martin Powers Barn. Salem: Oregon State Historic Preservation Office, 1984.

building are wire nails, with only a few nails affixing the exterior sheeting being square cut nails. While wire nails were in use before the 1890s and were developed in the early 19th century, the invention of machinery for their quick and efficient production was not perfected until the 1860s and1870s.[19] The time when wire nails were equal in production numbers to cut nails was 1892 and the transition from square to wire was swift.[20] It is likely that the cut nails that are seen in this structure are leftovers from previous construction projects on the farm and the remnants used in the construction the barn.

Initial inspection of the barn revealed relatively few suitable locations for dendrochronological testing. The trees utilized in the framing were relatively young and generally less than 50 years old with little sensitivity and therefore poor candidates for the study. Additionally, the rings observed in the hewn frame were wide and indicative of juvenile growth patterns. Furthermore, there were only limited areas where the outermost rings were present on a hewn member that was structurally sound enough for sampling. The four posts in the center of the barn have remained the driest and most structurally intact in the structure, yet there was still significant insect damage that had to be avoided when taking the samples.

Secondary areas of the barn, such as the exterior cladding and interior partition walls, contained milled boards of Douglas fir that looked more promising than the hewn frame members since they were from older trees and contained sufficient rings to provide

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19 William Hampton Adams. 2002. "Machine Cut Nails and Wire Nails: American Production and Use for Dating 19th-Century and Early-20th-Century Sites". (Historical Archaeology. 36, no. 4.) 69.

20 William Hampton Adams. 2002. "Machine Cut Nails and Wire Nails: American Production and Use for Dating 19th-Century and Early-20th-Century Sites". (Historical Archaeology. 36, no. 4.) 72.

a statistically significant sample for valid crossdating. Additionally, several of the partition boards selected for the sampling had their outermost rings intact, which could potentially supply a cut date for the lumber. While the lumber from the interior partition walls may not reveal the construction date of the structure, it can provide further information regarding dates of modification and was therefore useful for the purposes of this study.

Assessment of Wood Fabric

An examination of all the timbers used in the construction of the Powers Barn was undertaken to determine the suitability for their use in the study. The primary criteria for sample selection were sufficient numbers of rings in the cross-section and the presence of features that indicate that a cut date could be obtained, such as a visible wane or the presence of sapwood that could be used to estimate the cut date. Wood specimens from the barn were also examined with a 10x hand lens and microscopically under 40x to determine the tree species and ensure that it was Douglas fir.

The building fabric was also examined for potential problems regarding the integrity of the specimens, such as the presence of defects that might weaken the specimen such as insect boreholes or the presence of rot. These can make obtaining a sample difficult or make taking tree-ring width measurements difficult by obscuring or obliterating latewood/earlywood transitions. Only stable and intact wood could be utilized for the study when using a coring drill bit, but there was more leeway when utilizing samples sawn from larger pieces of wood since the defects caused by rot or insects can be more easily avoided during the sample measurement.

The number of rings present in each sample was of importance in establishing the statistical correlation between the specimens. Cook states in "Methods of Dendrochronology" that there is no single minimum number of rings that can be cross-dated, although experience in many laboratories suggests that reliable crossdating should not be expected for sequences less than about 40 years.[21] The Oxford Tree Ring Laboratory states however, that samples with ring counts as low as 50 may occasionally be dated, but only if the matches are very strong, clear and well replicated, with no other significant matching positions.[22] Generally, a longer sequence of continuous rings is better because it helps cut down on the possibility of a misdated series.

Establishing Cutting Dates

In order to potentially date the specimens collected from the Powers Barn it was important to locate areas on the structure that have the potential to yield a cut date on the timber used in the construction. To get an accurate date, the outermost ring must be present in the sample, which is sometimes confirmed by the presence of bark. An acceptable surface that may yield a cut date contains the outermost ring, which is

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21 E.R. Cook and L.A. Kairiukstis, eds., Methods of Dendrochronology: Applications in the Environmental Sciences. (Dordrecht, Netherlands: Kluwer Academic Publishers, 1990), 46.

22 Oxford Tree Ring Laboratory, "Basic Dendrochronology", http://dendrochronology.net/interp_ring_dates.asp# (accessed May 15, 2014)

continuous and intact around the smooth surface even when bark is absent.[23] However, this layer is often removed in many structures in the process of hewing or other surface preparations such as the peeling of bark with a drawknife.

The date assigned to the specimen is generally the year of the last complete ring if there are no indications that the new growth (indicated by visible earlywood but not latewood) had started. This is because one cannot be sure when in the trees dormant period that it was felled. For example, if the last complete ring dated to 1950, the tree could have been felled from late summer 1950 to early spring 1951, but the year assigned will be the year of last complete ring formation.

The cut date can also be estimated if there is sapwood present in the specimen, which is based on the available data for the estimated average thickness of the sapwood for various species. For Douglas fir, the sapwood width is approximately 1 ¾" - 2 ¼" depending on the diameter of the tree.[24] Sapwood is generally visually differentiated from the heartwood in Douglas fir by being of a lighter color and softer in texture than the reddish heartwood. If visual differentiation fails to see the sapwood/heartwood transition, there are chemical tests that can be used to provide further visual cues.[25] Sapwood width

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23 Henri D. Grissino-Mayer and Saskia L. van de Gevel. 2007. "Tell-Tale Trees: Historical Dendroarchaeology of Log Structures at Rocky Mount, Piney Flats, Tennessee". (Historical Archaeology. 41, no. 4), 36.

24 U.S. Department of Agriculture, Sapwood Thickness of Douglas-fir and Five Other Western Softwoods. (Madison, Wisconsin, USDA Forest Service Research Paper FPL 124, 1968), 2.

25 U.S. Department of Agriculture, Technical Note Number 253, Color Tests for Differentiating Heartwood and Sapwood of Certain Oaks, Pines, and Douglas-Fir. (Forest Products Laboratory, Madison, Wisconsin, 1954), 2.

should only be used to provide an estimate of the cutting date and never presented as the actual cutting date.

The seasonality of the cutting can also be estimated as long as the outermost ring is present and complete in the sample. Observation under a microscope can reveal if the new years growth has started or if the tree was dormant. If the tree was dormant it was cut in the late summer to wintertime months and if new growth in the cells is observable it was cut in either the spring or summertime. If detailed features such as these are observable, it is possible to see if the trees were harvested all at once, or over a period of time. It is entirely possible that not all of the trees were cut and utilized within the same year because milled timbers are often left to season for a number of years to reduce their moisture content, improve their workability and reduce the chances of warping caused by uneven drying when placed in a building.

Collection Procedures: Structures

Specimens were obtained using a specially designed hollow drill bit attached to a cordless power drill that bores into timbers to remove a cylindrical sample. The sample locations preferably contained the outermost sapwood with the bark still attached, but acceptable with visible features indicating the outermost surface. A black line was made on the surface of the wood indicating the long axis of the log before drilling to ensure that the outer surface observed before drilling was still intact after the drill was removed and the sample extracted.

Two types of drill bits were used on the structure. The first type was a Berliner Dendro-Bohrer obtained from Pressler Industries in Germany and the other was domestically made from Phil Dunn Solutions. The Berlin type hollow drill bit produced a core that was 5.6 mm (.22 inch) in diameter with the total size of the hole being 3/8" inches across which was easily filled with a equally sized hardwood dowel. The Phil Dunn model produced a slightly larger sample that measured approximately 6.35 mm (.25 inch) and produced a hole ½" in diameter, also easily filled with commonly available standard-sized hardwood dowels. The specimens for both of the drill types were removed with a L-shaped length of wire with a small cutting spur on the end that was inserted adjacent to the core and then twisted to engage the cutting edge. The core could then be removed from the hole with the aid of the cutting device and then the holes were filled with hardwood dowels affixed with glue.

Once removed the sample was examined to check if it contained a sufficient number of rings and its location was mapped and notes taken on the condition of the sample, its suitability for further study, number of rings and other features present in the core.[26] The sample was then placed into a straw or other suitable container to support and protect it for transportation and further processing in the lab. The sample number and the inside and outside direction of the tree-growth was indicated on the tube.

Bulk specimens were also taken from sections of timbers with a handsaw where this collection method was allowed, such as on fallen structural members or at the ends of milled boards. The collection of these samples, which was done only on milled timbers,

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26 See Appendix E for completed collection forms.

allowed for a larger cross-section than the cores. These specimens included timber that did not contain the outermost tree-ring, but were intended for internal crossdating purposes and for improving the final floating chronology since these specimens were of old growth Douglas fir and had more substantial ring counts than specimens from the posts.

Table 1 Summary of Powers Barn Samples

Sample ID	Sample Type	Species	Dating Attempted	No. of Rings	Wane Present	Timber Type
SSPO01	S	PM	Yes	110	No	Milled lumber, board
SSPO02	S	PM	Yes	102	No	Milled lumber, board.
SSPO03	C	PM	Yes	54	Yes	Hewn post. Last 10 years not measured. Broken core.
SSPO04	C	PM	No	N/A	Yes	Hewn post. Fragmentary Core.
SSPO05	S	PM	Yes	91	Yes	Milled Lumber, board.
SSPO06	S	PM	Yes	71	No	Milled lumber. Eastern door frame
SSPO07	S	PM	Yes	90	No	Milled lumber, cross brace. Sapwood present. Unknown provenance
SSPO08	C	PM	No	22	Yes	Hewn post.
SSPO09	C	PM	Yes	61	Yes	Milled lumber, board.
SSPO10	S	PM	Yes	53	Yes	Milled lumber, board.
SSPO11	C	PM	Yes	38	No	Milled Lumber, cross brace. Unknown provenance
SSPO12	C	PM	Yes	64	Yes	Hewn post. Duplicate of SSPO03.
SSPO13	C	PM	No	N/A	Yes	Hewn post. Fragmentary core.
SSPO14	C	PM	Yes	56	Yes	Hewn post.
SSPO15	C	PM	Yes	43	Yes	Hewn post.
SSPO16	C	PM	No	41	Yes	Duplicate of SSPO15
SSPO17	C	PM	No	42	Yes	Duplicate of SSPO15

Key C-Core sample. 5.6 mm dia.; S-Slice or section; PM-*Pseudotsuga menziesii*

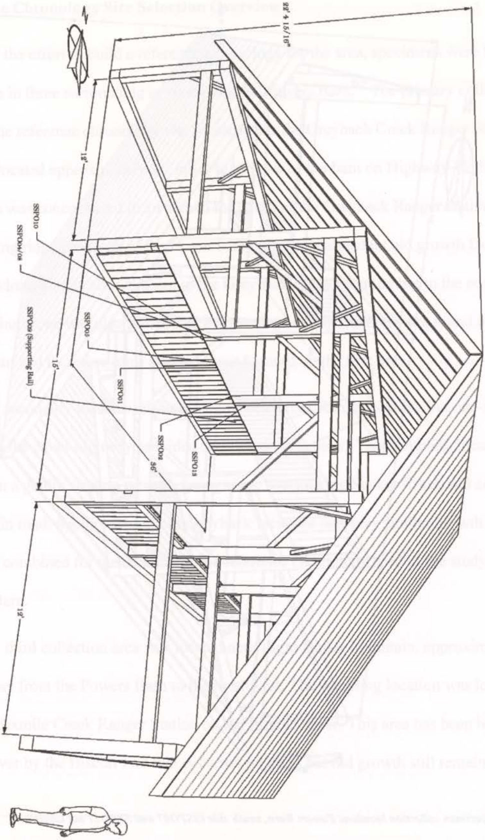

Figure 3 Specimen collection locations Powers Barn, north side (SSPO06 not labeled)

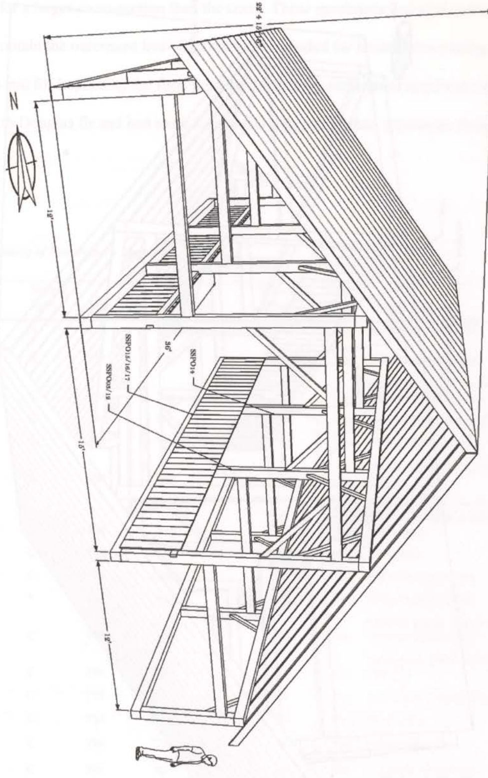

Figure 4 Specimen collection locations Powers Barn, south side (SSPO07 and SSPO11 not labeled)

Reference Chronology Site Selection Overview

In the effort to build a reference chronology for the area, specimens were taken from trees in three surrounding areas around the Powers Barn.[27] The primary collection area for the reference chronology was located near the Greyback Creek Ranger Station, which is located approximately six miles to the east of the barn on Highway 46. Sample collection was concentrated in an area to the south of the Greyback Ranger station on a north facing ridgeline south of the ranger station that had abundant old growth Douglas fir. An additional area also adjacent to the Greyback Ranger Station but to the north on a south-facing slope was also prospected but the rings at this location were found to be complacent and therefore most attention was focused on the first area.

A secondary location, also near Greyback Creek Ranger Station, but one-mile further up the caves highway provided additional specimens. This sampling location was located on a gently sloping western facing ridge overlooking Sucker Creek and adjacent to the main road. Specimens of both Greyback locations had very similar growth patterns and were combined for the creation of the reference chronology used in the study of the Powers Barn.

A third collection area was located near Eight Dollar Mountain, approximately 18 miles away from the Powers Barn to the northwest. The sampling location was located near the Sixmile Creek Ranger Station on the Illinois River. This area has been heavily burned over by the Biscuit Fire that occurred in 2001, but old growth still remains in

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[27] See Appendix C for maps with collection areas and Appendix D for completed collection forms

isolated pockets. Cores from this location were treated separately due to the additional distance from the study area and slightly different soil conditions and then analyzed by the computer program COFECHA to determine the correlation with the specimens collected at Greyback before being added into the reference chronology. They were found to have good correlation with samples from the Greyback location and the series were combined in the reference chronology.

The lack of stumps or signs of logging activities in both locations indicates that they had not been significantly modified and that they contained intact stands of timber. Trees species found in the Greyback stands were composed primarily of Douglas fir, madrone, tan oak and canyon live oak, sugar pine, and western white pine. At the Sixmile location on the Illinois River the composition of the forest was similar although the sites were drier due to the large amount of bedrock present, which led to a greater amount of conifers than at Greyback. Dominant species included Douglas fir, Jeffery pine and Manzanita. Gary oak and canyon live oak were the dominant oak species present at the Sixmile collection area.

Specimen Collection Procedures: Live Trees

To create a reference chronology, it was necessary to take at least one sample from 20-30 living trees from the surrounding forests, that grew approximately under similar growth conditions and were of the same tree species as the wood used to construct the buildings. All trees utilized in building of the local reference chronology come from trees within a 20-mile radius of the study location. Selected trees were healthy and straight to ensure the uniformity of the specimens and taken from sites that allow for uniform growth, that is not too wet or too dry, to ensure that the specimens reflect the broader environmental trends and not localized phenomena. Arthur Douglas stressed that site selection for dating be very stringent and that the trees selected for study should get little or no water except for the precipitation that falls very near them and do not have much power of conserving water supply; with conservation small rings may be very complacent.[28]

The trees from which specimens were taken were healthy Douglas firs of sufficient adequate age to yield sufficient rings to cross date with the Powers Barn specimens and would ideally yield samples of at least 180 years. The trees were to be symmetrical with a healthy looking crown and foliage and a straight trunk that did not exhibit curvature of the stump, which could contain reaction wood (uneven growth used by the tree to stabilize itself) that would affect the validity of the sample. Specimens were located no closer than 30 meters from each other to compensate for any localized conditions that may be present but not noted within the survey are such as localized seepage that may affect the growth of the tree.

Cores of trees were taken from the vicinity of the Powers Barn site during the months of February, March and May with a standard 16" silviculturists increment borer with a inside diameter of 5/16". A total of 30 specimens were taken from the three different sites around the Powers Barn Site ranging from 6 to 18 miles distant. The

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28 Arthur E. Douglass, Precision of Ring Dating in Tree-Ring Chronologies. (Tucson: University of Arizona Press, 1946) 17.

specimens were taken from breast height (1.3 m) from all trees. Upon extraction, the specimens were evaluated in the field. Features observed in the field included the mean ring width, sensitivity (frequency of visual recognizable signatures or pointer years), frequency and date of abrupt changes in ring width, rot, wounds or compression wood.[29] In some trees, two specimens were taken if needed, but one sample was sufficient for most trees. Specimens that did not meet the minimum criteria were discarded in the field and not recorded on the sample form.

If the trees were on a significant hill slope that could have affected the growth of the tree, the cores were taken from the sides to minimize the influence of reaction wood in the sample that might affect the results of the dating. The specimens were put into protective straws with the inside and outside of the tree indicated and the sample number assigned. The geographic locations of the specimens were recorded on the collection form using a Global Positioning System (GPS, NAD 83 projection), along with a brief description of the tree and setting. The samples were then placed in their individual protective holders and those were placed into a larger protective tube to safeguard the samples during transport. No hardwood plug was necessary for the living trees, as sap will fill the wound quickly and they will heal over in several years.

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29 E.R. Cook and L.A. Kairiukstis, eds., Methods of Dendrochronology: Applications in the Environmental Sciences, Softcover ed. (Dordrecht, Netherlands: Kluwer Academic Publishers), 29.

Sample Preparation

The live tree cores were allowed to dry for several days after returning from the field before mounting to minimize cracking of the specimens due to shrinkage resulting from being confined by the glue when mounted. In the lab, the core specimens were mounted on routed lengths of wood with wood glue and left to dry for 24 hours. The surface of the sample was then prepared for measurement by either sanding with progressively finer grits of sandpaper or using a blade to shave the surface, accentuating the rings and making it easier to measure ring width. Generally the surface made with a knife was sufficient to see the rings clearly and was the preferred surface preparation method. A side benefit of utilizing a blade for surface preparation was that it sheered through cell walls making earlywood/latewood transitions clear. Sanding with 320 and 400-grit sandpaper was employed in some samples that had especially soft wood that caused the cell walls to crumble instead of shear cleanly when prepared with a razor and making measurement difficult.

The orientation of the grain in the specimens was highly important during mounting. A.E. Douglas recommended that the grain be aligned at a 35-40° angle since this exposes the greatest amount of cellular structure for interpretation that could help the analysis with any possible doubtful ring.[30] Further enhancement of the rings could be made by rubbing various compounds on the sample, including alumina, anthracene and

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30 Arthur E. Douglass, Precision of Ring Dating in Tree-Ring Chronologies. (Tucson: University of Arizona Press, 1946) 8.

ordinary chalk.[31] Chalk was sufficient for clearing up any rings that were difficult to differentiate in specimens, but it was rarely needed as generally the rings in Douglas fir had clearly demarcated latewood and earlywood boundaries.

In the case of the Powers Barn core specimens, most of the them were shaved with a blade and if the rings were difficult to read a further hand sanding with 400 grit sandpaper proved sufficient to enhance the rings and provide a crisp boundary for measuring. The larger bulk specimens had to be sanded as their large size makes them unsuitable for preparation with a blade. They were sanded with a series of progressively finer grits from 150 to 400 with a random orbit sander. After finishing the surface of the specimens their quality was assessed by looking at sensitivity of the rings, total ring count and any defects present in the sample.

Tree Ring Measurement

The specimens were measured with a Velmex measuring system under binocular magnification of variable power depending on the size of the rings being examined to an accuracy of .001 millimeters. Measurement software utilized for this project was Measure J2X. The starting date for the measuring was 2013 in the live tree samples since there was no measurable growth for this year (2014) at the time of the sample collection. The barn samples were assigned the year "1" for the innermost complete ring. The

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31 E.R. Cook and L.A. Kairiukstis, eds., Methods of Dendrochronology: Applications in the Environmental Sciences. (Dordrecht, Netherlands: Kluwer Academic Publishers, 1990), 42.

measurements were used for statistical evaluation with the program COFECHA after visual crossdating had been attempted.

Skeleton Plotting

The initial procedure to date the samples and establish a chronology was to attempt to visually crossdate the samples and complete skeleton plots of the cores and other specimens in the lab to create a floating chronology for the barn specimens and a reference chronology from the live tree specimens. The arrangement and pattern of narrow rings can be compared to other specimens of both the known series (reference chronology) and unknown series (floating chronology). This is the beginning of the crossdating process, which can then link specimens of unknown age to specimens of a known age.

The tree rings of each core were counted under 3.5-10x magnification and decades (single dot), half centuries (two dots) and centuries (three dots) were marked with a mechanical pencil. In this quick analysis, it is the very narrow rings that get the most attention and are plotted on the graph paper, but very broad rings were also noted in the creation of the skeleton plots. The floating chronology for the site was then visually crossdated with the reference chronology created from the specimens obtained from the living trees. The reference chronology runs from the last year of growth (2013) to 1696, although it is only well correlated for the period of 1800 to 2013. The results were then statically verified with the computer software.

Statistical Verification of Crossdating With COFECHA

Over the years a number of computer programs based on the underlying statistics used in dendrochronology have been developed to help with analysis. First and foremost of these is the computer program known as a COFECHA (an invented Spanish word that means crossdate), which was used for analysis and quality control in this project. The current research climate with expectations of high productivity researchers do not have the time to completely check each others dates and in response to this Richard Holmes developed the quality control computer program called COFECHA.[32] COFECHA is a program that allows the user to identify areas of missing rings, false rings or other problems that may have occurred either in collection, analysis or are simply related to variations found within the tree, but it can also do much more.

The primary purpose of this program is to identify specimens that may cause problems with the analysis and to identify or "flag" those specimens with low correlation for closer inspection. For example, series with correlation of less than .3281 in the standard 50-year segment length are flagged in the output. These low correlation specimens (< .3281) can still be used for interpretation, but the assurance that they are correct is less than the 99% threshold that a .3281 correlation provides. The segment lengths examined can also be varied to identify sections of cores that contain low correlations, such as those caused by missing rings, and can help identify those sections that need to be reexamined and corrected or eliminated from the chronology. The

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32 James H., Speer, and Karla M. Hansen Fundamentals of Tree-Ring Research. (Tucson: University of Arizona Press, 2010) 115.

standard 50-year segment length with 25-year overlap is a generally accepted standard and set up as a default by the program, and was also used as the standard of this study. It created the strong dating in the samples and the results were less erratic than if the segment length was shorter.

The output file generated by this program contains necessary information regarding the correlation of each core (series) to the reference chronology created in COFECHA as well as statistics for each core such as the total number of rings, dates covered by the core and mean sensitivity (variations in growth caused by environmental conditions). It also provides series statistics that are useful to find specimens that have high correlation to each other that helps in creating the floating chronology. The series inter-correlation is a measure of the stands level signal, and mean sensitivity is a measure of the year-to-year variability in the reference chronology.[33]

COFECHA also has the ability to create and save a reference chronology that can be used for comparison with individual series. It standardizes the tree-ring series in order to remove age-related growth trends, or natural and human disturbances that could affect chronology development. This correction of ring width for the changing age and geometry of the tree is known as standardization and the transformed values are called ring-width indices.[34] The standardized indices of individual trees are averaged to obtain the mean chronology (mean standardized indices) for a sample site.[35] In this reference

33 James H., Speer, and Karla M. Hansen Fundamentals of Tree-Ring Research. (Tucson: University of Arizona Press, 2010) 120.

34 Harold C. Fritts, Tree Rings and Climate. (London: Academic Press, 1976), 25.

35 Harold C. Fritts, Tree Rings and Climate. (London: Academic Press, 1976), 25.

chronology the program highlights rings that are exceptionally large or small as adjusted for age related trends and can identify years in which pointer years occur to aid further chronology development by the dendrochronologist.

The program can also assist in crossdating of specimens in a couple of different ways. During a normal run of the computer program it provides an option to insert an undated series and statistically compare it to the reference chronology. However, COFECHA was never intended to be the sole approach to date sample of wood or to replace crossdating with skeleton plots. It provides statistical match between segments of each core and the reference chronology that is made of the measurements that are entered into the program.[36] It will then provide a series of dates that offer potential statistical matches for the segments examined, but it is up to the analyst to determine the final date, as the highest correlating date is not always the true date and the examination of several specimens is often necessary to determine the true date. The checking of the data with the computer is to be done after skeleton plots and other methods of cross correlation have been attempted and it is never to be the sole method of correlation.

COFECHA can also assist with the internal crossdating process and the creation of a floating chronology when the user skips the initial step of entering a dated series into the program and instead only enters an undated series. This data analysis will produce an output that compares various series in the data file to one another to check if there is a statistical match between the ring measurements of various series. Series with T-values (a

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36 James H., Speer, and Karla M. Hansen Fundamentals of Tree-Ring Research. (Tucson: University of Arizona Press, 2010) 116.

measure of intercorrelation) over 3.5 have a high correlation with the other series to which it has been compared. This feature enables identification of series that have high intercorrelation and can be helpful for building of the floating chronology. This feature is also helpful since some series will have high intercorrelation with each other but not to the reference chronology and utilizing this feature can help link hard to date series to the master through another specimen. As with the date suggestions provided by the computer, caution is advised as spurious T-values in excess of 7 have been noted, so it is essential that matches with reference chronologies be well replicated, and that this is confirmed with visual matches between the two graphs.[37] Matches with t-values of 10 or more between individual sequences usually signify having originated from the same parent tree.[38]

EDRM

A specialized program that proved to be very useful in manipulation and editing of the data in series was EDRM (Edit Ring Measurements). This simple program can adjust the dates in specimens, change the output format, export spreadsheet data or insert data if it is discovered that there is a missing ring. This program is most often used after COFECHA has identified some sections of a core that needs to be corrected or

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37 Oxford Tree Ring Laboratory, "Basic Dendrochronology", http://dendrochronology.net/interp_ring_dates.asp# (accessed May 15, 2014)

38 Oxford Tree Ring Laboratory, "Basic Dendrochronology", http://dendrochronology.net/interp_ring_dates.asp# (accessed May 15, 2014)

eliminated.[39] It was used extensively during the course of the study to modify the terminal dates of specimens while maintaining the Tucson format of the original measurement files.

39 James H., Speer, and Karla M. Hansen Fundamentals of Tree-Ring Research. (Tucson: University of Arizona Press, 2010) 133.

3. RESULTS

Powers Barn History

According to interviews done in conjunction with a historic buildings survey conducted in 1984, the Martin Powers Barn was constructed in about 1887 for Jeanette Clark Powers and her husband Martin Powers.[40] The primary source for the information is an interview conducted on June 15, 1984 with Effie Smith who is the daughter-in-law of Henry Orange Smith, and a friend of Samuel Bunch, son of William and Mary Bunch. Her source for the information on this building came from Samuel Bunch.[41]

Jeanette Clark was born in about 1867 to Mary and Augustus Clark. Her father died shortly after her birth, and her mother was remarried to William Bunch in 1869. The Clarks had obtained the land that was originally the donation land claim of William H. Watkins.[42] He settled in the area in 1854, sold his land in 1862 and moved to Portland. It is unclear if he immediately sold to the Clarks or if there was an intermediate buyer for the property.

Jeanette Clark grew up with her mother and stepfather on the land her mother had inherited after the death of Augustus Clark. In 1886 her mother and stepfather, William Bunch, gave Jeanette the north 66 acres of her father's land claim including the land that

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40 Oregon Inventory of Historic Properties, Historic Resource Survey Form: Martin Powers Barn. Salem: Oregon State Historic Preservation Office, 1984.

41 Oregon Inventory of Historic Properties, Historic Resource Survey Form: Martin Powers Barn. Salem: Oregon State Historic Preservation Office, 1984.

42 See Appendix B for a 1857 map of the area showing the Watkins farm

the current barn occupies. On September 8, 1887, Jeanette Clark and Martin Powers were married at the home of her grandmother, Sarah Parks Kelly. Shortly after, Alexander White, born 1841, son of Samuel and Cynthia White, donation land claimants nearby, were hired to supervise construction of the Powers Barn.

Martin Powers, a native of Virginia, and Janette lived on the property for several years and raised a large family. They sold their farm to Henry Orange Smith in 1902 and moved away. Two generations of the Smith family farmed until 1991 when the barn and 16 adjacent acres were donated to the Oregon Department of Transportation. The intent of the Smith family members donation was to create a scenic and historic wayside along Highway 46, with the historic barn as the centerpiece of the wayside. According to site records, the Powers Barn is one of the oldest in the Illinois Valley and in Josephine County. The Powers Barn forms part of a group of several other buildings in the area including the Henry Orange Smith Barn and granary to the south, which together form one of the best clusters of agricultural buildings in the county. The residences have all disappeared and only the barns survive.

Figure 5 Hewn post and beam intersection with trunnels, layout lines and hewing marks

Site and Architectural Description

The Martin Powers barn is a relatively small hewn timber frame barn that measures 36-feet east to west and 45-feet north to south.[43] The barn sits immediately adjacent to the highway, much obscured by blackberry bushes and a few large oaks and a ponderosa pine. It is located on the banks of Tycer Creek, which is a tributary of the East Fork Illinois River. The original purpose of the barn is unknown, but until recently it has been used for hay storage and for the feeding and sheltering of sheep. A large oak tree immediately to the north of the structure has lost a branch that has impacted the structure,

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43 See Appendix A for photos of barn and architectural details

caused the northeast corner of the structure to collapse, and shifted the entire structure slightly to the south. The barn is currently suffering from a number of other structural maladies and is in poor to fair condition. The roof remains intact and the interior is protected from the majority of the weather for the time being.

The frame of the barn is constructed of approximately 8-inch square hewn posts and beams with a housed through-tenon that is secured with riven and rounded 1-inch Douglas fir pegs (trunnels). The posts and beams were evidently squared with an ordinary axe, as the hewing marks are small, curved and perpendicular to the length of the log rather than parallel or angled which is typically found when a broad axe is used. The cross braces of the barn are made of (possibly band-sawn) 2 ¾" x 4" x 6' long milled timber and placed into mortises in the hewn posts and beams. The cross braces are not secured into the mortise with either nails or pegs, only a friction fit. The vertical posts rest on an approximately 8-inch square hewn sill, which in turn rest on rough fieldstone piers that are located at the junction of the vertical posts to the sill.

There are four bents to the barn and the interior is partitioned into three sections with central aisle and two side aisles that have been modified to feed livestock with very roughly constructed Douglas fir pole mangers constructed of approximately 3-inch diameter unpeeled Douglas fir poles. The above the livestock feeding mangers are expediently constructed mows again constructed of small diameter unpeeled Douglas fir poles decked with sawn 1-inch thick boards of Douglas fir. There are large forged spikes nailed through the Douglas fir saplings into the supporting hewn beams, but the boards forming the hayloft are affixed with wire framing nails as are found throughout the remainder of the barn. The hayloft in this configuration is not original and appears to have been a very late addition to the barn due to the crude construction techniques compared to the rest of the structure.

The roof of the barn is composed of a variety of components and appears to have been replaced or repaired, perhaps as many as two or three times as evidenced by different construction techniques and materials. The rafters found in the peak of the barn on the eastern half are composed of milled wood measuring approximately 2 x 6" with nailing surfaces (purlins) composed of perpendicularly applied Douglas fir planks measuring 1-inch thick of varying widths and lengths. This nailing surface is also found throughout the remainder of the roof and in sections it appears that this is similar to the original nailing surface for the roofing material. The rafters in the western half of the structure and in the lower reaches of the roof in the remainder of the structure are composed of peeled round Douglas fir poles of approximately 4 inches in diameter.

According to the Oregon SHPO Historic Resource Record the roof may have been replaced in the 1960s, although it does not specify to what extent or which sections of the roof were replaced. There is some indication that the sections containing the peeled Douglas fir poles are original since these are the only locations that still contain remnants of cedar shingles that were apparently the original roofing material. The roof is currently sheathed in a corrugated galvanized metal roofing material. Sections of the roof have been replaced over time as indicated by bright new metal roofing in some areas and other areas having roofing that has been weathered and rusted.

The exterior wood sheeting is likely original or an early addition, although it was not part of this study and therefore a date cannot be derived. It is composed of 12-inch wide 1-inch thick circular sawn boards that are affixed to the structure vertically. The fasteners used were primarily wire framing nails although in several locations the heads of square nails can be observed, particularly on the areas immediately surrounding the western entrance to the central aisle. Use of wire and square nails occurs concurrently throughout the structure and it does not appear that any one location holds a preponderance of square cut nails, this indicates that the barn was either constructed at a period of transition or the person used leftover stock from a previous project. There are no battens on the gaps between the boards, which is fairly typical for barns since it helps interiors dry out more rapidly by improving ventilation.

There are two entrances to the central aisle of the barn, with one to the east and one to the west. It does not appear that these entrances ever had doors although the entrances on both sides are much degraded and modified so that one has difficulty picturing if they were enclosed or not. Flanking the main aisle are two smaller aisles that were historically used for the feeding of livestock and for hay storage.

There is a significant difference in wood used in the frame of the building versus the milled timber that constituted the rest of the structure. The frame of the structure used younger trees that were generally less than 50 years old and likely around 12-inches in diameter before the hewing process. These posts and beams are characterized by wide growth rings and little heartwood development. The continuous length of the posts and beams measure from 6 to 36 feet long and come from straight and relatively knot free stock. Conversely the milled timber appears to be from old-growth Douglas fir and exhibits well-developed heartwood and tight rings indicating mature trees and closed canopy growth.

The overall condition of the barn is generally poor and there is considerable insect damage to many of the horizontal internal members of the structure. The damage by insects appears to be the work of carpenter ants, termites and powder post beetles. One of the beams on the south side has broken due to rot and insect damage and others are in similar condition. The vertical posts that support the building are in far better condition but still have insect boreholes throughout their length. The posts and beams on the periphery of the barn are in the worst shape with extensive areas of brown rot and insect damage and were not suitable for this study due to their degraded state. The sill logs on which the barn rests have also rotted away except for a section on the south side of the center aisle and another fragmentary section on the northwest corner of the center aisle. There are also remnant and much degraded boards from a floor in the south aisle, but it is not apparent if this was applied to the entire floor of the barn or if it was constructed later only on that side.

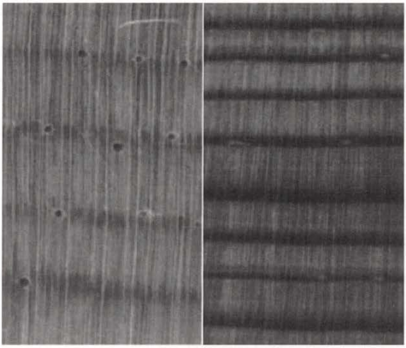

Figure 6 Ponderosa pine (Jeffery pine identical) (left) and Douglas fir (right), note resin canals (Hoadley, 1990)

Determination of Wood Species

One of the initial steps in the study of the Martin Powers Barn was the determination of the materials and techniques used in its construction. There are number of different softwood species commonly found in the study area that could have been selected for the construction of the barn including Jeffrey Pine (*Pinus jeffreyi*), Ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziessi*), incense cedar (*Calocedrus decurrens*), western white pine (*Pinus monticola*), sugar pine (*Pinus lambertiana*) and red cedar (*Thuja plicata*). Part of this study was the determination if lowland Douglas fir is suitable subject for dendrochronological study and finding a structure utilizing it for the majority of its construction was of great importance. Since there were numerous softwood species present in the area, steps were taken to determine if the barn was constructed wholly of Douglas fir, partially, or not at all.

The two of most common trees located within the Cave Junction area are Jeffrey pine and Douglas fir and both are a common construction material in the region with Douglas fir being the preferred species. Jeffery pine is commonly found on the serpentine soils that are found throughout southwestern Oregon. Jeffrey pine and its biological cousin ponderosa pine are characterized by numerous medium resin canals found evenly distributed throughout the wood and an abrupt earlywood/latewood transition.[44] Douglas fir however, only has sporadic resin canals of medium size and its heartwood is distinctly reddish brown (Figure 6).[45] Upon microscopic analysis, it was found that all specimens from the barn were of Douglas fir, which was used for both the hewn frame members and all the dimensional lumber found in the structure.

Origin of Wood Used in the Construction of Powers Barn

The origin of the wood used in the construction of the barn is somewhat in question since there is no historic documentation that the wood utilized in the construction of the barn was local. The assumption is that it came from a local source, where local, for the definition of this paper, means within a 20-mile radius. It can be

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44 Bruce R. Hoadley. Identifying Wood: Accurate Results with Simple Tools. (Newtown, Conn: Taunton Press, 1990) 147-48.

45 Bruce R. Hoadley,. Identifying Wood: Accurate Results with Simple Tools. (Newtown, Conn: Taunton Press, 1990) 150-51.

postulated that the framing members were almost certainly from locally felled trees because the area where the barn is located has ample stocks of Douglas fir of sufficient height and diameter to fashion into posts and beams.

The source of the milled wood used in the structure is more questionable. Even during the 1880s when the structure was reportedly constructed there was good network of roads for transport of goods such as lumber. However, products such as lumber were commonly produced and utilized locally if the area could support the industry. Examination of the historical records for the area showed that there were mills and other lumbering industries in the area that could have supplied wood for this building. They indicate that there were at least two sawmills located in Kerby, Oregon approximately 15 miles from the site in 1915.[46] Kerby is a mining town dating from the 1857 and was a center and former county seat for Josephine County. Therefore, like any mining town, Kerby and the surrounding area would consume lumber at a prodigious rate and would likely have their own mills from the beginning to satisfy this trade. However records of these earliest mills are absent.

An equal distance to the south of the barn was another mining boomtown named Waldo, which had its origins in 1852 as a place called "Sailors Diggings", and like Kerby was also briefly the county seat of Josephine County.[47] In 1915 one sawmill was still left in Waldo even though the town itself was in severe decline due to the gold running out.[48]

46 Ralph Friedman. In Search of Western Oregon. (Caldwell, Idaho: Caxton Printers, 1990), 239.

47 Lewis A McArthur and Lewis L. McArthur. Oregon Geographic Names. (Portland: Oregon Historical Society Press, 1992), 874.

48 Ralph Friedman. In Search of Western Oregon. (Caldwell, Idaho: Caxton Printers, 1990), 237.

Therefore, even as late as 1915, well into the decline of the mining industry in the surrounding area, there were still numerous local mills from which the wood could have come from. With ample choices in the local area to supply the wood for the construction of the barn, the milled lumber should be considered to be of local origin much like the framing members.

External Crossdating

Of the 24 specimens from live trees in both the Greyback area and Sixmile sample locations included in the reference chronology for the area, three flags (segments of series with a below threshold correlation or correlation higher at another location) were identified in two of the specimens when processed with the COFECHA program.[49] Upon examination of the output produced by COFECHA it was discovered that the reasons were low correlations (below the .3281 correlation minimum for a 99% certainty of match set by the program with a 50 year segment length) and having a higher correlation at another date within plus or minus ten years that could indicate a missing ring.

Upon examination of the alternative placements identified by the program and reexamination of the samples it was determined that there were no missing rings since the alternate locations were more than plus or minus one or two positions. Such minor corrections as these indicate the possibility of a missing ring but larger than that generally indicate localized biological response to disturbance or other localized environmental

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49 See Appendix F for COFECHA output sheets

factors acting upon the tree. Upon examination of flags, all other series were determined to be suitable for inclusion to the reference chronology. In total, 24 specimens (30 total collected) of live trees from the three surrounding areas were utilized to build the reference chronology for the Powers Barn spanning the years 1696 to 2013 (Table 2).

Table 2 COFECHA output for live tree series used to create reference chronology

PART 7: DESCRIPTIVE STATISTICS: Sun Page 7

							//-------- Unfiltered --------\\					//---- Filtered -----\\			
Seq	Series	Interval	No. Years	No. Segmt	No. Flags	Corr with Master	Mean msmt	Max msmt	Std dev	Auto corr	Mean sens	Max value	Std dev	Auto corr	AR ()
1	LTP001B	1857 2013	157	6	0	0.679	1.33	3.42	0.683	0.877	0.198	0.68	0.264	-0.013	1
2	LTP002A	1874 2013	140	6	0	0.685	1.68	3.53	0.641	0.865	0.161	0.67	0.215	-0.012	1
3	LTP003B	1903 2013	111	4	0	0.445	2.04	4.38	0.713	0.873	0.126	0.47	0.188	-0.025	1
4	LTP004A	1920 2013	94	4	0	0.550	1.44	4.32	0.621	0.781	0.166	0.63	0.217	-0.016	2
5	LTP005A	1865 2013	149	6	0	0.532	1.14	2.13	0.302	0.593	0.177	0.67	0.215	-0.018	1
6	LTP006B	1901 2013	113	4	0	0.555	1.68	2.96	0.511	0.818	0.159	0.52	0.209	0.006	1
7	LTP007A	1935 2013	79	3	0	0.626	2.68	3.87	0.410	0.526	0.118	0.34	0.135	0.004	1
8	LTP008A	1864 2013	150	6	0	0.525	1.10	2.05	0.282	0.718	0.150	0.66	0.199	0.007	1
9	LTP009B	1696 2013	318	10	0	0.480	0.69	2.15	0.401	0.931	0.151	0.56	0.182	-0.003	1
10	LTP010B	1756 2013	258	10	0	0.522	0.86	1.90	0.325	0.873	0.157	0.49	0.191	-0.002	3
11	LTP011A	1941 2013	73	3	0	0.513	3.23	6.46	0.984	0.782	0.165	0.44	0.192	0.001	1
12	LTP013A	1945 2013	69	3	0	0.394	2.86	4.31	0.544	0.644	0.130	0.36	0.173	0.058	1
13	LTP014B	1869 2013	145	6	2	0.487	1.37	3.31	0.645	0.927	0.142	0.46	0.183	0.040	1
14	LTP015A	1914 2013	100	4	0	0.678	2.54	4.91	0.816	0.587	0.236	0.54	0.252	0.014	2
15	LTP016A	1931 2013	83	3	0	0.650	3.11	5.89	1.246	0.782	0.202	0.58	0.228	-0.001	1
16	LTP017A	1930 2013	84	3	1	0.418	3.00	5.24	0.885	0.706	0.178	0.55	0.213	0.006	1
17	LTP018A	1923 2013	91	4	0	0.566	2.43	5.90	0.976	0.834	0.171	0.65	0.203	-0.025	1
18	LTP020A	1864 2013	150	6	0	0.529	1.85	3.84	0.826	0.915	0.150	0.62	0.177	-0.016	1
19	LTP023A	1842 2013	172	7	0	0.632	1.33	2.78	0.432	0.776	0.160	0.60	0.200	-0.006	4
20	LTP024A	1841 2013	173	7	0	0.593	1.28	2.50	0.441	0.833	0.144	0.64	0.206	0.041	1
21	LTP025A	1843 2013	171	7	0	0.630	1.35	2.27	0.378	0.755	0.166	0.47	0.194	0.001	1
22	LTP026A	1808 2013	206	8	0	0.680	0.98	2.63	0.584	0.942	0.145	0.40	0.171	0.013	1
23	LTP029A	1816 2013	198	8	0	0.545	1.11	3.20	0.661	0.879	0.200	0.80	0.277	-0.022	1
24	LTP030A	1820 2013	194	8	0	0.574	1.20	2.41	0.476	0.849	0.163	0.71	0.213	0.017	1
Total or mean:			3478	136	3	0.566	1.50	6.46	0.563	0.820	0.162	0.80	0.204	0.001	

In contrast to other regions in the United States such as the American Southwest, the average mean sensitivity of the specimens recovered from the living trees in the region surrounding the Powers Barn were low with a mean value of only .16, which can make the crossdating of the specimens tricky because many of the climatic signals are suppressed. The specimens are visually complacent and had a mean sensitivity that ranged from a low of .118 to a high of .236. According to the National Climatic Data Center the aggregate mean sensitivity for the species is .33 with a intercorrelation of .75

for tested series.[50] For the purposes of dendrochronological dating it is desirable to have specimens with a mean sensitivity around 0.2 or higher.[51] The relatively low sensitivity is caused by the trees generally favorable tree growth conditions in the Cave Junction area and the region as a whole. Intercorrelation statistics for the various series with the master was good with a mean of .566 (Table 2).

An examination of the NOAA tree-ring archive revealed only one other study on Douglas fir near the Powers Barn that could be used as a comparison for this study.[52] Lisa Graumlich conducted a study in 1981 near the Abbot Creek drainage immediately to the west of Crater Lake, which is approximately 100 miles to the northeast from Cave Junction. When compared to the specimens collected for the Powers Barn reference chronology it was found to have an intercorrelation of .45 with this study, but would consistently suggest different dates due to higher correlations either higher or lower in the sequence making this chronology unreliable for something as distant as the Powers barn.

The Graumlich study did compare favorably to the Powers study in terms of mean sensitivity intercorrelation amounts. Sensitivity for Abbot Creek was approximately .18 and series intercorrelation was .58, both of which are similar to the specimens taken from around Cave Junction. Sample size was also fair to good with 22 specimens represented in the study, which is similar to this study. The site of the Graumlich reference

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50 National Climatic Data Center, http://www.ncdc.noaa.gov/paleo/treering/cofecha/speciesdata.html (Accessed 06/01/2014)

51 James H., Speer, and Karla M. Hansen Fundamentals of Tree-Ring Research. (Tucson: University of Arizona Press, 2010) 107.

52 The NOAA website (http://www.ncdc.noaa.gov/) contains a searchable database of dendrochronology studies. This study was compared to the Abbot Creek reference chronology done by Lisa Graumlich in 1983 located near Crater Lake, Oregon.

chronology is not only at a considerable distance from the Cave Junction study area, but is also developed at a higher elevation (4,750’ as opposed to 1,500’ to 2,500’ in this study), which can affect the sensitivity of the samples. Soil conditions and other environmental factors are significantly different at that location as well, with volcanic soils as opposed to the serpentine derived soils of Southwest Oregon. It was shown by the examination of this chronology that it is important to develop an accurate local reference chronology of the same species and environmental conditions for the most accurate dating, especially in complacent species such as Western Oregon Douglas fir.

Internal Crossdating

The sampling of The Powers Barn produced 17 specimens from 13 locations throughout the structure including several duplicates from a post and a sill log, but not all of them were suitable for further analysis (Table 1). Twelve of the specimens had features indicating the outermost rings as indicated by the presence of a wane on the original surface. Upon return to the lab and further examination and preparation of the specimens, the number of samples was further reduced to 11 that could be potentially utilized for dating. Ideally, each of the posts and beams composing the barn would have been sampled, but many of the hewn timbers used in the construction of the barn were too young to yield the recommended 50-year minimum needed for accurate dating. Additionally, the condition of the barn is poor and sampling locations were limited to those areas where cores could be extracted, and even with careful selection a number of cores were broken during the drilling process due to the presence of extensive insect galleries found throughout the sapwood of the hewn frame. The central aisle of the barn was the primary sampling location since it was most protected by the weather and therefore had the most intact and stable wood.

A skeleton plot was produced for each of the specimens taken from the Powers Barn. On these plots the narrowest of the rings in comparison to its immediate neighbors were noted with a line on the graph paper and broad rings were noted with a capital B. Initially visual crossdating of the specimens from the structure proved challenging utilizing only skeleton plots. The trees from which the specimens have been taken showed limited mean sensitivity (0.16) and few obvious pointer years. Additionally, there was moderate to high variability between the specimens with pointer years, aligning only about a third of the time between related specimens. This was mitigated somewhat by including broad years in the skeleton plots, which helped alleviate the lack of narrow pointer years used for visual cross-dating. The inclusion of all of these features was vital for the success of crossdating the specimens.

Skeleton plotting found strong internal crossdating within certain Powers Barn specimens from the inner partition wall (SSPO05, 10 and 14), but these were the exception and in general, internal correlations between the other cores were low. Skeleton plotting and visual crossdating also did not find strong patterns within the live tree core specimens and the differences in the widths of the rings were very slight making crossdating and the creation of a reference chronology with this method difficult. For these reason COFECHA was utilized to create the reference chronology for the live tree samples, which was then plotted as a skeleton plot and utilized in conjunction with the skeleton plots created for the barn samples. This method proved successful in eliminating much of the “noise” present in the samples and highlighting the pointer years.

Of the 11 specimens from the building that had sufficient number of rings to be dated, seven were placed into the floating chronology and the remainder were unable to be placed because of poor correlation with the master or the other samples. The seven that were placed into the floating chronology had good correlations to each other or to the master or to both. Following the placement of the specimens using visual matching with skeleton plots, the results were statistically analyzed and tested with COFECHA against the reference chronology and any segments of series that were flagged were examined for alternative placement locations. The standard preset for the program, which is a 50-year segment length with a 25-year overlap, was utilized for the analysis since it showed strong dating potential for the series, including ones exhibiting juvenile growth such as was found in the hewn frame of the barn.

When a series proved difficult to date, smaller segments of 40 or 30 years were used to isolate problems or display low correlating segments and attempt alternate placements. The dates suggested by COFECHA for segments lengths below 40 years became very erratic and were only used to potentially find problem segments and not to verify placement in the master chronology. It also proved beneficial to examine larger segments of up to 100 years with a 25-year lag. Since there were so few pointer years the longer segment lengths were helpful in amplifying the climatic signal present in the samples. This was especially useful for specimens with near the minimum number of rings (50) combined with juvenile growth that would, if broken into short segments, become very erratic in their placement in the chronology. All series were run through the program with several segment lengths to see if there was agreement between them. Some series were relatively easy to place while others proved much more difficult.

Of critical importance in building the floating chronology were two boards from the inner partition walls that had a wane and a core sample from a post. Two specimens (SSPO05 and 10) were very strongly correlated to each other (possibly from the same tree) in the initial run of COFECHA, which determined if internal crossdating was present. The correlation suggested by the computer was confirmed in the skeleton plots and they visually correlated extremely well to one another and allowed the placement of two other specimens with them (SSPO14 and 15). These four samples, while correlating very strongly to each other did not correlate strongly to the reference chronology that was developed by COFECHA from the living tree specimens. The solution for their placement was to create a site master chronology from the floating chronology consisting of these four specimens and then to compare the site master to the reference chronology. The result was still weakly correlated but reinforced the results from the individual runs against the reference chronology. The remaining three specimens (SSPO06, 07 and 09) were placed into the site master because of moderate to strong correlation with the reference chronology, but not with the floating chronology. The results were then crosschecked with both the reference chronology and internally against the other specimens resulting in good intercorrelation rates for all segments with only one flag for below threshold correlation noted. The site master versus the reference chronology produced no flags and a correlation rate of .49, which was within the range of variation found in the natural forest.

When individual specimens were run against the master and were confirmed as having the best correlation with the master and the other specimens the sample was assigned a date. As was noted previous section, the highest statistical correlation was not always the best fit for the specimens. High correlations that were far outside of expected date range for the samples were eliminated such as dates from the early 1800s prior to the settlement of the area or the late 20th century where changes in the appearance of the wood (in manufacturing and condition) would be noticeably different from the existing fabric. Finding groupings of dates within the specimens was also a high priority since it was assumed that the construction of the barn took place within a relatively short period of time and that the modifications done to the interior were also done over a short period of time. Looking for these patterns eventually bore fruit and two groupings of dates were identified within the barn among those specimens that had their outermost rings.

Table 3 COFECHA output with intercorrelation statistics for series creating site master (SS) and live trees (LT) forming the reference chronology

PART 5: CORRELATION OF SERIES BY SEGMENTS: Sun Page 5

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under 0.3281 but highest as dated; * = correlation higher at other than dated position

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	LTP001B	1857 2013					.65	.62	.72	.74	.58	.53
2	LTP002A	1874 2013					.62	.62	.68	.65	.64	.70
3	LTP003B	1903 2013							.43	.50	.42	.50
4	LTP004A	1920 2013							.52	.63	.58	.58
5	LTP005A	1865 2013					.34	.36*	.62	.63	.55	.61
6	LTP006B	1901 2013							.46	.50	.59	.59
7	LTP007A	1935 2013								.66	.62	.58
8	LTP008A	1864 2013					.36	.47	.65	.55	.44	.49
9	LTP009B	1696 2013	.48	.52	.53	.50	.51	.52	.50	.53	.43	.46
10	LTP010B	1756 2013	.66	.62	.65	.68	.55	.60	.65	.52	.33	.44
11	LTP011A	1941 2013								.49	.53	.52
12	LTP013A	1945 2013								.51	.42	.34
13	LTP014B	1869 2013					.31A	.42	.67	.65	.45	.47
14	LTP015A	1914 2013							.68	.65	.67	.67
15	LTP016A	1931 2013								.61	.65	.74
16	LTP017A	1930 2013								.50	.34*	.34
17	LTP018A	1923 2013							.65	.68	.63	.53
18	LTP020A	1864 2013					.62	.52	.46	.55	.48	.43
19	LTP023A	1842 2013				.68	.63	.57	.59	.62	.60	.63
20	LTP024A	1841 2013				.71	.64	.58	.52	.52	.57	.36
21	LTP025A	1843 2013				.62	.55	.57	.57	.63	.67	.67
22	LTP026A	1808 2013			.63	.75	.74	.71	.52	.52	.76	.76
23	LTP029A	1816 2013			.52	.53	.60	.51	.40	.55	.63	.51
24	LTP030A	1820 2013			.69	.69	.65	.63	.35	.43	.65	.53
25	SSP005	1840 1930				.49	.43	.39	.40			
26	SSP006	1752 1822	.51	.50								
27	SSP007	1794 1883		.41	.45	.31A	.36					
28	SSP009	1871 1931					.42	.49	.43			
29	SSP010	1878 1930						.35	.37			
30	SSP014	1835 1890				.52	.55					
31	SSP015	1853 1895					.48					
Av segment correlation			0.55	0.51	0.58	0.59	0.53	0.53	0.54	0.58	0.55	0.54

Cutting Dates

The results from the data analysis indicate two date clusters found in the barn (Table 4). One of them relates to the construction of the barn c. 1895, and the other indicates the date of modification of the interior c. 1931. Both of these dates seem consistent with the material culture utilized within the barn for its construction. Of the seven dated series, five had their outermost rings intact from which a cut date could be obtained, one had sapwood from which cut date could be estimated, and a cutting date was not able to be determined for the final sample because its outer ring and sapwood was absent.

Two series out of the seven samples taken from the hewn frame of the barn could be dated. One of the logs supplied a cut date of 1895 (SSPO15, a sill log) and the other correlated well to 1890 (SSPO14, a hewn post). There were other higher correlations for the placement of these specimens but none of the other suggested dates were clustered in close proximity to one another, as one would expect in a building constructed in a short time. Additionally, the suggested dates were far outside the expected date range of construction. The outermost rings were intact in both of these samples and there was no indication of new growth beyond the latewood transition indicating that the logs were cut during either the late summer of 1895 or early spring of 1896 and late-summer 1890 to early spring 1891. Numerous runs of the computer program were needed to confirm the placement of the series and with such short segment lengths there were numerous possibilities in which these segments could fit. However, by cross correlating with other samples throughout the floating chronology that were better correlated with the master it seems likely that these dates are correct.

Another cluster of dates was related to the interior partition walls of the main aisle in the barn. These timbers were all installed at roughly the same period of time as indicated by the construction techniques and the identical saw marks left on the surface. Therefore, much like the hewn posts of the supporting structure, clusters of several dates were needed to confirm the age of this addition. These are milled lumber, but two of the boards (SSPO05 and 10) that form the inner partition walls had a wane that contained the outermost ring layers. Additionally, one of the supporting rails (SSPO09) of the partition boards had an intact wane as well and supplied a cut date.

Upon examination of the data, a cluster of dates was identified around 1930 for the samples. The dates for three samples included two that dated to 1930 (SSPO05 and 10) and one to 1931 (SSPO09). Observations of the last rings indicate that SSPO05/10 were felled either in the late summer of 1930 to the early spring of 1931 and SSPO09 indicates that it might have been felled in the summer of 1931 to the early spring 1932.

The remaining two series that were able to be dated included one sample from a framing member that contained only heartwood (SSPO06) and a sample from a cross brace (SSPO07) that contained sapwood from which an estimate of the cutting date could be obtained. SSPO06 correlated very strongly to 1822 with the reference chronology, but had limited utility for this study as it did not provide a useful date to help with the confirmation of the construction of the barn, but it did help reinforce the early part of the site master chronology. SSPO07 proved much more useful since it contained sapwood from which a cut date could be estimated. Utilizing the estimated thickness of sapwood for Douglas fir (1.75-2.25" for trees over 15" in diameter) a cut date estimate of 1883 to

1901 was projected, which compares favorably with the other dates determined for the frame of the barn.

Table 4 Cutting dates for Martin Powers Barn

Sample ID	Sample Type	Timber Type	Dates AD Spanning	Number of Rings	Ring Type	Correlation With Master	Mean Width mm	Std Devn mm	Mean Sensitivity mm	Comments	Inferred Period Of Cutting
SSPO05	S	Milled lumber, board	1840-1930	91	R	0.467	1.05	0.232	0.161	1930 ring appears complete	Tree cut anytime from summer 1930 to spring 1931
SSPO06	S	Milled lumber	1752-1822	71	VV	0.519	1.38	0.508	0.167	Sample is only heartwood	Cutting date not possible to determine
SSPO07	S	Milled lumber, cross brace	1794-1883	90	V	0.416	1.23	0.349	0.151	1-5/8" of sapwood present	Cutting date not possible to determine. Estimated at 1883-1901 based on average Douglas fir sapwood (1.5" to 2.25") and number of rings per inch in sample sapwood (24)
SSPO09	C	Milled lumber, board	1871-1931	61	R	0.364	1.77	0.559	0.154	1931 ring complete	Tree cut anytime from summer 1931 to spring 1932
SSPO10	S	Milled lumber, board	1878-1930	53	R	0.326	1.19	0.298	0.182	1930 ring complete	Tree cut anytime from summer 1930 to spring 1931
SSPO14	C	Hewn post	1835-1890	56	R	0.530	2.17	0.533	0.132	1890 ring complete	Tree cut anytime from summer 1890 to spring 1891
SSPO15	C	Hewn post	1853-1895	43	R	0.493	2.51	0.737	0.120	1895 ring complete	Tree cut anytime from summer 1895 to spring 1896

Key: C-Core Sample 5.0mm dia.; S- Slice or Section; B-Bark is present indicating outer ring is fully intact (Considered a cutting date); R-Outermost ring is continuous and intact around a smooth surface, but no bark present (Considered a cutting date): V-The date is within a few years of the cutting date, based on presence of sapwood; VV-Impossible to determine how far outer ring is from the true outer surface (no sapwood and rings in the heartwood are likely missing)

4. DISCUSSION

Sites Development and Modification

As indicated by the cluster of dates that was found in the hewn frame of the barn it appears that the barn was not constructed in 1887 as indicated by the oral interviews but rather in either late 1895 or early 1896 based on the cutting date determined for the frame of the barn, which was found in the sill. The reason for the erroneous date could be a case of simple transposition of the dates in the recollections of the interviewees, replacing the 96 with a 87. Through the analysis of this structure there is an absolute certainty that the barn was not built in the 1887, for when the samples are tested with that date against the reference chronology there is virtually no correlation. Even without discovering the cut date of the tested series from the barn there was an equal utility in discovering that there was almost no statistical probability that the barn could have been constructed in 1887 or within several years of that date.

The construction date discovered by this analysis in retrospect appears to be a better fit for the available oral histories and other historic data available about the Powers family and the operation of the farm. Since Janette and Martin Powers were not married until September of 1887 and the land was given to Janette the previous year, it seems likely that it would have taken the new family some time to become established. The construction date found in this analysis appears to conform more to when the family was working at building and expanding the farm over several years and this was part of that expansion in the mid-1890s. The barn does appear to have been built by Martin Powers or somebody that he had hired to do the work for him since the construction date of the barn falls within the period of ownership from 1886 to 1902 when the Powers family owned land before selling it to Henry Orange Smith.

Examination of the date of modification for the barn is almost as intriguing as the dates of construction for the entire barn. The evidence points to a significant modification of the barn c. 1931-32 to update the barn for some new use. It is also interesting that this modification occurred in the first years of the Great Depression and perhaps either signaled a change in farming methods or types of agricultural goods produced on the farmstead. Further research into the families occupying the property and their livelihoods could indicate if a shift in agriculture or economic activity occurred.

The estimated date from the cross brace indicates that it is original to the structure, but since there was only one sample taken from a cross brace from which a date could be estimated, confirmation would require several more samples to determine if they are all original. Initial observations done during the fieldwork indicated that they might have been replacements dating from a later rehabilitation of the barn due to the imprecise fit of the braces to the frame. The analysis of the brace indicated the estimated cut date is well within the range of the construction of the barn and therefore seems to indicate that they were original and not part of the alteration of the barn that occurred in the 1930s.

Internal and External Crossdating Issues

There are a number of challenges that occurred in the crossdating of the samples from the Powers Barn and one of the primary problems was the age of the trees involved in the analysis of the frame of the barn. The wood from the beams and posts was quite young when it was felled and displayed a lot of youthful vigor that is characteristic of Douglas fir when it is first establishing itself in a stand. During this time much of the climatic signal is suppressed by this vigorous growth. This masks the climatic signal in the tree and makes dating difficult since it makes the pointer years less prominent. It was noticed in the samples that there was noticeably different amounts of correlation with the reference chronology and the sample between the inner and outer segments of the series.

The inner part of the series invariably gave less accurate results than the outer rings in the series. Upon noticing these patterns, it was compensated by analyzing the whole series from samples from the posts and beams rather than short segments. Even a 50-year segment length with a 25-year lag would sometimes give spurious results. Analyzing the whole of the series was found to be more reliable (with caution) and the results less ambiguous than what were found analyzing shorter segments. As was the case with most of the other samples, analysis was undertaken at different resolutions to identify problem areas and to possibly compensate for them. The young growth coupled with short series length found in the samples, caused low correlation with the master due to the suppressed climate signal within the samples and led to the majority of the samples from the frame being considered not to be datable.

Future research undertaken on similar buildings will have to take into account the factors introduced by young wood that was used in these timber frame barns. It would appear that for the construction of these barns people were selecting relatively straight, tall trees with small branches, thin bark, and of 25 to 65 years of age. Such trees would be advantageous to work with when hewing, but to dendrochronologist this is quite onerous since the trees utilized have such as high component of young wood with a suppressed climate signal. However, as was shown in this study, even with the low climate signal these samples can be dated on occasion. Visual crossdating is difficult because of the rapid growth and lack of pointer years and therefore the use of computer aids is desirable to help pinpoint them to aid in dating.

Short segment lengths were another issue that came about during the analysis of the data for this paper. Since most segment lengths were short and had a mean of just 65 years, their dating was difficult because of more than one probable matching location with reference chronology. Longer segment lengths would have been advantageous, but due to do the type of construction used that had a selection bias towards younger trees for the frame of the structure, this was not possible. The segment length of a number of the tested series was on the cusp of being unreliable for dating, which made their placement more difficult and when series are that short they can fit into many more possible positions than if there was a segment of more than 100 years in length.

Another disadvantage that this study had was the lack of other reference chronologies within the region to crosscheck the results to see if they are accurate and representative for the region or if another area provided better results, which could indicate the presence of imported wood. It also would have been advantageous to have these other reference chronologies to verify that the climatic signal seen in the reference chronology created in this study is typical and where the boundaries of its reliability are.

Issues in Site Selection

One of the primary challenges in this study was finding suitable study locations. Initially three areas were identified as potential study locations that were located along the length of Western Oregon. These areas were identified for the fact that they were in public ownership and reasonably close to timber from which specimens of live trees could be taken. However upon further pursuit of the sites as the study progressed it was found that the locations were not as ideal as first assumed. This was particularly true for sites in the Willamette Valley where a long history of habitation and historic burning has eroded the amount of large trees available for crossdating. The locations that were available for the sampling of live trees were found in areas that have been extensively cut over and burned historically, limiting the number of old trees that could reach back far enough into history to build chronology of sufficient length, which needs to range from 150-200+ years. Additional problems included that most of the remaining trees of sufficient age were concealed in moist refugia. This can cause the tree to grow complacently and to be not as useful for study due to the difficulty of identifying the key-years that help with crossdating.

Additionally there are problems of ownership and interagency communication and permissions. Much time was lost in the course of this study waiting for communications regarding site selection and permissions for sampling within the study area. The number of areas suitable for sampling is extremely limited and therefore it takes communication with knowledgeable people who are familiar with the method, including its possibilities and limitations, to identify suitable locations. Working with knowledgeable individuals within the local forestry community, while rewarding, was time consuming and caused much loss of efficiency during the course of this study.

As stated previously, finding trees suitable for dating was a challenge not only for permissions but also for suitable ages as well. Much of what we see in Western Oregon is second growth or third growth trees that only appear to be old growth on first inspection. Only when these trees are sampled is the dramatic rate of growth revealed; a tree of 30 inches in diameter may be only 100 years old. These astounding rates of growth come from the tree being in the heart of its range at optimal conditions. Dendrochronology today still primarily studies trees that are at the margins of their range and therefore susceptible to environmental variations. Douglas fir in Western Oregon does not have that limitation since it is not at the margins of its range but instead in its primary habitat. This creates difficulty for anyone hoping to obtain useful data from the trees, but as was seen in this study that useful information is still obtainable, but it is presented in a subtle way.

Challenges in Data Collection

The sampling of the Powers Barn suggested some of the major challenges that might not be unique to historic structures in the region. First and foremost was the lack of suitable sampling locations on the building. The frame of the barn while made of hewn members had a lot of insect damage and very few surface areas that were suitable for sampling, but still contained areas where the inner bark surface could be seen. These locations were very important in obtaining specimens because they can indicate a cut date for the timbers. It was found that while there was a significant number of places where the surface still existed, insects were attracted to the sapwood and created extensive galleries just beneath the surface that would render the specimen fragile and unusable. The more rot resistant heartwood was not as affected by either insect damage or the brown rot. Also interestingly the horizontal members of the building appeared to be more affected by insect damage than the vertical members. This may have to do with the roughly constructed mows constructed above the bays that had many nooks and crannies that could hide and protect insects and also helped retain moisture. It was therefore very challenging to find areas of intact wood without insect damage that also contained sections with the inner bark surface intact.

Of the two types of drill used on the project the Berliner Dendro-borher drill bit performed better in the softwood found in the structure. The other drill that was of a common hole-saw type design did not perform as well since the offset of its teeth had a tendency to grip the core and twist them, which caused the loss of several specimens. The use of this type of drill was stopped when it became apparent that it was designed for more stable wood and was not suitable for the fragile insect gallery filled matrix found in the Powers Barn. Additionally, the teeth found in the drill may perform better in denser and drier wood, but with the long fibers found in damp Douglas fir the teeth of the bit had a tendency to get clogged with fibers and become ineffective. If the sampling was done in firmer wood or done at the end of the summer when the wood within the structure was drier, this type of drill bit may have been more successful. The Berlin type, with its sharper teeth, more effectively sheared the fibers and produced better cores for analysis even through areas that had areas of insect galleries and other unstable wood. The small core produced by this drill was still highly susceptible to any kind of bending and many cores were lost during chip clearing due to breakage.

The ideal method of collection was to cut specimens from whole timbers and not use the coring drill bits. The large sample size that can be attained by this method was preferable over the small cores due to the fact that rings could be seen over a broader area and therefore any insect galleries that may be present with the sample could be avoided. This was a problematic sampling strategy for the integrity of the building, as harm to the structure was not desirable and therefore permanently altering it by removing parts was less than ideal. So while sections were the preferred type of sample, their use had to be limited in order not to cause harm to the structure, maintain the historic fabric and not cause complications for any possible future restoration.

Origin of Wood Revisited

Examining the correlations between the live tree specimens and the crossdated specimens from the barn it is quite possible that some of the milled lumber came from a location adjacent to, but not necessarily in the Illinois River Valley. While the correlations are still very good, they have less statistical correlation than what is displayed by the reference chronology. It could mean that the specimens come from a location that is sufficiently far away so as to have different environmental conditions than present at the specimen collecting areas at Greyback and Sixmile and thus change the correlations slightly.

The dates obtained from interior partition walls were from the 1930s, which was during a time of expansive industrial development in the region and where resources were not always obtained and utilized locally. During this time road networks throughout the region and national forests were being expanded at an incredibly rapid rate to obtain new stands of previously unreachable timber. The use of trucks to transport the lumber made obtaining trees from faraway locations more practical and the radius from which the sawmills could obtain logs was greatly increased. The resulting lumber could also be transported easily to regional centers for sale. Since one of the fundamental aspects of dendrochronology is that growth patterns are links to a specific geographic location, the source for the lumber could be pinpointed with further study and chronologies developed and the specific region. Based on the observation of other sampling locations, such as a site near Crater Lake Oregon, correlations drop off significantly within 100 miles and with increased elevation. The correlation between the site chronology and reference chronology is close enough to still consider the milled lumber from the study to be of local origin.

Future Recommendations

While the outcome of this study did not produce the spectacular results that could have been found in other locations such as the southwest of United States where the conditions are right for the development of obvious pointer years, this study has nonetheless provided valuable information where there was none before. It is hoped that further research can be undertaken in this region to verify the findings that were presented in this paper. It is also important to remember that there are regions within the

State of Oregon that are more conducive to this kind of research such as Central and Eastern Oregon where the rainfall is much less than it is in Western Oregon and therefore more conducive to the production of pointer years within specimens.

It is in Western Oregon though that much of the historic attention has been placed regarding the settlement and development of Oregon. Not only was it the focus of the intentions of eastern settlers but it was also the home of many Native American groups some of whom no longer exist. Utilizing this technique provides one more tool in the study of these groups that can be exploited by creative individuals to help reconstruct past histories.

The hewn framed barns that were the subject of this study are rapidly disappearing from the landscape and it is therefore very important to document these buildings before they disappear from the Oregon landscape. Secondary buildings and structures have garnered far less attention from conservators and have been allowed to decay before their importance was realized. There is good documentation regarding the settlements of Oregon and the houses constructed, but as this paper has shown the documentation of their outbuildings and other small structures and objects is much less well documented. If the date for the Powers Barn was a decade off for a building a mere 119 years old the possibility that something from the earliest days of Oregon's history was misdated is too great to ignore. Tree-ring dating therefore can serve a valuable addition to research conducted regarding structures, objects and any other building in which the date is in dispute.

It is important to consider that in this study the trees are growing in their optimal conditions and therefore have little opportunity to become stressed by environmental conditions and develop obvious pointer years. Through the use of computer aided analysis and measuring devices, we are able to tease out the small variations within this environment that can help us date them. While Western Oregon is a less than ideal location to perform dendrochronology, this case study has shown that there is potential for future research in the region. However, even with computer aids, the requirement of selecting a proper site is clearly evident. Since so much of the construction during this early time was constructed with old growth timbers from very close to the construction site, the development of a local chronology would need to be developed for each individual site. The rewards for doing such hard work would be a greater understanding of a tool that can be extensively utilized to the future to great effect to check the accuracy of historic records and oral histories.

Conclusion

During the exploration of this topic a number of challenges to using dendrochronology for the dating of structures in Western Oregon were identified. Yet despite these challenges, this project has shown that through careful analysis of the data accurate results can still be obtained. Things to be mindful of when pursuing dendrochronology with these environmental conditions include the following.

- *Lack of available reference chronologies located near population centers*
- *Lack of trees of sufficient age (due to historic logging and burning)*
- *High rates of decomposition for wood in the Western Oregon climate and insect damage*

- *Complacency of the trees and suppressed climate signal making visual crossdating difficult*
- *Low to moderate correlations making placement within a master chronology difficult*
- *Climate signals in Douglas fir in its first few decades of life is suppressed due to vigorous growth*
- *Elimination of outer wane or sapwood in lumber and hewn beams making accurate dating difficult*
- *Selection of younger trees for hewn beams and sills, in the specific case of the Powers Barn*

Despite the challenges present in this project, performing dendrochronology on the structure discovered a number of significant findings regarding the construction history of the barn including the following.

- *The construction date of the barn is 1895-96 and not c. 1887 as was stated by the oral history*
- *A significant modification of the barn was made in 1931-32 where partition walls were added to the center aisle of the barn*
- *The trees used for posts and beams was cut from the late summer 1895 to the early spring 1896*
- *The wood used for the construction of the partition walls in the central aisle was likely imported from a area relatively distant from the Powers Barn, whereas the posts were obtained from the immediate area*

Despite the challenges of performing dendrochronology in Western Oregon, the discovery of multiple dates of construction and modification in the building demonstrate the efficacy of dendrochronology to show the constant evolution of buildings to suit their owners' needs. The addition of the inner walls of the building are a good example of this evolution and how in the 1930s this building was not meeting the requirements of the family and was modified to suit their new needs. That modification is now part of the story that the building tells but is one that may not have revealed so accurately without the application of dendrochronology. Additionally, now that there is a reference chronology established for the area, additional dendrochronology studies can easily be conducted on buildings in the Cave Junction area.

The completion of this study has shown the value of performing dendrochronology on historic buildings in Oregon. Even this small study on a building of a relatively young age has shown that there are discrepancies in the dates provided by written documentation, oral histories and what has been revealed by this project. The date of 1895-96 for the construction of the barn is not far off from the recollection of the family, yet this is significant. It demonstrates that while family histories are a rich source of information, they are still subject to error. It also demonstrates that no one method is perfect and that in order to provide an accurate assessment of a building and its construction history that several dating techniques are needed for accuracy.

APPENDIX A: SUPPLEMENTAL PHOTOGRAPHS

Figure 7 West elevation of Powers Barn, view to southeast

Figure 8 Southwest corner Powers Barn, view to northeast

Figure 9 Southwest corner, view to northwest

Figure 10 East elevation of barn, view to west

Figure 11 Center bay celling, view of cross bracing, remnant cedar shakes, round rafters and replacement milled rafters in roof peak

Figure 12 Center bay celling (south), view of cross bracing, nailing surfaces, round rafters, replacement rafters and broken beam in center of photo

Figure 13 View looking east at replaced roof section and supporting structure

Figure 14 View looking west at round rafters and supporting structure

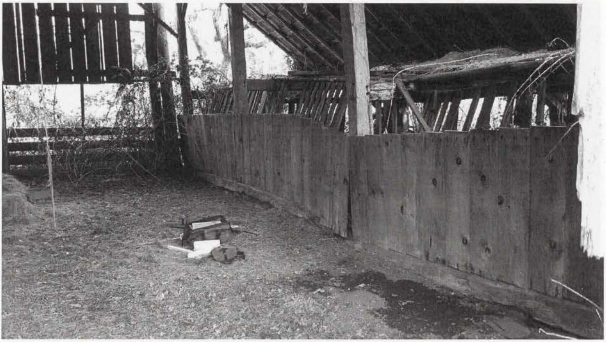

Figure 15 South interior partition, looking southeast. Note remnant sill, improvised hayracks and mow

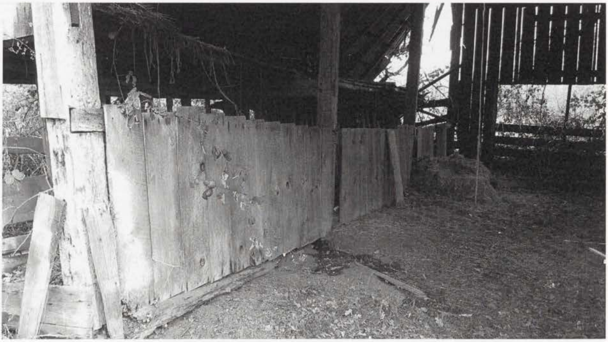

Figure 16 North interior partition, looking northeast. Note remnant sill, improvised hayracks and mow

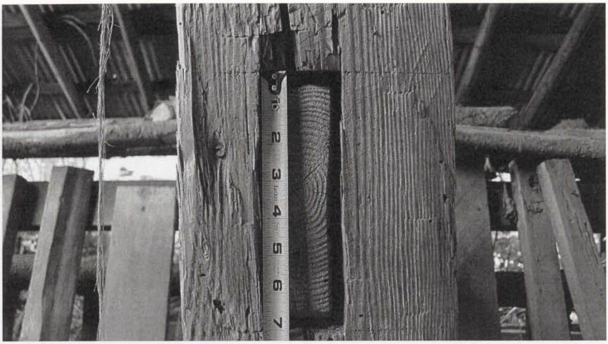

Figure 17 Through tenon detail, note layout lines and low number of rings in tree cross-section

Figure 18 Pegging of through tenon detail, note 1" Douglas fir pegs and layout lines

Figure 19 View of center aisle looking east with north and south partition walls, hayracks and mows visible

Figure 20 Fieldstone pier foundation under a post

APPENDIX B: HISTORIC PLAT OF WATKINS FARM

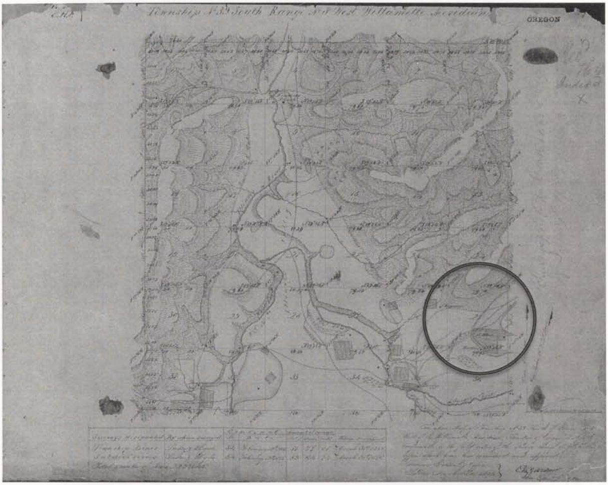

Figure 21 Location of original Donation Land Claim of William H. Watkins (circled) (BLM GLO map 1857)

APPENDIX C: U.S.G.S. MAPS

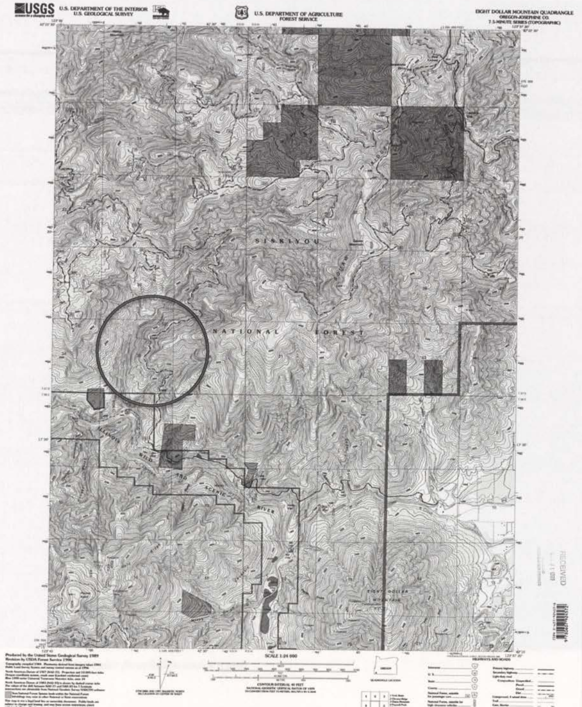

Figure 22 Sixmile creek collection area (circled), (map USGS 7.5' Eight Dollar Mountain, 1996)

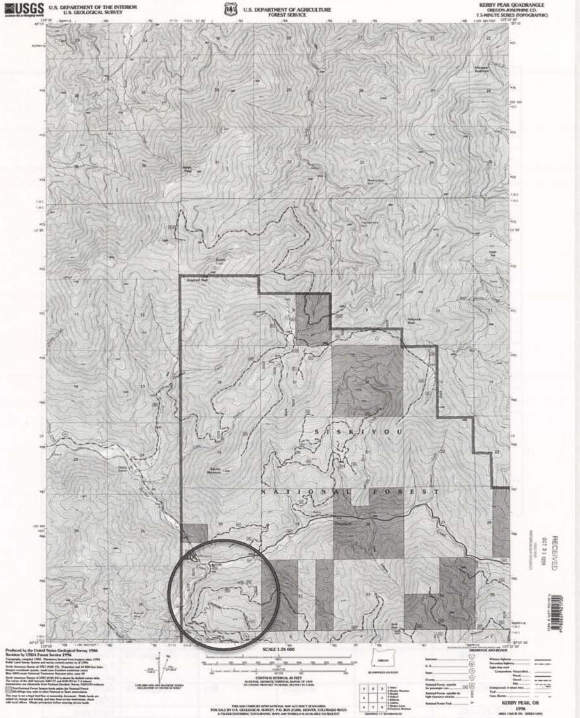

Figure 23 Greyback Creek (I & 2) collection area (circled), (map USGS 7.5' Kerby Peak, 1996)

APPENDIX D: COMPLETED LIVE TREE COLLECTION FORMS

Live Tree Core Collections

Site: Martin Powers Barn **Date**: 02/23/14, 03/26/14 and 05/04/14 **Page**: __1__ of __2__

Recorded by: S. Chilvers

Site Description: Live-tree sampling site. Site is located near the Greyback Creek Ranger station located at the junction of Greyback and Sucker Creeks and is the location of a campground. Trees on both the north and the south sides of Greyback Creek were sampled but the ones on the northern slopes were found to have greater sensitivity and denser growth rings. Samples are from the SOUTH side of the creek unless noted. Two samples were attempted to be taken from each tree. Elevation 1950-2500'

Sample ID	X Coordinate	Y Coordinate	Coring Height	DBH/Species	Notes
LT-PO-01A	0462668	4665475	BH	Douglas Fir	~28" DBH
LT-PO-01B	"		BH	Douglas Fir	
LT-PO-02A	0462317	4665345	BH	Douglas Fir	~28" DBH
LT-PO-02B	"		BH	Douglas Fir	
LT-PO-03A	0462306	4665599	BH	Douglas Fir	~30" DBH, taken from north side of creek. Poor sensitivity
LT-PO-03B	"		BH	Douglas Fir	
LT-PO-04A	0462306	4665392	BH	Douglas Fir	Second sample Not Taken. Rotten in center.
~~LT-PO-04B~~	N/A				Not taken
LT-PO-05A	0462307	4665367	BH	Douglas Fir	Pitch in center of tree, short cores in both samples
LT-PO-05B	"		BH	Douglas Fir	
LT-PO-06A	0462320	4665344	BH	Douglas Fir	
LT-PO-06B	"		BH	Douglas Fir	
LT-PO-07A	0462262	4665324	BH	Douglas Fir	Large growth rings with little sensitivity. Second sample not taken.
~~LT-PO-07B~~					Not Taken
Samples taken 03/18/2014 Below. Same location					
LT-PO-08A	462375	4665318	BH	Douglas Fir	Good core, some pitch, 28" DBH
LT-PO-08B	"	"	BH	Douglas Fir	Core broke into 3 pieces due to pitch pockets
LT-PO-09A	462360	4665331	BH	Douglas Fir	Good core, 3.5' DBH
LT-PO-09B	"	"			Good core
LT-PO-10A	462396	4665310	BH	Douglas Fir	Poor core extraction, 3.5' DBH
LT-PO-10B	"	"			Great core

Figure 24 Collection form for Greyback Creek sampling area (page 1 of 2)

LT-PO-11A	462293	4665221	BH	Douglas Fir	Low sensitivity, young. 28" DBH
~~LT-PO-11B~~	--				Not taken
LT-PO-12A	462298	4665163	BH	Douglas Fir	Wide growth rings, young. 28" DBH
~~LT-PO-12B~~	--				Not taken
LT-PO-13A	462319	4665283	BH	Douglas Fir	Wide growth rings, young. 30" DBH
~~LT-PO-13B~~	--				Not taken
LT-PO-14A	462309	4665335	BH	Douglas Fir	Good core.
LT-PO-14B	"	"			Good core.
Samples Taken 03/26/2014 Below. One Mile Further Up Road Near Greyback ck.					Single cores taken at this location. All trees were in a small area. Single UTM location point taken.
LT-PO-23A	462244	4664364	BH	Douglas Fir	Good core.
LT-PO-24A	"	"	BH	Douglas Fir	Good core.
LT-PO-25A	"	"	BH	Douglas Fir	Good core.
LT-PO-26A	"	"	BH	Douglas Fir	Good core.
Near Greyback#2 on 05/04/2014					
LTPO27	"	"	BH	Douglas Fir	Short series
LTPO28	"	"	BH	Douglas Fir	Short series
From Greyback #2 on 05/04/2014					
LTPO29	"	"	BH	Douglas Fir	Good core with good sensitivity and length
LTPO30	"	"	BH	Douglas Fir	Good core with good sensitivity and length

Figure 25 Collection form for Greyback Creek sampling area (page 2 of 2)

Live Tree Core Collections

Site: Powers Barn   Date: 03/18/2014   Page: __1__ of __1__

Field Crew: S. Chilvers

Site Description: Sampling site is located near Little Six Mile Creek along Forest Road NF-4105. Sites were primarily on sloping hillsides with a southwestern aspect. Area has been heavily burned over by the 2001 Biscuit Fire and many of the trees in the area have died. Rounds taken during sampling may have died anywhere between 2001 and 2014. Soils are rocky and poor in all sampling areas. Only single samples were taken at this location due to time constraints.

Sample ID	X Coordinate	Y Coordinate	Coring Height	DBH/Species	Notes
LT-PO-15A	0440225	4684729	BH	Douglas Fir	35" DBH, elv 2180'
LT-PO-16A	0440370	4683115	BH	Douglas Fir	30" DBH, elv 1780'
LT-PO-17A	0440301	4683115	BH	Douglas Fir	28" DBH, elv 1582'
LT-PO-18A	0440263	4683154	BH	Douglas Fir	34" DBH, wide rings.
LT-PO-19A	0440206	4683173	BH	Douglas Fir	34" DBH, wide rings.
LT-PO-20A	0440209	4683200	BH	Douglas Fir	32" DBH, sections of ring rot.
LT-PO-21	Unknown provenance		BH	Douglas Fir	Round taken from side of road. (Small)
LT-PO-22	Unknown provenance		BH	Douglas Fir	Round taken from side of road. (Large)

Figure 26 Collection form for Sixmile Creek collection area (page 1 of 1)

APPENDIX E: COMPLETED STRUCTURE COLLECTION FORMS

STRUCTURE Core Collections

Site: Martin Powers Barn **Date**: 02/23/2014, 03/26/2014 and 5/4/2014 **Page**: _1_ of _2_

Recorded by: S. Chilvers

Site Description: Powers Barn site, hewn timber frame barn located east of Cave Junction. ODOT property located adjacent to the Oregon Caves Highway along a creek in an oak savannah with adjacent areas covered in Ponderosa/Jeffery pine/Douglas fir. Samples were both cored and sawn from timbers and both the remaining wood and the samples were labeled for future reference.

Sample ID	Wane Present Y/N	Sample Description	Photo #	Notes
SS-PO-01	N	Sample cut from interior livestock partition wall on the north side, #18 board from western entrance. No outside features. Good sensitivity in sample.	193-3008	Sample broke when removed. Glued and taped back together. Sample number written on both samples.
SS-PO-02	N	Sample cut from interior partition on north side from #24 board from western entrance. No outside features. Good sensitivity in sample.	193-3010	Sample broken into several pieces. Clean break, each fragment labeled.
SS-PO-03	Y	Core sample taken with hollow bit from 2nd vertical post from western entrance on south side of structure. **Outermost layer features present.** Poor sensitivity in sample.	193-3014	Sample broken in 3 pieces with powdery sections that may not prove useful but contains outermost surface. Remainder of sample good.
SS-PO-04	Y	Core sample taken from 2nd vertical post from western entrance. **Outermost layer features present.** Attempted 3 samples. Interior very rotten under intact surface. Sample drill broke taking 3rd sample. No complete samples taken.	193-3009	Drill Broken. Very soft sample location with many insect boreholes.
SS-PO-05	Y	Sample cut from #17 interior partition board from western entrance on the north side adjacent to sample #SS-PO-01. Good sensitivity.	193-3008	Has exterior features present and good sensitivity. May be key sample.
SS-PO-06	N	Taken from the north side of the east entrance from a hewn fragment that may have been part of the doorframe but exact provenience is uncertain.	193-3011 193-3012 193-3013	Good sensitivity, poor provenience.
SS-PO-07	N	Taken from the end of a fallen cross-brace that was found between the 1st and 2nd bents on the south side but is probably from the 2nd interior post on the south side bracing the interior section.	193-3007	Good sensitivity but from a milled piece of wood of unknown original thickness.

Figure 27 Powers Barn samples (page 1 of 2)

Samples Below Taken on 03/26/14				
SS-PO-08	Y	Sample broke halfway through close to the center of the tree and has wide complacent rings.	3088	Taken from the second post on the north side of the barn. Outer edge features present.
SS-PO-09	Y	Core was taken from an upper rail between the third and fourth bent on the north side. (At fourth intact board from east side).	3089	Outer edge features present.
SS-PO-10	Y	Sample from interior partition board in front of second post on the north side from the west entrance.	3090	Outer edge features present.
SS-PO-11	N	Sample taken from interior cross brace of unknown provenience.	3091	Less than 50 rings.
Samples below taken on 05/04/2012				
SS-PO-12	Y	Duplicate of sample #3 from a few inches below that sample. Unbroken.	None	Outer edge present. Good Core
SS-PO-13	Y	Taken from #3 post on N side of entrance.	None	Outer edge present. Core Broken in several places.
SS-PO-14	Y	Taken from #3 post from west entrance on south side of barn	None	Outer edge present. Good core
SS-PO-15	Y	Taken from south interior sill log approximately 3' west of #3 post from west entrance.	None	Outer edge present. Good core
SS-PO-16	Y	Taken from south interior sill log approximately 2' west of #3 post from west entrance. Duplicate of #15	None	Outer edge present. Good core
SS-PO-17	Y	Taken from south interior sill log approximately 2.5' west of #3 post from west entrance. Duplicate of #15	None	Outer edge Present. Good core

2

Figure 28 Powers Barn samples (page 2 of 2)

APPENDIX F: COFECHA OUTPUT

```
[]  Dendrochronology Program Library                                        Run ZZ     Program COF    Sun    Page   1
[]
[]  P R O G R A M     C O F E C H A                                                                   Version 6.02P        0
--------------------------------------------------------------------------------------------------------------------------

QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS                                            cofechaOSX_pjk2012.f

File of DATED series:   combined

CONTENTS:

   Part 1:  Title page, options selected, summary, absent rings by series
   Part 2:  Histogram of time spans
   Part 3:  Master series with sample depth and absent rings by year
   Part 4:  Bar plot of Master Dating Series
   Part 5:  Correlation by segment of each series with Master
   Part 6:  Potential problems: low correlation, divergent year-to-year changes, absent rings, outliers
   Part 7:  Descriptive statistics

RUN CONTROL OPTIONS SELECTED                             VALUE

        1  Cubic smoothing spline 50% wavelength cutoff for filtering
                                                          32 years
        2  Segments examined are                          50 years lagged successively by  25 years
        3  Autoregressive model applied                    A  Residuals are used in master dating series and testing
        4  Series not transformed to logarithms            N
        5  CORRELATION is Pearson (parametric, quantitative)
           Critical correlation, 99% confidence level  0.3281
        6  Master dating series saved                      N
        7  Ring measurements listed                        N
        8  Parts printed                             1234567
        9  Absent rings are omitted from master series and segment correlations  (Y)

Time span of Master dating series is  1696 to  2013   318 years
Continuous time span is               1696 to  2013   318 years
Portion with two or more series is    1752 to  2013   262 years

                                    ****************************************
                                    *C* Number of dated series        31 *C*
                                    *O* Master series 1696 2013  318 yrs *O*
                                    *F* Total rings in all series   3943 *F*
                                    *E* Total dated rings checked   3887 *E*
                                    *C* Series intercorrelation    0.551 *C*
                                    *H* Average mean sensitivity   0.161 *H*
                                    *A* Segments, possible problems    4 *A*
                                    *** Mean length of series      127.0 ***
                                    ****************************************

ABSENT RINGS listed by SERIES:            (See Master Dating Series for absent rings listed by year)

            No ring measurements of zero value
```

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PART 2:  TIME PLOT OF TREE-RING SERIES:                                                    Sun   Page   2
---------------------------------------------------------------------------------------------------------------------------------
                                                                                                                Beg  End
1000      1100      1200      1300      1400      1500      1600      1700      1800      1900      2000 Ident     Seq year year  Yrs
 :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
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 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======== LTPO04A     4 1920 2013   94
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============== LTPO05A     5 1865 2013  149
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========== LTPO06B     6 1901 2013  113
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <======= LTPO07A     7 1935 2013   79
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============== LTPO08A     8 1864 2013  150
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <=============================== LTPO09B     9 1696 2013  318
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <========================= LTPO10B    10 1756 2013  258
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <====== LTPO11A    11 1941 2013   73
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <====== LTPO13A    12 1945 2013   69
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============== LTPO14B    13 1869 2013  145
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<========= LTPO15A    14 1914 2013  100
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <======= LTPO16A    15 1931 2013   83
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <======= LTPO17A    16 1930 2013   84
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======== LTPO18A    17 1923 2013   91
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============== LTPO20A    18 1864 2013  150
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <================ LTPO23A    19 1842 2013  172
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <================ LTPO24A    20 1841 2013  173
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <================ LTPO25A    21 1843 2013  171
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==================== LTPO26A    22 1808 2013  206
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=================== LTPO29A    23 1816 2013  198
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <================== LTPO30A    24 1820 2013  194
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <=========> .    . SSPO05     25 1840 1930   91
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <======> .    .    .    . SSPO06     26 1752 1822   71
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <=========> .    . SSPO07     27 1794 1883   90
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <=====> .    . SSPO09     28 1871 1931   61
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <=====> .    . SSPO10     29 1878 1930   53
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <=====>.    .    . SSPO14     30 1835 1890   56
 .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <===>.    .    . SSPO15     31 1853 1895   43
```

PART 3: Master Dating Series: Sun Page 3

Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab
															1696	-0.002	1
															1697	1.854	1
															1698	-0.581	1
															1699	-3.223*	1

PART 3: Master Dating Series: Sun Page 4

Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab
1700	1.181	1	1750	-1.372*	1	1800	-0.672	4	1850	-1.080*	11	1900	1.010	17	1950	-0.292	24
1701	-0.087	1	1751	-0.005	1	1801	1.735	4	1851	0.094	11	1901	0.686	18	1951	-1.352*	24
1702	0.902	1	1752	0.677	2	1802	0.907	4	1852	-0.005	11	1902	0.784	18	1952	-0.688	24
1703	-1.090*	1	1753	0.760	2	1803	0.262	4	1853	-0.269	12	1903	0.017	19	1953	1.499	24
1704	-1.860*	1	1754	0.477	2	1804	0.777	4	1854	-0.213	12	1904	-0.172	19	1954	0.911	24
1705	1.130	1	1755	0.847	2	1805	0.497	4	1855	0.335	12	1905	-0.329	19	1955	-0.342	24
1706	-0.424	1	1756	-0.557	3	1806	0.097	4	1856	-0.115	12	1906	0.051	19	1956	-0.579	24
1707	1.507	1	1757	-2.087*	3	1807	0.821	4	1857	-0.316	13	1907	0.162	19	1957	-0.413	24
1708	2.484*	1	1758	-0.455	3	1808	-0.957	5	1858	-0.880	13	1908	0.718	19	1958	1.120	24
1709	-0.268	1	1759	-0.539	3	1809	0.371	5	1859	-1.426*	13	1909	-0.858	19	1959	-0.707	24
1710	-0.532	1	1760	-1.666*	3	1810	0.600	5	1860	1.478	13	1910	-1.356*	19	1960	0.486	24
1711	-0.581	1	1761	0.359	3	1811	-2.339*	5	1861	1.742	13	1911	-1.002*	19	1961	-0.005	24
1712	0.638	1	1762	-0.448	3	1812	-0.318	5	1862	0.751	13	1912	0.418	19	1962	-0.626	24
1713	-0.793	1	1763	-0.905	3	1813	-0.135	5	1863	0.876	13	1913	1.459	19	1963	1.091	24
1714	2.717*	1	1764	1.237	3	1814	1.514	5	1864	0.310	15	1914	1.197	20	1964	0.674	24
1715	2.248*	1	1765	1.523	3	1815	1.310	5	1865	-1.262*	16	1915	0.986	20	1965	0.618	24
1716	0.285	1	1766	2.157*	3	1816	0.575	6	1866	1.613	16	1916	0.280	20	1966	-0.662	24
1717	-3.051*	1	1767	1.559	3	1817	-0.188	6	1867	-0.881	16	1917	-0.967	20	1967	0.632	24
1718	-1.613*	1	1768	0.482	3	1818	-1.226*	6	1868	0.507	16	1918	-1.479*	20	1968	-1.049*	24
1719	-0.362	1	1769	-0.883	3	1819	1.000	6	1869	-0.550	17	1919	0.053	20	1969	-1.215*	24
1720	-0.367	1	1770	-0.957	3	1820	-0.047	7	1870	0.115	17	1920	0.067	21	1970	-0.056	24
1721	0.013	1	1771	-0.695	3	1821	-1.710*	7	1871	0.584	18	1921	1.227	21	1971	0.314	24
1722	-0.655	1	1772	-0.049	3	1822	0.511	7	1872	-0.124	18	1922	-0.251	21	1972	-0.372	24
1723	-1.706*	1	1773	2.437*	3	1823	-0.334	6	1873	0.891	18	1923	0.336	22	1973	-1.817*	24
1724	-0.840	1	1774	1.569	3	1824	-0.985	6	1874	-0.337	19	1924	-1.343*	22	1974	-0.101	24
1725	-1.213*	1	1775	0.336	3	1825	0.874	6	1875	-0.721	19	1925	-0.459	22	1975	-0.483	24
1726	0.449	1	1776	0.221	3	1826	0.463	6	1876	0.155	19	1926	-0.411	22	1976	0.148	24
1727	1.936	1	1777	-0.551	3	1827	0.215	6	1877	-0.465	19	1927	0.457	22	1977	-0.400	24
1728	0.519	1	1778	-0.841	3	1828	-0.703	6	1878	0.310	20	1928	-0.462	22	1978	0.648	24
1729	-0.591	1	1779	-1.575*	3	1829	0.529	6	1879	0.848	20	1929	0.009	22	1979	-0.263	24
1730	1.049	1	1780	-0.728	3	1830	0.011	6	1880	-0.014	20	1930	0.306	23	1980	0.923	24
1731	1.747	1	1781	0.065	3	1831	-0.509	6	1881	-0.401	20	1931	0.312	22	1981	1.193	24
1732	2.065*	1	1782	-0.520	3	1832	1.318	6	1882	-0.329	20	1932	0.328	21	1982	-0.644	24
1733	0.634	1	1783	-0.317	3	1833	-0.308	6	1883	-0.613	20	1933	0.062	21	1983	0.506	24
1734	-0.989	1	1784	-1.167*	3	1834	-1.440*	6	1884	0.785	19	1934	-0.284	21	1984	1.154	24
1735	-0.899	1	1785	0.852	3	1835	0.236	7	1885	1.440	19	1935	-0.675	22	1985	-0.278	24
1736	1.033	1	1786	1.038	3	1836	0.790	7	1886	0.363	19	1936	1.117	22	1986	0.373	24

Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab
1737	1.327	1	1787	-1.961*	3	1837	0.583	7	1887	-0.204	19	1937	-0.806	22	1987	-0.371	24
1738	1.951	1	1788	-0.922	3	1838	0.248	7	1888	-0.161	19	1938	-0.097	22	1988	-0.150	24
1739	-0.317	1	1789	-0.051	3	1839	-0.427	7	1889	-0.341	19	1939	-1.481*	22	1989	-1.284*	24
1740	1.076	1	1790	0.673	3	1840	0.776	8	1890	-2.035*	19	1940	-0.646	22	1990	-0.298	24
1741	0.742	1	1791	0.626	3	1841	1.640	9	1891	-0.624	18	1941	0.749	23	1991	-0.255	24
1742	-1.744*	1	1792	-0.211	3	1842	0.558	10	1892	-0.351	18	1942	1.258	23	1992	-1.071*	24
1743	-3.089*	1	1793	1.327	3	1843	-0.897	11	1893	-0.162	18	1943	0.475	23	1993	0.180	24
1744	-2.027*	1	1794	1.705	4	1844	-1.068*	11	1894	1.552	18	1944	0.154	23	1994	0.217	24
1745	-0.977	1	1795	-0.950	4	1845	1.122	11	1895	-0.230	18	1945	0.137	24	1995	0.233	24
1746	-1.623*	1	1796	-1.873*	4	1846	0.715	11	1896	0.265	17	1946	-0.549	24	1996	1.380	24
1747	0.032	1	1797	-0.991	4	1847	-1.675*	11	1897	-0.608	17	1947	0.325	24	1997	1.382	24
1748	-1.320*	1	1798	0.409	4	1848	0.472	11	1898	0.046	17	1948	2.229*	24	1998	1.485	24
1749	0.401	1	1799	-1.236*	4	1849	-1.599*	11	1899	-0.461	17	1949	-0.599	24	1999	0.027	24

PART 3: Master Dating Series: Sun Page 5

Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab	Year	Value	No Ab
2000	0.875	24															
2001	-0.852	24															
2002	-0.364	24															
2003	-0.348	24															
2004	-0.724	24															
2005	0.321	24															
2006	-0.555	24															
2007	-1.916*	24															
2008	-0.267	24															
2009	-1.243*	24															
2010	0.404	24															
2011	1.150	24															
2012	0.950	24															
2013	0.209	24															

PART 5: CORRELATION OF SERIES BY SEGMENTS: Sun Page 5

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under 0.3281 but highest as dated; * = correlation higher at other than dated position

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	LTPO01B	1857 2013					.65	.62	.72	.74	.58	.53
2	LTPO02A	1874 2013					.62	.62	.68	.65	.64	.70
3	LTPO03B	1903 2013							.43	.50	.42	.50
4	LTPO04A	1920 2013							.52	.63	.58	.58
5	LTPO05A	1865 2013					.34	.36*	.62	.63	.55	.61
6	LTPO06B	1901 2013							.46	.50	.59	.59
7	LTPO07A	1935 2013								.66	.62	.58
8	LTPO08A	1864 2013					.36	.47	.65	.55	.44	.49
9	LTPO09B	1696 2013	.48	.52	.53	.50	.51	.52	.50	.53	.43	.46
10	LTPO10B	1756 2013	.66	.62	.65	.68	.55	.60	.65	.52	.33	.44
11	LTPO11A	1941 2013								.49	.53	.52
12	LTPO13A	1945 2013								.51	.42	.34
13	LTPO14B	1869 2013					.31A	.42	.67	.65	.45	.47
14	LTPO15A	1914 2013							.68	.65	.67	.67
15	LTPO16A	1931 2013								.61	.65	.74
16	LTPO17A	1930 2013								.50	.34*	.34
17	LTPO18A	1923 2013							.65	.68	.63	.53
18	LTPO20A	1864 2013					.62	.52	.46	.55	.48	.43
19	LTPO23A	1842 2013				.68	.63	.57	.59	.62	.60	.63
20	LTPO24A	1841 2013				.71	.64	.58	.52	.52	.57	.36
21	LTPO25A	1843 2013				.62	.55	.57	.57	.63	.67	.67
22	LTPO26A	1808 2013			.63	.75	.74	.71	.52	.52	.76	.76
23	LTPO29A	1816 2013			.52	.53	.60	.51	.40	.55	.63	.51
24	LTPO30A	1820 2013			.69	.69	.65	.63	.35	.43	.65	.53
25	SSPO05	1840 1930				.49	.43	.39	.40			
26	SSPO06	1752 1822	.51	.50								
27	SSPO07	1794 1883		.41	.45	.31A	.36					
28	SSPO09	1871 1931					.42	.49	.43			
29	SSPO10	1878 1930						.35	.37			
30	SSPO14	1835 1890				.52	.55					
31	SSPO15	1853 1895					.48					
Av segment correlation			0.55	0.51	0.58	0.59	0.53	0.53	0.54	0.58	0.55	0.54

```
PART 6:  POTENTIAL PROBLEMS:                                                   Sun   Page   6
------------------------------------------------------------------------------------------------

 For each series with potential problems the following diagnostics may appear:

 [A] Correlations with master dating series of flagged  50-year segments of series filtered with  32-year spline,
     at every point from ten years earlier (-10) to ten years later (+10) than dated

 ===============================================================================================

 LTPO05A    1865 to  2013

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1    0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
     ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
     1875 1924   -8   -.04 -.26  .42* .28  .23  .14 -.20 -.34 -.03 -.33  .36| .12  .03 -.27 -.18 -.12  .10  .15  .12 -.05 -.01

 [*] Early part of series cannot be checked from 1696 to 1751 -- not matched by another series

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 LTPO14B    1869 to  2013

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1    0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
     ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
     1869 1918    0   -.02 -.10 -.22  .17  .03 -.24 -.05 -.31 -.05  .05  .31* .19  .00 -.14 -.19  .01  .19  .27  .26  .20 -.28

 ===============================================================================================

 LTPO17A    1930 to  2013

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1    0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
     ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
     1950 1999   -7    .17  .05 -.22  .45*-.16  .11  .04 -.03 -.19 -.17  .34|-.08 -.20  .09 -.12 -.05  .07  .14 -.03 -.07  .28

 ===============================================================================================

 SSPO07     1794 to  1883

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1    0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
     ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
     1825 1874    0    .23 -.12  .12  .06 -.15 -.03  .07  .03 -.25  .03  .31*-.22  .14  .06 -.38  .05 -.06 -.05  .06  .05  .04
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PART 7:  DESCRIPTIVE STATISTICS:                                               Sun   Page   7
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Seq	Series	Interval	No. Years	No. Segmt	No. Flags	Corr with Master	//-------- Unfiltered Mean msmt	Max msmt	Std dev	Auto corr	Mean sens --------\\	//---- Filtered Max value	Std dev	Auto corr -----\\	AR ()
1	LTPO01B	1857 2013	157	6	0	0.674	1.33	3.42	0.683	0.877	0.198	0.68	0.264	-0.013	1
2	LTPO02A	1874 2013	140	6	0	0.657	1.68	3.53	0.641	0.865	0.161	0.67	0.215	-0.012	1
3	LTPO03B	1903 2013	111	4	0	0.454	2.04	4.38	0.713	0.873	0.126	0.47	0.188	-0.025	1
4	LTPO04A	1920 2013	94	4	0	0.541	1.44	4.32	0.621	0.781	0.166	0.63	0.217	-0.016	2
5	LTPO05A	1865 2013	149	6	1	0.534	1.14	2.13	0.302	0.593	0.177	0.67	0.215	-0.018	1
6	LTPO06B	1901 2013	113	4	0	0.556	1.68	2.96	0.511	0.818	0.159	0.52	0.209	0.006	1
7	LTPO07A	1935 2013	79	3	0	0.626	2.68	3.87	0.410	0.526	0.118	0.34	0.135	0.004	1
8	LTPO08A	1864 2013	150	6	0	0.499	1.10	2.05	0.282	0.718	0.150	0.66	0.199	0.007	1
9	LTPO09B	1696 2013	318	10	0	0.503	0.69	2.15	0.401	0.931	0.151	0.56	0.182	-0.003	1
10	LTPO10B	1756 2013	258	10	0	0.567	0.86	1.90	0.325	0.873	0.157	0.49	0.191	-0.002	3
11	LTPO11A	1941 2013	73	3	0	0.513	3.23	6.46	0.984	0.782	0.165	0.44	0.192	0.001	1
12	LTPO13A	1945 2013	69	3	0	0.394	2.86	4.31	0.544	0.644	0.130	0.36	0.173	0.058	1
13	LTPO14B	1869 2013	145	6	1	0.505	1.37	3.31	0.645	0.927	0.142	0.46	0.183	0.040	1
14	LTPO15A	1914 2013	100	4	0	0.674	2.54	4.91	0.816	0.587	0.236	0.54	0.252	0.014	2
15	LTPO16A	1931 2013	83	3	0	0.650	3.11	5.89	1.246	0.782	0.202	0.58	0.228	-0.001	1
16	LTPO17A	1930 2013	84	3	1	0.418	3.00	5.24	0.885	0.706	0.178	0.55	0.213	0.006	1
17	LTPO18A	1923 2013	91	4	0	0.573	2.43	5.90	0.976	0.834	0.171	0.65	0.203	-0.025	1
18	LTPO20A	1864 2013	150	6	0	0.527	1.85	3.84	0.826	0.915	0.150	0.62	0.177	-0.016	1
19	LTPO23A	1842 2013	172	7	0	0.630	1.33	2.78	0.432	0.776	0.160	0.60	0.200	-0.006	4
20	LTPO24A	1841 2013	173	7	0	0.578	1.28	2.50	0.441	0.833	0.144	0.64	0.206	0.041	1
21	LTPO25A	1843 2013	171	7	0	0.621	1.35	2.27	0.378	0.755	0.166	0.47	0.194	0.001	1
22	LTPO26A	1808 2013	206	8	0	0.660	0.98	2.63	0.584	0.942	0.145	0.40	0.171	0.013	1
23	LTPO29A	1816 2013	198	8	0	0.528	1.11	3.20	0.661	0.879	0.200	0.80	0.277	-0.022	1
24	LTPO30A	1820 2013	194	8	0	0.567	1.20	2.41	0.476	0.849	0.163	0.71	0.213	0.017	1
25	SSPO05	1840 1930	91	4	0	0.468	1.05	1.59	0.232	0.609	0.161	0.49	0.188	-0.002	3
26	SSPO06	1752 1822	71	2	0	0.526	1.38	2.99	0.508	0.835	0.167	0.45	0.207	0.004	1
27	SSPO07	1794 1883	90	4	1	0.398	1.23	2.27	0.349	0.766	0.151	0.42	0.184	0.016	1
28	SSPO09	1871 1931	61	3	0	0.385	1.77	3.07	0.599	0.820	0.154	0.37	0.198	0.030	4
29	SSPO10	1878 1930	53	2	0	0.324	1.19	1.91	0.298	0.585	0.182	0.46	0.213	-0.036	1
30	SSPO14	1835 1890	56	2	0	0.533	2.17	3.83	0.533	0.728	0.132	0.38	0.149	-0.004	3
31	SSPO15	1853 1895	43	1	0	0.482	2.51	3.97	0.737	0.888	0.120	0.29	0.148	0.022	1
Total or mean:			3943	154	4	0.551	1.50	6.46	0.548	0.810	0.161	0.80	0.202	0.002	

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