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# Application of a New Tree-Ring Based Drought Reconstruction Method at Multiple Forest Sites Across Indiana, U.S.A.

Kayla Mechelle Pendergrass
*University of Southern Mississippi*

The University of Southern Mississippi

# APPLICATION OF A NEW TREE-RING BASED DROUGHT RECONSTRUCTION METHOD AT MULTIPLE FOREST SITES ACROSS INDIANA, U.S.A

by

Kayla Mechelle Pendergrass

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Approved:

_____
Dr. Grant L. Harley, Committee Chair
Assistant Professor, Geography and Geology

_____
Dr. Carl A. Reese, Committee Member
Professor, Geography and Geology

_____
Dr. Bandana Kar, Committee Member
Assistant Professor, Geography and Geology

_____
Dr. Karen S. Coats
Dean of the Graduate School

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ABSTRACT

APPLICATION OF A NEW TREE-RING BASED DROUGHT RECONSTRUCTION METHOD AT MULTIPLE FOREST SITES ACROSS INDIANA, U.S.A

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This thesis research used techniques of dendrochronology to investigate the efficacy of using multiple co-occurring species (MCOS) in a climate reconstruction model compared to a single species (SS) in four old-growth forests in Indiana: Pioneer Mothers Memorial Forest (PM), Donaldson Woods (DW), Hoot Woods (HW), and Lilly Dickey Woods (LD). The objectives of this study were to [1] evaluate the climate response of all chronologies ($n$ = 19; 7 species) to determine the most appropriate climate variable for reconstruction and [2] determine if the MCOS model outperforms the SS model at each individual study site. Model comparison was conducted with $r^2$, adj. $r^2$, standardized residuals, root-mean-square error (RMSE), F statistic, and Akaike Information Criterion (AIC). Summer (June–August; JJA) Palmer Drought Severity Index (PDSI) was the best predicated climate variable, thus two separate models (SS and MCOS) were created at each site for reconstruction. The MCOS outperformed the SS at each site. During the instrumental period (1895–2000), the MCOS at PM, DW, HW and LD explained 50%, 49%, 36%, and 50% of the variance in JJA PDSI, respectively; whereas explained variance of the SS was 40%, 45%, 33%, and 47%. Further, adj. $r^2$, standardized residuals, RMSE, and AIC all suggest that using the MCOS method to reconstruct drought outperforms the SS method. Future tree-ring based climate reconstructions should

consider using the MCOS model because it allows reconstructions to go further back in time and produces more accurate estimates of climate conditions.

# DEDICATION

This thesis is dedicated to my partner, Mark, for his love and support, especially through the past two years; my Grandmother, Barbara, for being the woman I look up to and strive to be; and my parents for always pushing me to achieve my goals.

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| LD | Lilly Dickey |
| HW | Hoot Woods |
| PM | Pioneer Mothers |
| DW | Donaldson Woods |
| MCOS | Multiple Co-Occurring Species |
| SS | Single Species |
| U.S. | United Sates |
| PDSI | Palmer Drought Severity Index |
| USDA | United States Department of Agricultural |
| WGD | Wisconsin Glacial Divide |
| NCDC | National Climate Data Center |
| RC | Regional Chronology |
| PCA | Principle Component Analysis |
| PCR | Principle Component Regression |
| DNR | Department of Natural Resources |
| Ca. | Calendar age |

# CHAPTER I

# INTRODUCTION

## 1.1 Eastern United States Characteristics

In the Eastern United States (U.S.), the dominant forest type is a mixed deciduous and evergreen forest. This mixture of deciduous and evergreen species results in forests with hundreds of different species that share a unique feature of recording the climatic conditions (e.g. temperature and precipitation) they experience throughout the growing season. This capability allows researchers to investigate climatic conditions that occurred beyond the instrumental period and the response of species to climate conditions, overall aiding in environmental management and future climate forecasting. Current and impending climate change creates an urgency to understand how species will respond and how forest ecosystems will be altered (Pederson 2004). Species range limits, composition, and structure are among a few things that will alter forest ecosystems, which makes further investigations of species and their response to climate important to understand.

Temperature, precipitation, and soil moisture all play major roles in primary and secondary tree growth throughout the growing season. Soil moisture is measured using a drought index such as Palmer Drought Severity Index (PDSI). The PDSI is a drought metric that uses a simplified monthly water-balance to estimate soil moisture (Palmer 1965). Low soil moisture yields drought conditions, one of the most devastating natural disasters that the U.S. experiences today (Ross & Lott 2003). Drought is defined as a prolonged period of dry weather conditions; an accumulation of low rainfall and a shortage in the water supply. The consequences associated with drought affects both humans and the environment, resulting in deficits in the water supply, increased fire

regimes, insect outbreaks, tree mortality, and extreme economic costs. These disturbances negatively affect the entire country, especially in the western U.S. In recent decades, the western U.S. has experienced a shortage in reservoir water storage, drops in lake levels, and increased fire outbreaks (Cook et al. 2007). The economic costs associated with these impacts have become the most costly of all natural disasters in the U.S. During the period 1980–2003, 10 separate drought events were estimated to cost more than one billion dollars each. Previous studies estimate that $114 billion of $349 billion went to droughts alone (Ross & Lott 2003).

The severity and intensity of droughts that occurred during the instrumental period (*ca.* 1895–current) can be compared to past droughts (i.e. beyond instrumental period) with climate proxies that enable climate reconstructions. Tree rings are widely used as a climate proxy for drought reconstructions (Fritts 1976). In the Eastern U.S., certain species (i.e. *Tsuga canadensis, Taxodium distichum, Quercus alba*) have been identified as being the leading species for dendrochronology research (Pederson et al. 2012a). However, with the changing climate, increased insect outbreaks, and diseases many of the foundation species are on the verge of extinction. Hessl and Pederson (2012) found that *Castanea dentata* and *Ulmus americana* have all but disappeared from forests in Eastern North America. In addition, *Tsuga canadensis* and *Tsuga caroliniana* are following the same trajectory, as much of their range is threatened by the wooly adelgid (Hessl & Pederson 2012). These species and others (e.g. *Q. alba, Juniperus virginiana, Q. montana*) have become common species in dendrochronological research in the Eastern U.S. because of their longevity and sensitivity to climate variations (Hessl & Pederson 2012, Pederson et al. 2012b). However, the use of long-lived novel species in dendro-

chronological research is important because of the potential for capturing a unique climate signal, as well as replacing more common species that are becoming extinct (Hessl & Pederson 2012, Pederson et al. 2012a).

The decline of species like *Tsuga caroliniana* is just one reason for new techniques and methods in tree-ring based research. In the Eastern United States, dendrochronological studies have focused on the same species that have always provided adequate results, ignoring many others in the Eastern Deciduous Forest biome. With the effects of a changing climate, it is important to find new ways that can help improve methods.

## 1.1 Study Overview

This research uses dendrochronological techniques to determine if using multiple co-occurring species (MCOS) improves the power of climate reconstruction models at four old forests in Indiana (Pioneer Mothers Memorial Forest (PM), Donaldson Woods (DW), Hoot Woods (HW), and Lilly Dickey Woods (LD)). Typically, climate reconstruction models use one species from one or multiple locations or multiple species from multiple locations (Maxwell et al. 2014). Using multiple species from the same location is a new concept that this thesis focused on for drought reconstructions in the Eastern U.S. This new method is believed to provide more accurate reconstruction models compared to the traditional single species models. Overall, this project investigates model accuracy between two opposite climate reconstruction techniques (Single Species (SS) vs. MCOs) in four old forests.

## 1.2 Justification

"Old-growth" and "virgin forests" are considered to either be untouched by anthropogenic disturbances (e.g. logging, livestock grazing) or those that might have been

disturbed but still contain trees 150 years old or older (Frelich 2002). These forests are also described as being original, primary, primeval, or ancient. Climate reconstructions rely heavily on using longer-lived species to describe old forests. The western U.S. contain larger quantities of longer-lived species compared to the Eastern U.S., which represents a larger portion of the U.S. agricultural region and has experienced extensive logging practices that have led to a decline in old forests (Pederson et al 2012). The shortage of old forests in the Eastern U.S. paired with the origination of dendrochronology in the western U.S. help to explain why dendrochronological research has been historically focused in the western U.S.

Despite the numerous old forests in the state of Indiana, only one chronology has been developed (*Q. alba* in Pulaski Woods by Dr. Ed Cook from the Tree-Ring Lab at Lamont-Doherty Earth Observatory (International Tree Ring Data Bank, 2015)). In Indiana, the Department of Natural Resources (DNR), which handles these old forests, would not allow any dendrochronology researchers access to the forests. This has led to a dearth of dendro-based research in Indiana. However, with recent access to these forests, I will not only be testing the MCOS model, but I am able to provide a drought reconstruction for Indiana and the surrounding area with the data from these old forests.

## 1.5 Research Questions

The purpose of this research is to determine which method (MCOS or SS) used in a drought reconstruction provides the most accurate results. To accomplish this goal, the following objectives were identified:

- [1] Evaluate the climate response of all chronologies across the 4 study sites (PM, DW, LD, HW) and determine the most appropriate climate

variable for reconstruction.

- [2] Build the SS and MCOS reconstruction models for each study site using the appropriate predictand chronologies.
- [3] Determine if the MCOS model outperforms the SS model at each individual study site.

These objectives were employed to address the main research questions, which include:

- [1] What is the best predicted climate variable (i.e. temperature, precipitation or PDSI) and season across all chronologies at each study site?
- [2] How do the SS and MCOS compare in regard to model skill and accuracy, temporal length, and representation of drought across the region?
- [3] What information about past drought variability can be gleaned from the drought reconstructions across southern Indiana?

These research questions will determine the efficacy of the MCOS model across multiple forests in southern Indiana. In a previous study, Maxwell et al. (2014) suggested that the MCOS model outperforms the SS model at a single study site (PM). In this study, I compare the MCOS and SS models at multiple forest locations to determine if the MCOS model is reliable in climate-based reconstructions in the Midwest.

## 1.6 Summary

This thesis is organized into the following chapters. Chapter II provides a literature review of dendrochronology and the evolution of climate reconstructions. It concludes with an overview of the MCOS model. Chapter III provides details (e.g. soil type, climate, topography) about each study site and the general area in which they are located within Indiana. Chapter IV outlines and describes the methods employed to collect and process the chronologies created and used in this study, along with the processes used to develop the SS and MCOS models. Chapter V provides results from each site. A discussion of the results and major conclusions are provided in Chapter VI.

# CHAPTER II

# REVIEW OF RELATED LITERATURE

## 2.1 Climate Proxies

Reconstructing past climate conditions, such as temperature, precipitation, stream flow, sea surface temperatures, and droughts require the performance of climate reconstructions. Climate reconstructions provide insight into the past where historical documents lack information regarding past climatic events. This can aid in better understandings how the climate system is operating today, and how it might change in the future. These reconstructions are possible with paleoclimate proxies capable of recording climate conditions. Numerous proxies around the world record climatic data including: foraminifera (Gehrels 1999), isotopes from coral reefs (Quinn et.al 1993; Delong et al. 2012), ice cores (McManus et al. 1994; Ramirez et al 2003), fossil pollen (Willard et al. 2001), sediment cores (Delcourt & Delcourt 1985), and tree rings (Mann 2002). For this study, tree rings are the paleoclimate proxy used for reconstructing climate. Tree rings are a widely used proxy in the field of paleoclimatology because they can provide a well replicated, annually resolved, precisely dated climate proxy record (Fritts 1976).

## 2.2 Dendrochronology

Dendrochronology is the science of using tree rings, dated to their exact calendar year of formation, to study patterns of processes that operate in the physical and cultural sciences. The science of dendrochronology originated in 1904 by A.E. Douglas at The University of Arizona. Tree rings are a broadly used paleoclimate proxy used today because of their ability to provide annual data that can provide precise dates (Fritts 1976). Over the years, the field of dendrochronology has expanded into subfields such as,

dendroclimatology, dendroarchaeology, and dendroecology. The field of dendroclimatology, under which this research is classified, investigates past climates based on annual tree ring growth. In the field of dendroclimatology, tree-ring chronologies are the proxy for reconstructing past climates, investigating climate responses, and examining climate-growth relationships (Carrer & Urbinati 2004, Cook et al. 2000, 2007, Henderson & Grissino-Mayer 2009, Lamarche & Fritts, Leland et al. 2013, Mérian & Lebourgeois 2011, Trouet et al. 2006, 2013). These studies assist in understanding how species respond to climate variables (e.g. temperature, precipitation, hurricanes, droughts, etc.), and how the persistence and severity of such climate variables have changed over time.

*2.2.1 Climate Reconstructions*

The typical method when using tree rings as the proxy for climate reconstructions is using chronologies from a single species. This technique is partially derived from dendrochronological research originating in the western U.S. where a low diversity of tree species exists. Because of the low diversity, dendroclimatic reconstructions were based on species that contained the best climate signal in the best environment (e.g. *Pinus ponderosa* and *Pseudotsuga menziesii*) (Spear 2010, Maxwell et al. 2014). The chosen species were conifers because they are (1) the longest-lived species of the area and (2) the easiest to sample and analyze (Schulman 1954). This single species method then transferred to the Eastern U.S. where a higher diversity of long-lived, canopy-dominated species exists. Methods from the west were performed in the east and species that had the best climate signals (e.g. *Taxodium distichum* and *Quercus sp.*) (Stahle et al. 1985) were the chosen species of the east for climate reconstructions (Spear 2010). Over the past

several decades, researchers have disregarded many other species in the EDF, even long lived species (e.g. *Liriodendron tulipifera, Carya ovata)* by following techniques adopted from the west.

In recent years, there have been increased investigations on the effects of using multiple species in stream flow and modern climate reconstructions (Cook & Jacoby 1977, Cook et al. 1999, Pederson et al. 2001, Cook & Krusic 2004, Frank & Esper 2005, Maxwell et al 2011, Pederson et al. 2012a, 2012b). These investigations have performed research in a variety of forms including:

- Using multiple species from multiple locations (not from a single forest) to reconstruction climate over large regions (e.g. Western and Eastern U.S.) (LaMarche & Fritts 1971, Fritts et al. 1980, Pederson et al. 2012b).
- Investigating droughts in a specific area (e.g. local scale) using one or multiple species (Cook & Jacoby 1977, MacDonald & Tingstad 2007, Stambaugh et al. 2011, Pederson et al. 2012a).
- Reconstructing seasonal rainfall in a region (Stahle & Cleaveland 1992).
- Using a multiple species network to reconstruction stream flow (Maxwell et al. 2012).

Most studies that have used multiple species focused on large regions or continental scales, which have combined multiple species from different environments. These studies have shown the benefit of using multiple species, but not at a single location (Maxwell et al. 2014).

Several studies show that climate reconstructions using dendrochronological techniques could be improved by combining multiple species from the same location

(Maxwell et. al 2011, Qiufang & Liu 2013, Maxwell et al. 2014). This idea of combining species from the same location attributes to the amount of species variance within a forest with regard to their response to climatic conditions. For example, certain species tend to be more sensitive to soil moisture (e.g. *Q. alba*) than other species (e.g. *Liriodendron tulipifera)*; therefore, the potential of the true climate signal of the forests will not be captured when only using one species (Pederson et al. 2012b, Maxwell et al. 2014). A new method proposed by Maxwell et al. (2014) suggests that using a Multiple Co-Occurring Species model (MCOS) containing multiple species from a single forest could provide more robust models of climate. However, Maxwell et al. (2014) only presents data from one old-growth forest in Indiana. This study intends to determine if this method improves the power of reconstruction models at multiple locations (n = 4) throughout Indiana. Testing this method in multiple locations is important because it will determine if findings from Maxwell et al. (2014) were an artifact of some variable at the one site used (i.e. micro-climate conditions, topography, soils, land-use history) and provide substantive evidence and support to the reliability of using MCOS in climate reconstructions.

### 2.3 Multiple co-occurring species

The studies that have investigated the use of multiple species in stream flow and modern climate reconstructions (Cook & Jacoby 1977, Cook et al. 1999, Pederson et al. 2001, Cook & Krusic 2004, Frank & Esper 2005, Maxwell et al 2011; Pederson et al. 2012a, 2012b) were conducted at the regional and continental scales. While these studies have shown the benefit of using multiple species, none of the research conducted was focused on a single location (Maxwell et al. 2014). There have been two studies that have

investigated multiple species at single locations (Qiufang & Liu 2013, Maxwell et al. 2014), but with different techniques and spatial scales.

The first study by Qiufang and Liu (2013), focused on studying the climate response of three species at different elevations in the Luliang Mountains. This study incorporated a regional scale to the idea of conducting research at a single location . Qiufang and Liu (2013) developed a regional chronology (RC) by determining to arithmetical average of the four standardized chronologies and used it in the analysis alongside the single chronologies. They compared the single chronologies and RC to climatic data and the RC resulted in higher correlation values than the single species. They determined that regardless of the difference in species and located at different elevations, they were all suitable for climate investigations. They concluded that, based on correlation values of the RC, the different species provided a common regional climatic signal. Qiufang and Liu (2013) suggested that a composite of all species from this area would be more successful in reconstructing climate data compared to a single species model.

Research conducted by Maxwell et al. (2014) explored the use of the MCOS at a single study site. The main objective of their study was to test the hypotheses that [1] using multiple co-occurring species from a single location would further increase the accuracy of climate reconstructions and [2] better represent how climate influences tree growth in a forest. The goals set forth by Maxwell et al. (2014) analyzed the difference between using single species and multiple species in a drought reconstruction to determine if combining species would increase or decrease the climate signal. They created the composite chronology differently than Qiufang and Liu (2013) by using a nested approach, which maximizes reconstruction length and provides a more robust

investigation of the loss in signal reliability among the species (Meko 1997). This method avoids any mixing of climate signals of different species in climate reconstructions (Fritts 1976). Maxwell et al. (2014) discovered that using MCOS in a reconstruction outperformed each individual species model.

*2.3.1 Performance of a Composite Chronology*

Based on previous research (Qiufang &Liu 2013, Maxwell et al. 2014), we can attribute the proficiency of models using composite chronologies to at least three factors: climate response, increased time series length, and temporal stability. The first factor (climate response), improves the accuracy of climate models by combining climate signals from multiple species and allowing for a more representative account of the response of a forest to climatic variables, since not all species respond to climate in the same manner. For example, Maxwell et al. (2014) showed PDSI has the highest correlations with all three species (e.g. *L. tulipifera, Q. alba, Q. rubra*) in their investigation during the summer months (June, July, and August (JJA)). However, *L. tulipifera* was the only species that recorded a significant moisture signal during the previous year. Their composite chronology, made up of all three aforementioned species, had the highest correlation values during the current summer months compared to the individual species, and retained the previous year's moisture signal that *L. tulipifera* provided. This demonstrated that combining multiple species into one composite chronology increases correlation values and retains signals that would not be included without that particular species.

The second factor (increased time series length) plays a role in a study to increase the amount of time accounted for in a reconstruction. The record of a reconstruction is bound by the ages of the chronologies by which the reconstruction is created. When using

only one species, the researcher is limited by the years that their chronology represents (Maxwell et al. 2012). As the chronology extends back in time, the sample depth decreases, which decreases the accuracy of the reconstruction. By combining multiple species, with different time series, the researcher is capable of extending the reconstruction further back in time. They are also increasing sample depth in areas that would otherwise be low if only using one species in the reconstruction. Maxwell et al. (2014) extended their composite chronology back to 1718 by combing the three species and increased their sample depth during the period of ca. 1800–1880.

The third factor (temporal stability) is the stability of the relationship between chronologies and climate variables through time. Maxwell et al. (2014) demonstrated that during the instrumental period (ca. 1895–2010), the composite chronology was more stable during the summer months (JJA) and remained consistent throughout the entire period compared to their single species chronology. The correlation between their single species chronology (*Q. alba*) and JJA PDSI ended abruptly 1997.

These three factors provide evidence on the advantages of using MCOS. The overarching advantage of a composite chronology using MCOS that Maxwell et al. (2014) discovered is that their drought reconstruction from PM outperformed all single species chronologies. Maxwell et al. (2014) provides evidence that a composite chronology has the ability to improve a climate reconstruction over a SS model; however, their study was conducted at only one forest site. The main focus of this research is to determine if the MCOS model produces a reconstruction model that is more accurate at reconstructing climate compared to the SS method across multiple sites in Indiana.

# CHAPTER III

# SETTING

## 3.1 Introduction

Indiana is an agricultural state where corn, wheat, and potatoes are the primary products provided by the State. In 2013, Indiana was ranked number 10 amongst the top ten leading agricultural producers of the U.S. According to the United States Department of Agricultural (USDA), Indiana held the number 10 ranking with $11,650,357 in cash receipts, while California ranked number 1 ($46,355,952), and Illinois ranked number 5 ($17,318,827) (USDA 2015). Indiana's soil characteristics make this area capable of being in the top ten producers of agricultural yields (Franzmeier et al. 2004). In northern Indiana, the nutrient rich soil that allows for quality agricultural production is a result of the last glacial advance that covered most of the state (Franzmeier et al. 2004). The Wisconsin Glacial Divide (WGD) outlines the boundary of the last glaciers advancement 2 million years ago. The glacier left the land north of the WGD scorned and flat, while hills and lowland regions dominate the landscape south of the WGD. North of the WGD the underlying surface consists of glacial till and loess (Franzmeier et al. 2004).

Indiana is known mainly as a leading producer in agricultural products for the U.S. (Franzmeier et al. 2004), but has also managed to keep intact 809 ha of old forests (DNR). These forests have been protected by organizations like the US Forest Service and the Department of Natural Resources (DNR), which have prohibited dendrochronological sampling within the forests. The sampling restrictions have prevented any chronology development in Indiana except for one *Q. alba* chronology from Northern Indiana developed by Dr. Ed Cook from the Tree-Ring Lab at Lamont-Doherty Earth Observatory

(International Tree-Ring Data Bank, 2015). However, recently granted permits allowed for the collection of live and dead samples from four old forests in Indiana.

The four forests in this study include Pioneer Mothers Memorial Forest (PM), Donaldson Woods (DW) Hoot Woods (HW), and Lilly Dickey Woods (LD). All study sites are located south of the WGD in south-central Indiana (Figure 1). These sites were selected based on their old age.

### 3.2 Study Sites

The first site included in this study was Lilly Dickey Woods (LD) in Browns County, Indiana (39°14'35.44" N, 86°12'35.86" W). Indiana University (IU) acquired LD in 1942. *Quercus, Fagus*, and *Acer* species dominate the 223 ha of unglaciated thin soils at LD (Lindsey 1969). Lilly Dickey is the youngest forest in this study as a result of past logging events.

The second forest, Hoot Woods (HW), is located in Owen County, Indiana (39°43'23'16.39" N, 86°48'34.48" W). This forest contains 36 ha of relatively undisturbed *Fagus-Acer* species. This forest is privately owned but managed by The Nature Conservancy (Petty & Lindsey 1961). HW also has evidence of past logging and, as a result, is the second youngest forest in this study. LD and HW receive an average temperature of 17.4° C and an average total precipitation of 1202 mm (NOAA).

The third study site, Pioneers Mother Memorial Forests (PM) contains 35.6 ha of old forest dominated by the *Quercus, Fagus,* and *Acer* species. This forest is within the Hoosiers National Forest in Orange County, Indiana (38.536 N, 86.459 W) and has been undisturbed (i.e. logging) since before Joseph Cox purchased it in 1816. PM was later purchased by the US Forest Service and was designated as a Research Natural Area in

1944 (Higgs 1993). The PM study site was previously used in Maxwell et al. (2014) study. Thus, in addition to the chronologies presented by Maxwell et al. (2014), I collected samples and developed two additional chronologies (*Carya ovata* and *Juglans nigra)* from the PM site for this study.

The fourth study site, Donaldson Woods (DW), is located in Spring Mill State Park in Lawrence County, Indiana (38°43'58.54" N, 86°24'35.20" W) and covers 51 ha in which the *Fagus, Acer*, *Quercus,* and *Carya* species dominate the canopy. DW is considered an undisturbed old-growth mesophytic forest dominated by karst features such as caves and sinkholes (Higgs 1993). The mean annual air temperature at the PM and DW sites is 12.1° C, while the mean annual total precipitation is 1204 mm (NOAA).

The four forests share a similar climate and vegetation structure but vary in topography, elevation, and soil type. The southern Indiana region receives an average annual precipitation between 80 mm in the driest month (February) and 140 mm during the wettest month (May). The average summer (July) temperature is 30° C and the average winter (January) temperature is 4° C (NOAA). All study sites are composed of species such as: *Acer saccharum, F. grandifolia, L. tulipifera, Q. alba, Q. rubra, C. ovata,* and *Fraxinus americana*. In general, this area of Indiana consists of rolling hills and deep valleys in well-developed karst environments, where limestone and thin soils persist in elevations ranging from 99–383 m. At LD and HW however, these features are less pronounced which is a result of their proximity to the WGD. The soil and bedrock at LD and HW are different from PM and DW. LD and HW are located in Brown and Owen Counties, respectively, which has discontinuous loess over weathered sandstone and shale.

PM and DW contain discontinuous loess over weathered limestone (Franzmeier et al. 2004).

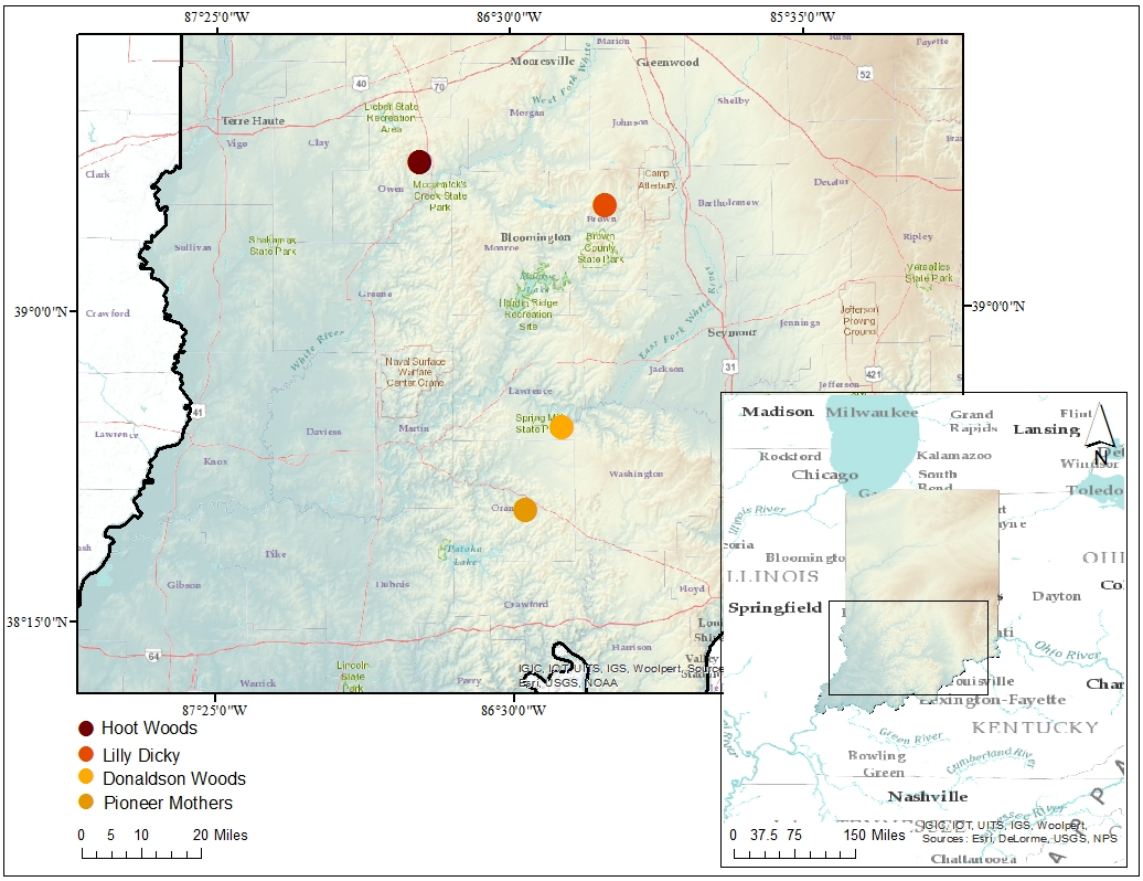


*Figure 1*. Site map displaying the locations of tree ring samples collected from Lilly Dickey, Hoot Woods, Pioneer Mothers, and Donaldson Woods in South-Central Indiana.

# CHAPTER IV

# METHODS

## 4.1 Field Methods

A targeted sampling design that allowed for the sampling of the oldest, canopy-dominant, climate sensitive trees (e.g. *Quercus spp.,* growing on steep slopes*)* was used at the four study sites (Cook et al. 1999, Speer 2010, Pederson et al. 2013). Standard dendrochronology field methods were used to extract two cores per tree at approximately 1.3 m from the ground parallel to the slope (Fritts 1976, Stokes & Smiley 1968, Speer 2010) at LD, HW, and PM. In addition, remnant wood was collected using a chainsaw at LD and DW to remove cross sections from dead and downed trees. Because of permit restrictions, living samples could not be collected at DW; therefore, only dead samples were collected. The proper identification of all species at DW was possible because of a recent storm event that resulted in large amounts of downed trees in an early state of decay.

## 4.2 Laboratory Procedures

In the lab, samples were mounted and sanded with progressively finer grit sandpaper (Orvis & Grissino-Mayer 2002) until the cellular structure was visible at 10x magnification. Each core was then visually crossdated using standard dendrochronological techniques (Stokes & Smiley 1968). WINDENDRO, capable of measuring to 0.01mm accuracy, was used to measure the samples, while COFECHA (Holmes 1983) statistically verified the accuracy of visual crossdating. COFECHA provides a measure of the strength of the signal (e.g. climate) that all tree samples share at a site, with the interseries correlation. Interseries correlation is the average correlation of each series with a master

chronology derived from all other series (Holmes 1983, NOAA 2015). Correlation varies with values ranging from high (0.90, e.g. drought sensitive conifers) to the lowest values that are still reliably crossdated ( ca. 0.40). Typically, most chronologies have interseries correlations between 0.55 and 0.75 (Holmes 1983, NOAA 2015).

Individual species chronologies from all 4 sites (19 total chronologies) were developed after each measurement series was standardized (detrended) in the statistical program ARSTAN (Cook 1985). Forest dynamic disturbances (e.g. natural disaster effects to individual species, canopy gaps, insect outbreaks, and individual tree mortality) can provide a source of interference that masks the desired signal (e.g. climate signal); therefore, tree series are detrended to remove unwanted interference (Cook and Kairiukstis 1990), along with any age related growth trend. A 2/3 spline (67% cut-off length of each series) was used to preserve as much of the low frequency climate signal as possible, while removing any biological growth factors and high frequency interference (Cook 1985; Cook & Kairiukstis 1990, Pederson et al. 2012b). This method allowed for the preservation of climate related variations and revealed realistic estimates of growth and annual variability (Pederson et al. 2004).

### 4.3 Climate Response

The computer program DendroCLIM2002 (Biondi & Waikul 2004) uses bootstrapped confidence intervals to estimate the significance of correlation function coefficients. The correlation coefficients are univariate estimates of Pearson's product moment correlation, while *function* is an indication of a sequence of coefficients calculated between the tree-ring chronology and the monthly climate variables (Biondi & Waikul 2004). This method was used to calibrate the SS chronologies against instrumental

Indiana divisional climatic data from the National Climatic Data Center (NOAA 2015) to examine the climate response of the SS chronologies from each site. I used Indiana divisions 5 (LD), 4 (HW), and 8 (PM, DW) mean monthly temperatures, total precipitation, and mean monthly Palmer Drought Severity Index (PDSI; Palmer 1965), during the period 1895–2013 CE from the previous growing season March to current growing season December, to statistically analyze the relationship between tree ring growth and climate variables.

Moving window correlation analysis was also performed in DendroCLIM2002 using a moving window of 44 years to examine the temporal strength of the climate response, along with identifying any changes between variables in the climatic sensitivity from March of the previous growing season to December of the current growing season. The moving window correlation analysis consists of calculating correlation coefficients on the upper 44 years of data. Then the uppermost sample is eliminated, and the next 44 years are included in the statistical calculations. The window continues this process, shifting downward one sample at a time until all data has been incorporated. This produces a series of changing correlation coefficients through time (Biondi & Waikul 2004).

### 4.3 Climate Reconstructions

Correlation analysis revealed mean PDSI during the period June–August (JJA) to be the best climate variable to include in the reconstructions based on the strongest relationship with annual tree growth. For each site, two JJA PDSI reconstruction models were developed, one consisting of the SS chronology and one consisting of the best combination of all the species chronologies developed at each site (MCOS). The SS

chronologies are represented by the species that had the best climate signal while the MCOS chronologies are made up of the best combination of multiple species.

*4.3.1 SS Climate Reconstruction*

Following methods laid out by Cook et al. (1999, 2002), I developed all models by using a Principal Component Regression (PCR) in the program PcReg. This program uses multiple tree-ring chronologies to perform operations to calibrate a reconstruction with linear regression and validate that reconstruction against independent climate data (i.e. instrumental PDSI) not used in the calibration (Cleveland et al. 2011). The general mechanisms driving PcReg begins with a Pearson Correlation to assess the relationship between chronologies and climate data. The next step uses a stepwise multiple linear regression model (e.g. y = UB + e); after both tree-ring chronologies and climate series are autoregressed (whitened) to make the series become independent of each other (Cook et al. 1999, 2002). In this model, Cook et al. (1999, 2002) describes *y* as being the vector of the predictand data (i.e. tree-ring indices), *U* as principal components scores (PCs) from the tree-ring chronologies, *B* as the matrix of standardized regression coefficients (beta weights), and *e* as the vector of the regression model errors.

The stepwise multiple linear regression model is then developed over the calibration portion of the data, which is the common period (e.g. 1895–2000) between the predictors and predictand while the pre–1895 portion of the data is used for verification tests of the tree-ring model estimates (Cook et al. 1999, 2002). The tree-ring chronologies used as predictors are related to their PC scores as U=XF. Cook et al. (1999, 2000) describes, x as the matrix of standardized tree-ring chronologies used as predictors and F as the orthonormal matrix of column eigenvectors calculated from the correlation matrix

of X. The next step applies PCs in U, extended to the first year covered by the proxies, to produce a series of estimates y = UB. This is accomplished after the regression coefficients B have been estimated for the calibration period. The final process uses the mean and standard deviation of the predictand data to back-transform the produced standardized estimates to original units. Thus, using PCs from the tree-ring chronology correlation matrix as a proxy, the climate reconstruction is produced (Cook et al. 1999, 2002).

A split-sample technique for calibration and verification processes was used to assess the accuracy of the reconstruction for all models. The instrumental PDSI record was divided in half, consisting of an early and late portion. The late portion, as well as the early portion, was used to develop a calibration regression model for PDSI using the standardized tree-ring chronologies as the dependent variable. The reduction-of-error statistic (RE) (Fritts 1976), and the coefficient-of-efficiency statistic (CE) (Nash & Sutcliffe 1971) were completed for further verification to ensure the two calibration models were statistically significant.

*4.3.2 MCOS Climate Reconstruction*

The species that made up the MCOS models were dependent on the combination of species that provided the strongest climate signal (Table 1). To yield the most robust MCOS model at each site, a total of 36 models were computed based on the following formula:

$$\text{EQ 1. 1 } \left\{\left(\frac{n!}{(n-r_t)!(r_t!)}\right) + \left(\frac{n!}{(n-r_{t+1})!(r_{t+1}!)}\right) \ldots . .\right\}$$

where, $n$ is the number of species from which to choose (e.g. 4 species from HW; 5 species from PM), $r_t$ is the number of members in the set of species included in a

combination (e.g. r=t; r≠1; r < n) (Equation 1). This resulted in the MCOS models having different species and number of species (Table 1).

The MCOS models are developed with a combination of different species with different climate signals, and most likely have different time series length. Because of this, they cannot be combined into one chronology by averaging the tree rings; this would create the potential for the climate signals of different species to be mixed together (Fritts 1976). To account for this, a nested approach to a PCR was used, in the program PCREG, that avoids the mixing of different climate signals in climate reconstructions. The nested approach maximizes the time series by allowing the reconstruction to extend to the first year covered by any tree in the combination of species. The SS model is limited in its time coverage, because of only having one species in the model. The MCOS model maximizes the reconstruction length and improves the replication; which helps increase the predictive skill of the model (Meko 1997). In the nested approach, the shorter chronologies are dropped out beyond the common period and new reconstruction nests are created (Pederson 2013).

The MCOS model development followed the same PCR steps described in section 4.3, with the exception of developing multiple regression nests. This nested technique involves conducting correlation analyses between all predictors chosen for the PCR and PDSI. If predictors were significantly correlated ($p < 0.05$) with mean JJA PDSI during the calibration period, the predictors were reduced to principal components (PCs) using a rotated (varimax) principal component analysis (PCA, Richman 1986). The predictor variable for each nest where the PCs with eigenvalues > 1, and were retained for the multiple regression (Cook et al. 1999, 2002, Maxwell et al. 2011, Maxwell et al. 2014).

Table 1

*The number of combinations ran (using Equation 1) to determine which species make up the best MCOS chronology for Lilly Dickey, Hoot Woods, Pioneer Mothers, and Donaldson Woods. Species in the table represent the species used in each MCOS.*

| ID | Species | # of Combinations |
|---|---|---|
| LD_MCOS | *Quercus alba*<br>*Liriodendron tulipifera* | 11 |
| HW_MCOS | *Liriodendron tulipifera*<br>*Fraxinus americana* | 11 |
| PM_MCOS | *Quercus alba*<br>*Quercus rubra*<br>*Liriodendron tulipifera*<br>*Juglans nigra* | 26 |
| DW_MCOS | *Quercus alba*<br>*Quercus velutina*<br>*Liriodendron tulipifera* | 26 |

*(# of comb.) Number of combinations performed to determine the best combination

In this study, the first PCR regression model was developed for the MCOS by calibrating the common period of all chronologies. The common period differed between LD_MCOS (1908–2000), HW_MCOS (1920–2000), and PM and DW (1895–2000). A second model followed that calibrated the length of the next common period, consisting of at least one fewer chronology. This process was repeated until multiple models were created and all of the data were dissolved. This resulted in LD (2), HW (2), PM (4), and DW (4) total separate regression models (nests). Each nest reconstruction had its own set of calibration and verification statistics, where the full calibration period was split in half with early and late periods, and performed separate calibration and verification statistics to verify model skill. The final reconstruction was developed by splicing together the nested models.

## 4.4 SS and MCOS Comparison

The following statistics were calculated as a measure of the goodness of fit between the actual and estimated PDSI. These statistics were compared between the two models to determine which model (SS or MCOS) provided the most accurate results. Different metrics, such as Reduction of Error (RE), Coefficient of Efficiency (CE), Coefficient of determination ($r^2$; explained variance), Adjusted $r^2$ (adj. $r^2$), model residuals, Root Mean Square Error (RMSE), F statistic, and Akaike's Information Criterion (AIC), were used to compare the performance between the two models. All statistics were calculated in PcReg.

The first step in model development was to determine whether the model passed all RE and CE statistics (i.e. $p < 0.05$ and positive). The RE in the verification period measured the skill of the prediction. The skill of the reconstruction was in excess of instrumental PDSI when RE > 0; and the reconstruction skill was to be less than instrumental PDSI when RE < 0 (Cook et al. 2000). The CE over the verification period examined the regression equation as it was applied to new data, and represented the true $r^2$ of that equation. The same theoretical range as RE, applied to CE, but the skill determination was based on the verification mean. The CE was more rigorous and also more difficult to pass compared to the RE (Cook et al. 2000).

After the model was determined to meet the RE and CE requirements, the next primary statistic of interest in climate reconstructions was the $r^2$ (Cook 1985). This metric statically measures how close the data are to the model (i.e. regression line). This value measures the proportion of the variation in the tree-ring chronologies explained by the climate data for the linear regression model (Charfield 2004). The adj. $r^2$ represents the $r^2$

after considering the number of independent variables that are used in the model and adjusts the statistics accordingly (Charfield 2004). By comparing the $r^2$ and adj. $r^2$ of the SS and MCOS model, I can determine which model explains more variance in the data, and overall is a more robust model.

The standardized residuals were calculated to compare the strength of the difference between the observed and the predicted values (standardized residual = observed – expected / √expected) (Chartfield 2004). When examining the standardized residuals, if the residual was > 2, the observed frequency was overestimating the expected. If the residual was < -2 the observed was underestimating the expected (Chartfield 2004). The purpose of comparing the standardized residuals between the two models was to determine which model had lower residuals and less outliers; therefore, was the more accurate model.

The RMSE was calculated to determine the spread of the independent values (tree-ring chronologies) around the dependent variable (climate data). The RMSE is a measure of the distance of a data point from the fitted regression line. This determines how much error is associated with the model (Chai & Draxler 2014). When developing a model, the goal is to have as little error as possible associated with the model. This metric determines which model has less error and overall more accurate.

Additional metrics to support the best performing model are the F statistic and the AIC values. The F-value is a test statistic for multiple independent variables that tests the statistical significance of a model (Chartfield 2004). Akaike's Information Criterion (AIC) (Akaike 1974) is an index used to aid in the choosing between competing models. The AIC focuses on the strength of evidence and gives a measure of uncertainty for each

model (Akaike 1974). The AIC seeks a model that has the closest fit to the instrumental data, but with the fewest parameters. AIC is defined as AIC=2k–2ln(L), where k is the number of parameters and L is the maximized value of the likelihood function (Akaike,1974, Chartfield 2004). This metric is a goodness of fit measure that determines which model has the smallest residual error. When comparing models, the model with the lowest AIC score is determined to be the model that best represents the predictor data. If all models were considered to be poor, the AIC would select the best of the poor models (Chartfield 2004).

# CHAPTER V

# RESULTS

## 5.1 Tree-Ring Chronologies

The four study sites in Indiana make up 19 chronologies with 7 species (*Q. alba, Q. montana. Q. rubra, Q. velutina, C. ovata, L. tulipifera,* and *Juglans nigra)* (Table 2). A list of chronologies and codes (e.g. DWO = *Carya ovata* from Donaldson Woods) can be found in Table 1. For this study, 403 increment cores were analyzed (from 222 trees) across all four study sites. Tree core sample depth at each site ranged from 76 samples (from 40 trees) at HW to 102 samples (from 50 trees) at DW (Table 2). The oldest chronology, DWO, spanned the period 1676–2013 (Table 2; Figure 2 and 3). The youngest chronology, HWR, spanned the period 1892–2013 (Table 2; Figure 2 and 4). All chronologies demonstrated comparable and strong interseries correlations with minimum and maximum values of 0.52 and 0.72, respectively (Table 2). Similar growth patterns between all 19 chronologies are seen when examining the standardized chronologies in Figure 1 and in more detail in Figures 3–6.

## 5.2 Climate Response

The correlation analyses revealed all species at LD, HW, PM, and DW to have similar patterns of strong positive correlations with precipitation and PDSI during the current year growing season. The chronologies also had strong negative correlations with temperature during the current year growing season. LDO was the only chronology that did not share the same climate response as all other chronologies by presenting no significant correlations with the three climate variables throughout the 22-month analysis. PDSI demonstrated the strongest relationship between all climate variables during current

year summer (JJA) and; therefore, was used as the best predicted climate variable in the climate reconstructions (Figure 7).

The temporal strength of the individual species that had the highest correlation with PDSI during JJA was tested from each site. These were the species used in the SS models (i.e. LDT, HWF, PMA, and DWA). The moving interval correlation analysis for radial growth and average JJA PDSI revealed to be stable through each full series chronology (e.g. 1895–2000) having strong significant correlation values ($p = 0.05$) (Figure 8).

Table 2

*Chronology data for Lilly Dickey, Hoot Woods, Pioneer Mothers, and Donaldson Woods. This table includes the species at each site and their site code; the number of samples collected; each chronologies interval and *EPS date; and the series intercorrelation.*

| Site (Code) | Species | Tree (Series) | Interval | *EPS (>0.8) | Series Corr. |
|---|---|---|---|---|---|
| **Lilly Dickey** | | | | | |
| LDA | *Quercus alba* | 10 (20) | 1863–2013 | 1901–2013 | 0.72 |
| LDV | *Quercus velutina* | 9 (18) | 1863–2013 | 1896–2013 | 0.64 |
| LDM | *Quercus montana* | 10 (20) | 1867–2013 | 1902–2013 | 0.61 |
| LDO | *Carya ovata* | 9 (18) | 1876–2013 | 1901–2013 | 0.63 |
| LDT | *Liriodendron tulipifera* | 10 (19) | 1869–2013 | 1908–2013 | 0.63 |
| **Hoot Woods** | | | | | |
| HWR | *Quercus rubra* | 9 (18) | 1892–2013 | 1920–2013 | 0.61 |
| HWT | *Liriodendron tulipifera* | 9 (17) | 1790–2013 | 1878–2013 | 0.63 |
| HWO | *Carya ovata* | 11 (21) | 1798–2013 | 1870–2013 | 0.59 |
| HWF | *Fraxinus americana* | 11 (20) | 1854–2013 | 1920–2013 | 0.53 |
| **Pioneer Mothers** | | | | | |
| PMA | *Quercus alba* | 20 (30) | 1817–2011 | 1866–2011 | 0.58 |
| PMR | *Quercus rubra* | 26 (44) | 1861–2012 | 1901–2012 | 0.59 |
| PMT | *Liriodendron tulipifera* | 21 (22) | 1717–2012 | 1815–2012 | 0.60 |
| PMO | *Carya ovata* | 6 (12) | 1886–2012 | 1916–2012 | 0.58 |
| PMN | *Juglans nigra* | 11 (22) | 1781–2013 | 1806–2013 | 0.60 |

Table 2 (continued).

| Site (code) | Species | Tree (Series) | Interval | *EPS (>0.8) | Series Corr. |
|---|---|---|---|---|---|
| **Donaldson Woods** | | | | | |
| DWA | *Quercus alba* | 13 (26) | 1725–2013 | 1750–2011 | 0.62 |
| DWR | *Quercus rubra* | 7 (14) | 1827–2013 | 1852–2007 | 0.61 |
| DWV | *Quercus velutina* | 11 (22) | 1731–2012 | 1756–2008 | 0.64 |
| DWT | *Liriodendron tulipifera* | 9 (19) | 1708–2013 | 1754–2003 | 0.60 |
| DWO | *Carya ovata* | 10 (21) | 1676–2013 | 1756–2001 | 0.62 |

*EPS is the Expressed Population Signal and Series Corr. is Series Intercorrelation.

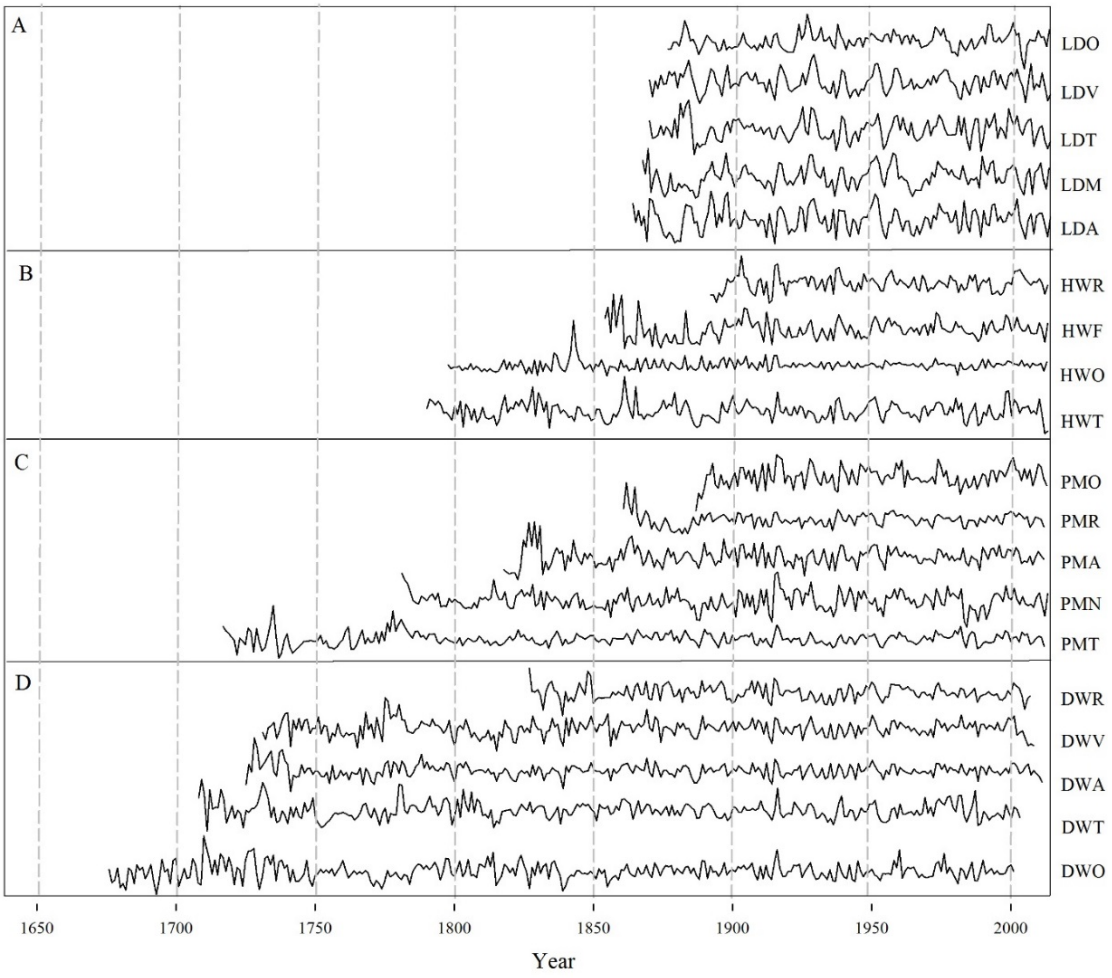


*Figure 2*. Standardized site chronologies displaying similarities between all chronologies across each site. Vertical gray dashed lines indicate 50-year intervals. A (Lilly Dickey) contains species chronologies for LDO *(Carya ovata), LDV (Quercus velutina), LDT (Liriodendron tulipifera), LDM (Quercus montana), LDA* (*Quercus alba).* B (Hoot Woods) contains species chronologies for *HWF (Fraxinus americana), HWO (Carya*

*ovata), HWT (Liriodendron tulipifera).* C (Pioneer Mothers) contains species chronologies for PMO *(Carya ovata), PMR (Quercus velutina), PMN (Juglans nigra), PMA* (*Quercus alba), PMT (Liriodendron tulipifera).* D (Donaldson Woods) contains species chronologies for DWR (*Quercus rubra*), DWV *(Quercus velutina),* DWA (*Quercus alba),* DWT *(Liriodendron tulipifera)* DWO *(Carya ovata).*

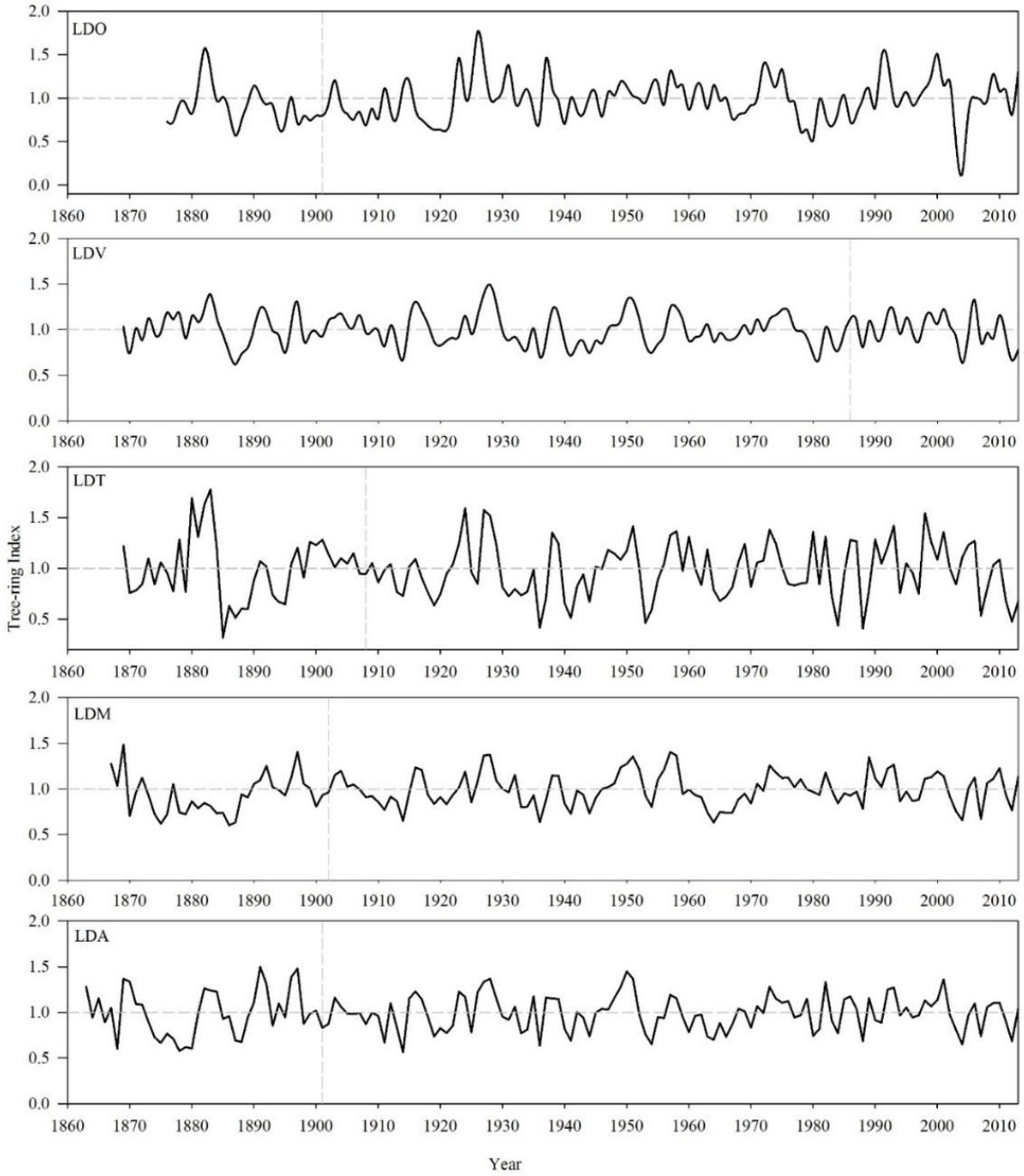


*Figure 3*. An in-depth graph of the standardized ARSTAN chronologies from Lilly Dickey for LDO *(Carya ovata), LDV (Quercus velutina), LDT (Liriodendron tulipifera), LDM (Quercus montana), LDA* (*Quercus alba).* The horizontal gray line represents average tree ring growth. The vertical gray line represents the Expressed Population signal (EPS).

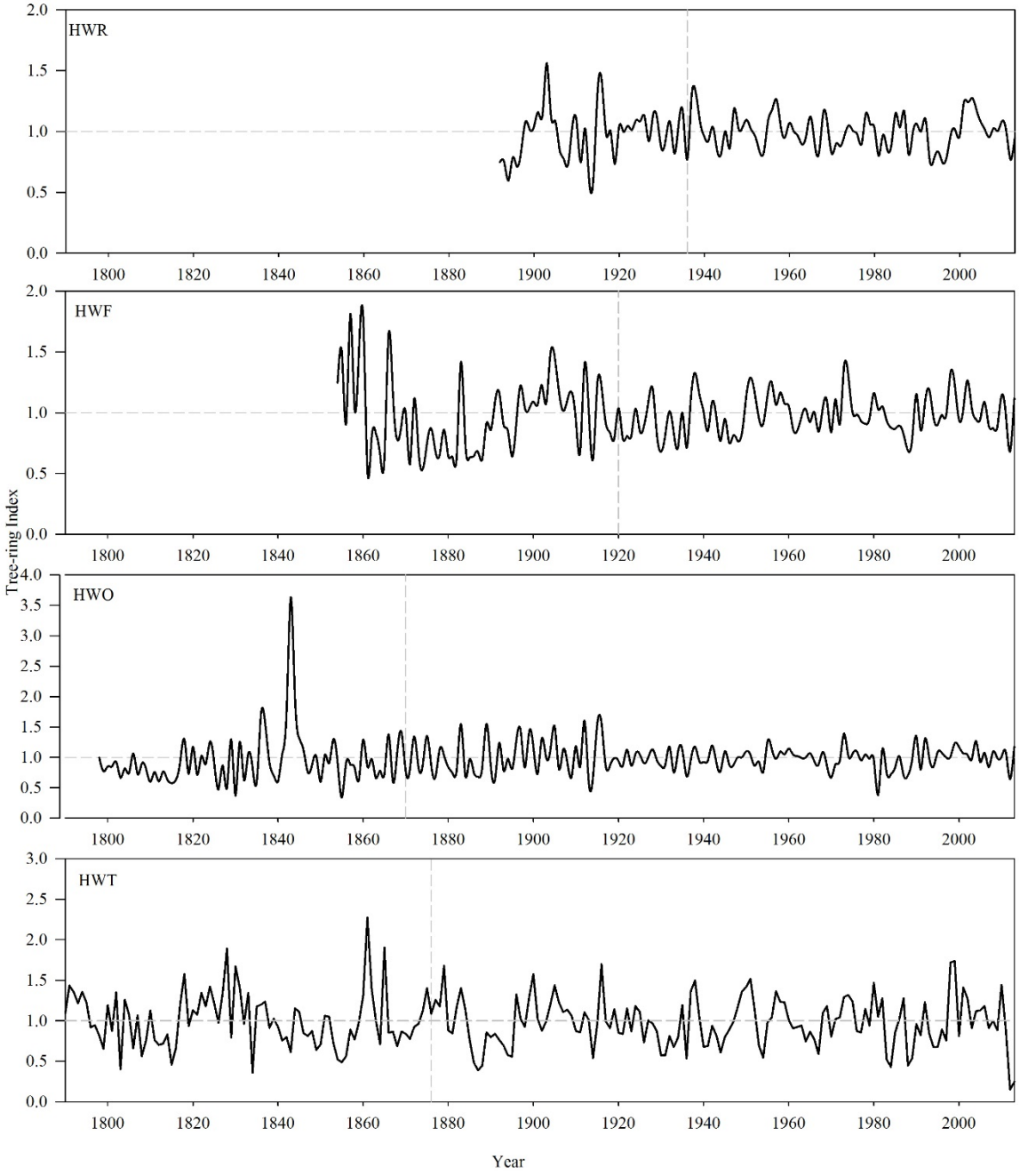


*Figure 4*. An in-depth graph of the standardized ARSTAN chronologies from Hoot Woods for HWR (*Quercus rubra), HWF (Fraxinus americana), HWO (Carya ovata), HWT (Liriodendron tulipifera).* The horizontal gray line represents the average tree ring growth. The vertical gray line represents the Expressed Population signal (EPS). Note the y axes differ.

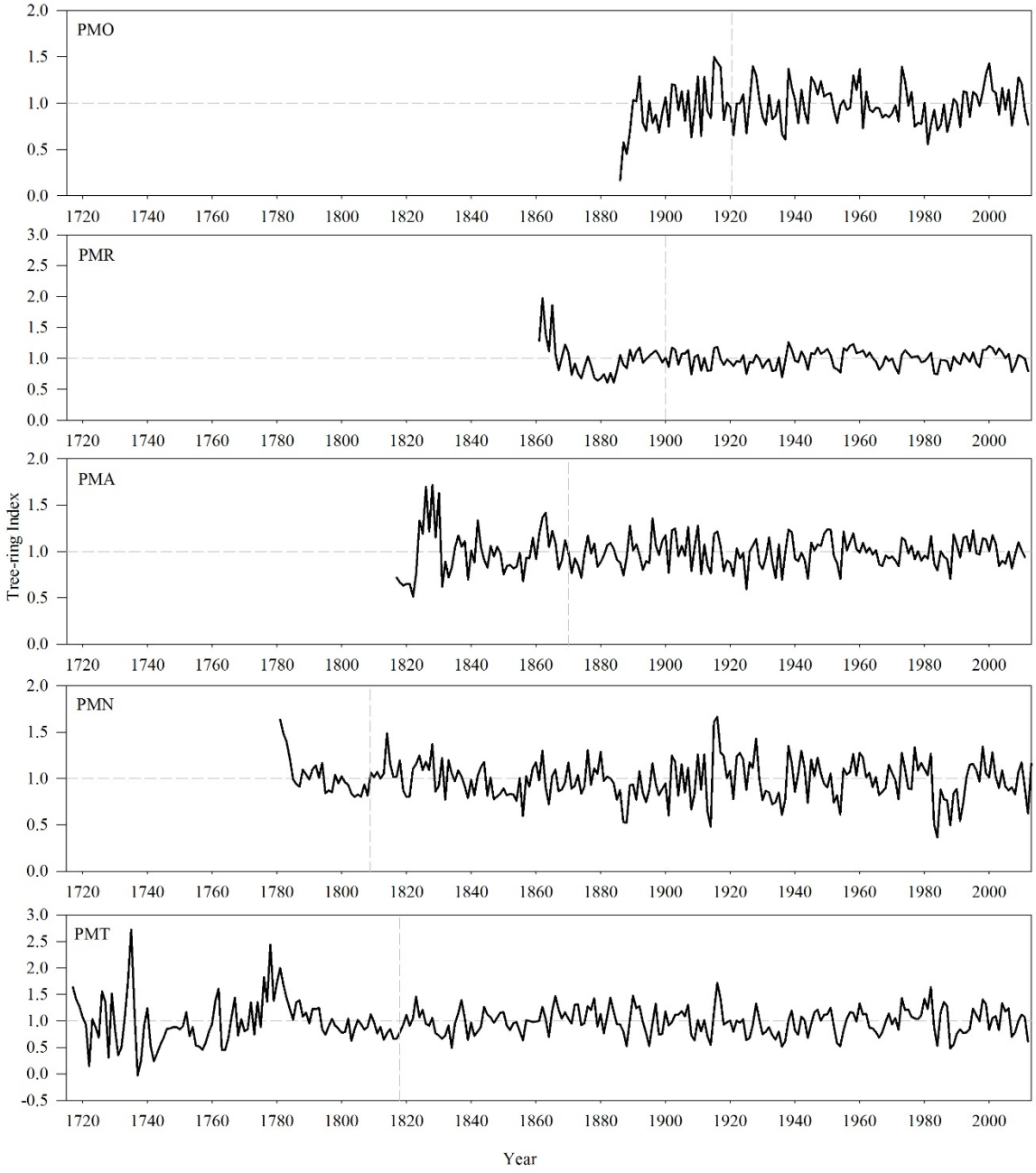


*Figure 5.* An in-depth graph of the standardized ARSTAN chronologies from Pioneer Mothers for PMO *(Carya ovata), PMR (Quercus velutina), PMN (Juglans nigra), PMA* (*Quercus alba), PMT (Liriodendron tulipifera).* The horizontal gray line represents the average tree ring growth. The vertical gray line represents the Expressed Population signal (EPS).

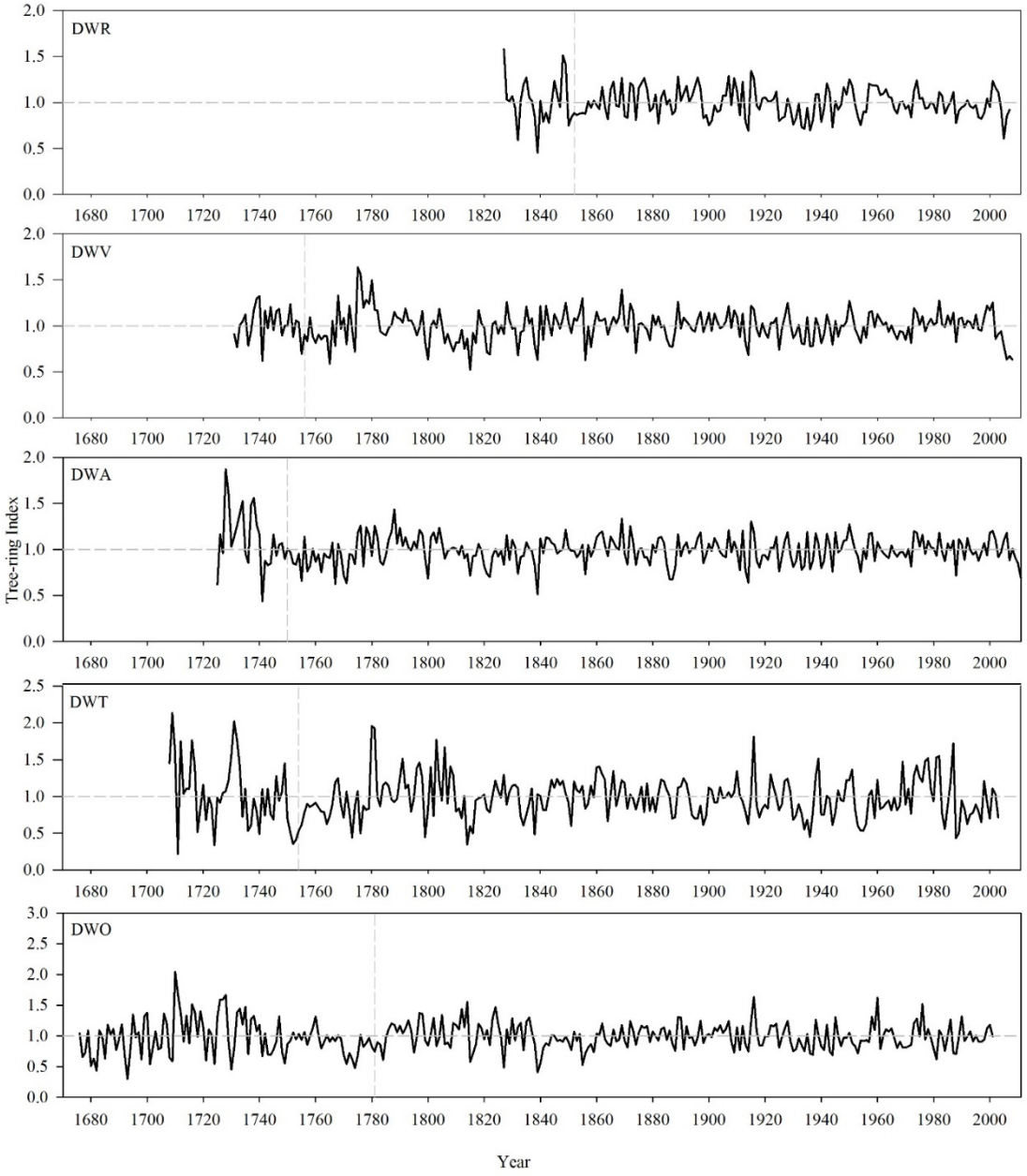


*Figure 6.* An in-depth graph of the standardized ARSTAN chronologies from Donaldson Woods for DWR (*Quercus rubra*), DWV *(Quercus velutina),* DWA (*Quercus alba),* DWT *(Liriodendron tulipifera)* DWO *(Carya ovata).* The horizontal gray line represents the average tree ring growth. The vertical gray line represents the Expressed Population signal (EPS). Note the y axes differ.

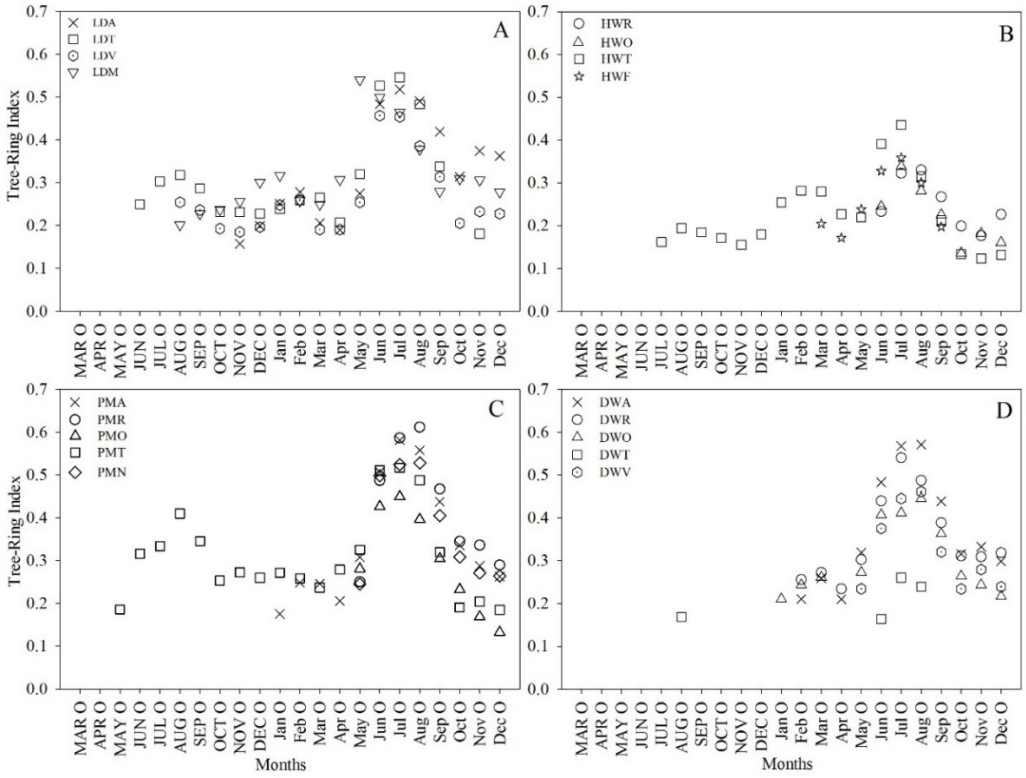


*Figure 7.* Correlation analyses for tree-ring data, A (Lilly Dickey); B (Hoot Woods); C (Pioneer Mothers); D (Donaldson Woods), with monthly PDSI from March of the previous growing season (represented by all capital letters (e.g. MAR)) to December of the current growing season (represented by lower case letters (e.g. Dec)). Only significant correlation values $p < 0.05$ are represented for each individual species for each site.

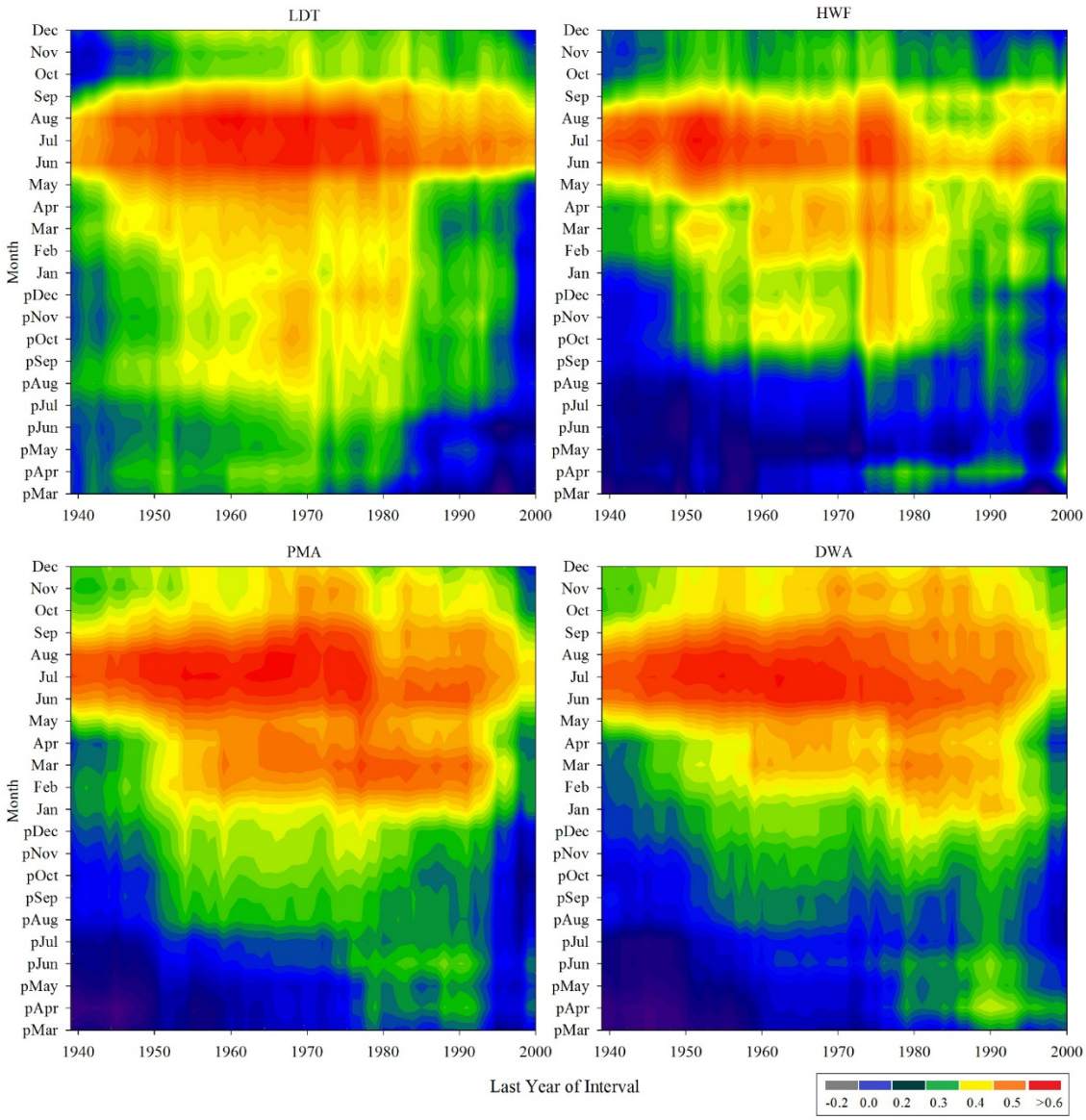


*Figure 8.* Moving interval correlation analysis for radial growth and average June, July and August (JJA) PDSI. This figure only displays the individual species from each site that had the highest correlation with JJA PDSI. LDT (*Liriodendron tulipifera)*, HWF *(Fraxinus americana)*, PMA *(Quercus alba)*, and DWA (*Quercus alba)*. The interval of examination is from the of period of 1895–2000, using a window of 48 years (x-axis), during March of the previous growing season to December of the current growing season (y axis). All shaded values (red–blue) represent correlation coefficients that are statistically significant (p=0.05).

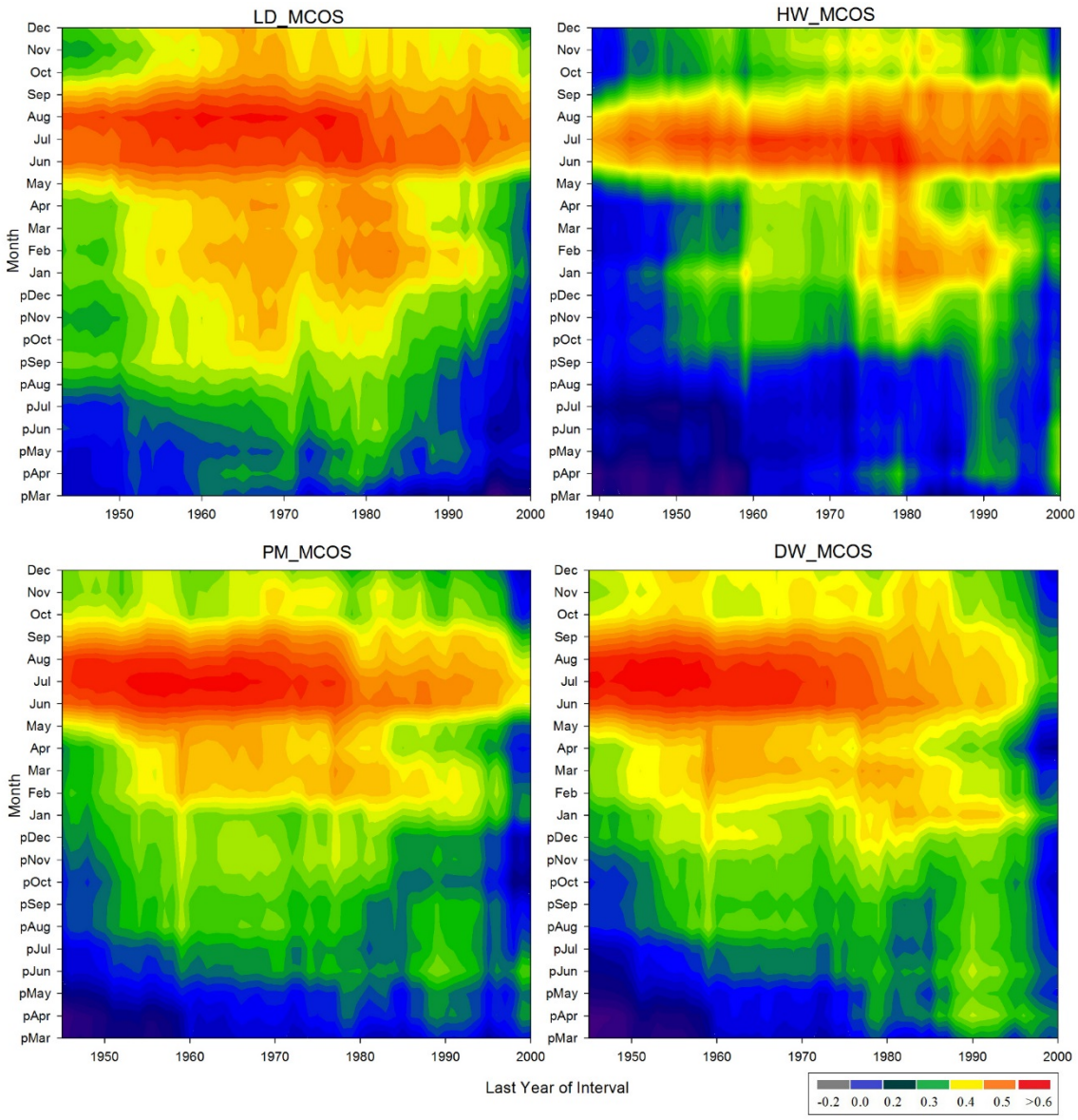


*Figure 9.* Moving interval correlation analysis for radial growth and average June, July, and August (JJA) PDSI for the MCOS chronologies from Lilly Dickey, Hoot Woods, Pioneer Mothers, and Donaldson Woods. The interval of examination is from the of period of 1895–2000, using a window of 48 years (x-axis), during March of the previous growing season to December of the current growing season (y-axis). All shaded values (red-blue) represent correlation coefficients that are statistically significant ($p = 0.05$).

## 5.3 Species Importance

The climate response and temporal stability of *L. tulipifera* from all sites contained a previous growing season moisture signal, not retained by any other species. This moisture signal indicates the importance of the previous year values on radial growth (Figure 7 and 8); which is apparent when examining the beta weights for the common period for all MCOS models (Table 3). The beta weights revealed that the most important species were *Q. alba* and *L. tulipifera* based off their abundance and relative variance explained. All species retained predictors from years *t* in the modeling, however *L. tulipifera* retained predictors from years *t* + 1 in all four sites. *Q. alba* also retained years *t* + 1 at LD.

Table 3

*The beta weights (species importance) for the species with the highest correlation with JJA PDSI used in Single Species (SS) models and the Multiple Co-Occurring Species MCOS models for Lilly Dickey, Hoot Woods, Pioneer Mothers, and Donaldson Woods.*

| ID | Species | Beta Weights |
|---|---|---|
| LD _SS | *Liriodendron tulipifera* | 0.80 |
| HW_SS | *Fraxinus americana* | 0.00 |
| PM _SS | *Quercus alba* | 0.00 |
| DW_SS | *Quercus alba* | 0.00 |
| LD_MCOS | *Quercus alba* | 0.37 |
| | *Liriodendron tulipifera* | 0.46 |
| HW_MCOS | *Liriodendron tulipifera* | 0.48 |
| | *Fraxinus americana* | 0.29 |
| PM_MCOS | *Quercus alba* | 0.18 |
| | *Quercus rubra* | 0.19 |
| | *Liriodendron tulipifera* | 0.32 |
| | *Juglans nigra* | 0.19 |
| DW_MCOS | *Quercus alba* | 0.26 |
| | *Quercus velutina* | 0.26 |
| | *Liriodendron tulipifera* | 0.25 |

The importance of the climate signal that *L. tulipifera* captures is also evident in the combination of species in the MCOS models. *L. tulipifera* was retained in each MCOS model (Table 1), and decreased the explained variance anytime it was taken out of the model. *L. tulipifera* proved to be the most important species out of all species used in the SS models, as a result of the previous year moisture signal it retains (Table 3).

## 5.4 Climate Reconstruction

Each PDSI model was constructed back to the respective date where sample depth was large enough to accurately represent the variance, as determined by the Expressed Population Signal (EPS) (Table 2) (Figures 3–6). The oldest reconstructions dated to 1750 with DW_MCOS, beyond 1750 the EPS drops below 0.80. The SS models were limited on the reconstruction date by having only one chronology (e.g. EPS date for LDT was 1908). Given that remnant wood was only collected from DW and DW chronologies end at ca. 2000, all other site chronologies were truncated to 2000 to be consistent in the interpretation of drought reconstructions relative to this region.

### *4.5.1 SS and MCOS Model Comparison*

36 model combinations were tested; however, only the calibration (RE) and verification (CE) statistics for the best MCOS combination, SS model, and All species in the site (Table 4) are reported. For each PDSI reconstruction, the calibration (RE) or verification (CE) remained significant ($p < 0.05$) and positive for their entire period. The nests used to develop the MCOS chronology reconstructions of PDSI (LD 1; HW 1; PM 3; DW 3) passed verification statistics; however, we focused on the common period of all models for this study.

During LD's common period (1908–2000), the explained variance in average JJA instrumental PDSI accounts for 47% for LD_SS and 50% for LD_MCOS. HW_SS explained 33% and HW_MCOS explained 36% of the variance during the common period (1920–2000). PM and DW had the same common period (1895–2000), where PM_SS explained 40%, PM_MCOS 50%, DW_SS 45%, and DW_MCOS 49% of the variance in average JJA instrumental PDSI (Table 5). The adj. $r^2$ values from each site during their common period range between 0.32–0.45 for SS models and between 0.35–0.49 for MCOS models. DW_SS had the largest adj. $r^2$ value of 0.32. HW_SS had the lowest adj. $r^2$ value 0.44. PM_MCOS had the largest adj. $r^2$ value of 0.49; while HW_MCOS had the lowest value 0.35 (Table 5 ).

The regression model residuals were examined between the SS and MCOS at each site to determine the model that best represented instrumental PDSI (Table 5 and Figure 12). Based on PDSI instrumental data, 1979 was the wettest year on record. The SS and MCOS models from PM and DW overestimated this pluvial event. PM_MCOS and DW_MCOS provided lower standardized residuals than PM_SS and DW_SS. HW and LD models did not overestimate the pluvial as much as PM and DW, but HW_MCOS and LD_SS had the lower standardized residuals (Figure 12). The driest month from instrumental data was 1954 and, from each site, the MCOS had lower standardized residuals than the SS models (Figure 12). When comparing year-to-year, the SS and MCOS reconstructions of average JJA PDSI transition between best representing instrumental PDSI. In general, MCOS PDSI reconstruction appeared to have lower standardized residuals and more accurately predicted extreme values.

Table 4

*Calibration and verification statistics for spilt sample June, July, and August PDSI reconstructions for Single Species (SS) and Multiple Co-Occurring Species (MCOS), and All species. Each species that was collected from a site was used for the "All" models.*

| **ID** | ***Person *r*** | | | | ***RE** | | | | ***CE** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1908–1955 | | 1956–2000 | | 1908–1955 | | 1956–2000 | | 1908–1955 | | 1956–2000 | |
| **LD** | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal |
| All | 0.64 | 0.75 | 0.72 | 0.65 | 0.40 | 0.50 | 0.49 | 0.42 | 0.20 | 0.50 | 0.36 | 0.42 |
| SS | 0.64 | 0.70 | 0.70 | 0.65 | 0.46 | 0.49 | 0.51 | 0.42 | 0.31 | 0.50 | 0.41 | 0.42 |
| MCOS | 0.67 | 0.72 | 0.73 | 0.68 | 0.48 | 0.52 | 0.53 | 0.46 | 0.34 | 0.52 | 0.44 | 0.46 |
| | 1920–1962 | | 1963–2000 | | 1920–1962 | | 1963–2000 | | 1920–1948 | | 1963–2000 | |
| **HW** | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal |
| All | 0.55 | 0.61 | 0.53 | 0.56 | 0.10 | 0.38 | 0.27 | 0.31 | 0.01 | 0.38 | 0.21 | 0.31 |
| SS | 0.58 | 0.56 | 0.56 | 0.58 | 0.37 | 0.32 | 0.32 | 0.34 | 0.27 | 0.32 | 0.27 | 0.34 |
| MCOS | 0.56 | 0.67 | 0.66 | 0.57 | 0.20 | 0.45 | 0.31 | 0.32 | 0.04 | 0.45 | 0.36 | 0.32 |
| | 1895–1948 | | 1948–2000 | | 1895–1948 | | 1948–2000 | | 1895–1948 | | 1948–2000 | |
| **PM** | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal |
| All | 0.57 | 0.64 | 0.64 | 0.57 | 0.31 | 0.44 | 0.39 | 0.33 | 0.05 | 0.43 | 0.11 | 0.29 |
| SS | 0.59 | 0.68 | 0.68 | 0.59 | 0.33 | 0.46 | 0.42 | 0.35 | 0.11 | 0.46 | 0.25 | 0.35 |
| MCOS | 0.63 | 0.77 | 0.78 | 0.63 | 0.35 | 0.59 | 0.53 | 0.40 | 0.25 | 0.60 | 0.49 | 0.40 |
| | 1895–1948 | | 1948–2000 | | 1895–1948 | | 1948–2000 | | 1895–1948 | | 1948–2000 | |
| **DW** | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal | Ver | Cal |
| All | 0.54 | 0.77 | 0.73 | 0.55 | 0.34 | 0.59 | 0.52 | 0.30 | 0.13 | 0.59 | 0.39 | 0.30 |
| SS | 0.59 | 0.73 | 0.72 | 0.61 | 0.36 | 0.53 | 0.49 | 0.37 | 0.16 | 0.53 | 0.34 | 0.37 |
| MCOS | 0.61 | 0.77 | 0.77 | 0.61 | 0.38 | 0.59 | 0.43 | 0.37 | 0.19 | 0.59 | 0.56 | 0.37 |

*Note: Pearson *r* (Correlation Coefficient) RE (Reduction of Error) CE (Coefficient of Error).

Table 5

*Single Species (SS) and Multiple Co-Occurring Species (MCOS) model statistics for Lilly Dickey, Hoot Woods, Pioneer Mothers, and Donaldson Woods.*

| ID | $r^2$ | Adj $r^2$ | F Level | AIC | *p* value | RE | RMSE[a] |
|---|---|---|---|---|---|---|---|
| LD_SS | 0.47 | 0.45 | 40.42 | -53.49 | 0.00 | 0.45 | 0.18 |
| LD_MCOS | 0.50 | 0.48 | 46.33 | -59.74 | 0.00 | 0.48 | 0.11 |
| HW_SS | 0.33 | 0.32 | 39.24 | -28.58 | 0.00 | 0.32 | 0.19 |
| HW_MCOS | 0.36 | 0.35 | 44.04 | -31.73 | 0.00 | 0.34 | 0.00 |
| PM_SS | 0.40 | 0.39 | 68.76 | -49.68 | 0.00 | 0.39 | 0.03 |
| PM_MCOS | 0.50 | 0.49 | 98.86 | -65.63 | 0.00 | 0.49 | 0.02 |
| DW_SS | 0.45 | 0.44 | 84.55 | -58.95 | 0.00 | 0.44 | 0.21 |
| DW_MCOS | 0.49 | 0.47 | 98.81 | -66.68 | 0.00 | 0.48 | 0.07 |

Note: [a] RMSE, Root-Mean-Square Error.

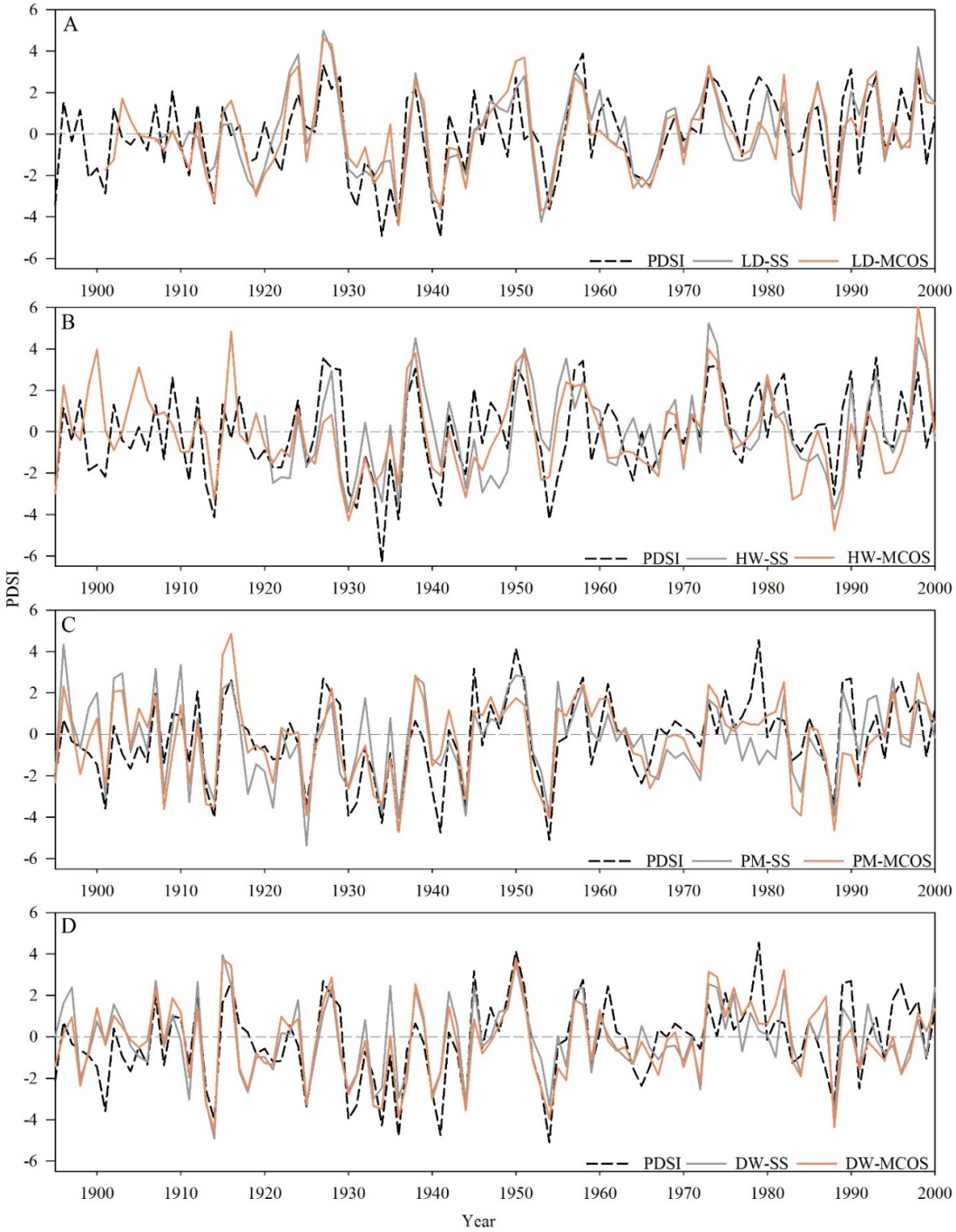


*Figure 10.* Instrumental average JJA PDSI (black dotted line) verses estimated Single Species (SS) (solid gray line) and Multiple Co-Occurring Species (MCOS) (solid orange line) during the common period of 1895–2000 for A (Lilly Dickey); B (Hoot Woods); C (Pioneer Mothers); D (Donaldson Woods). Each MCOS model estimation explains more of the actual PDSI variance than each SS model during the common period (1895–2000).

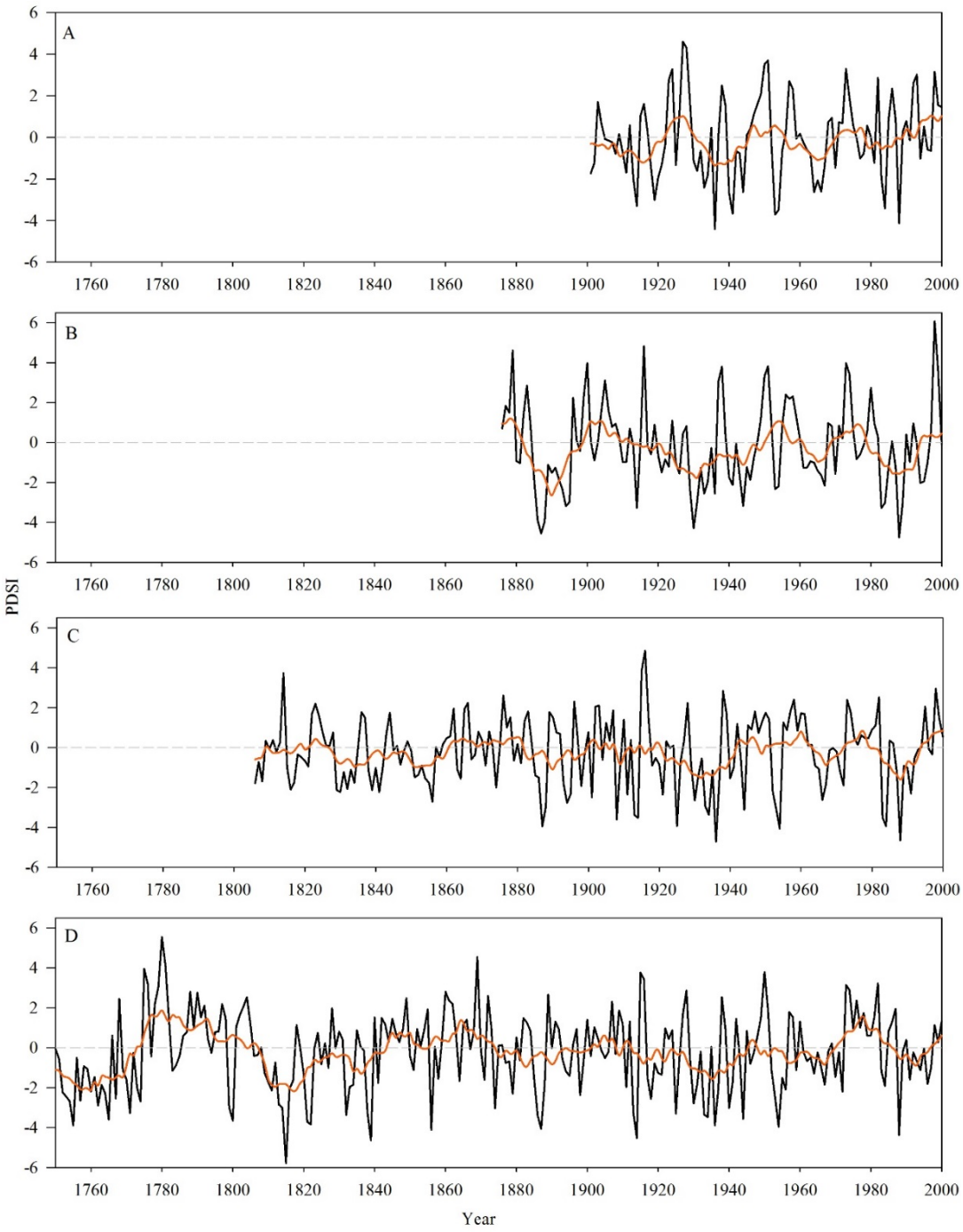


*Figure 11*. Full JJA PDSI reconstructions with a 11 year smoothing spline (orange line) from A (Lilly Dickey) 1901–2000; B (Hoot Woods) 1878–2000; C (Pioneer Mothers) ca. 1806–2000; and D (Donaldson Woods) 1750–2000.

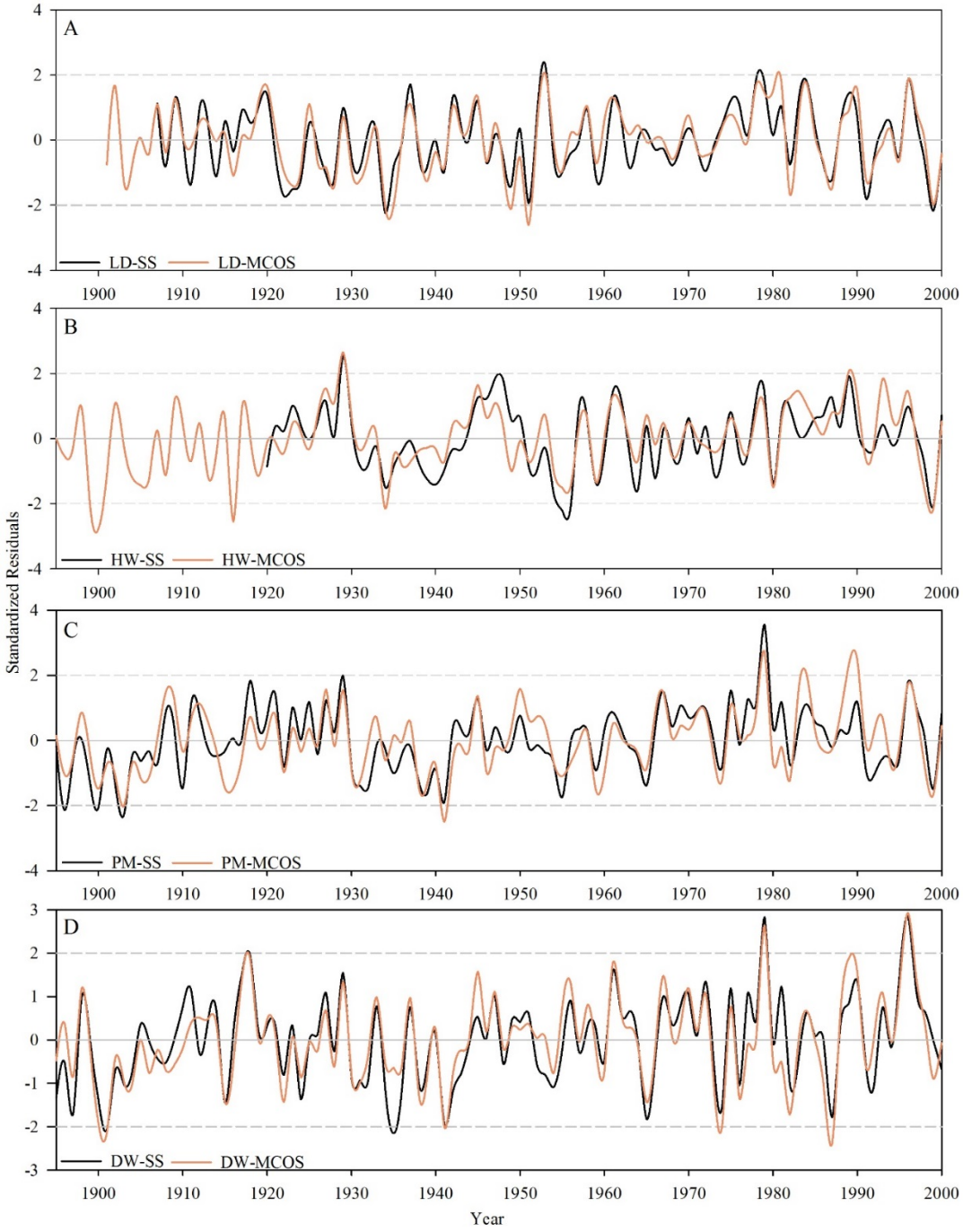


*Figure 12.* Standardized residuals of the Single Species model (SS) (black line) and Multiple Co-Occurring Species model (orange line) for Lilly Dickey, Hoot Woods, Pioneers Mother, and Donaldson Woods. The gray solid line represents how close the estimated model values (SS and MCOS) are to actual instrumental PDSI and the gray dotted lines represent two standard deviations from instrumental PDSI.

# CHAPTER VI

# DISCUSSION

## 6.1 Tree-ring Chronologies

The species that make up the 19 chronologies (*Q. alba, Q. montana. Q. rubra, Q. velutina, C. ovata, L. tulipifera, and J.* nigra) from the four study sites shared similar growth patterns (Figure 2), which are particularly noticeable with a decline in radial growth around 1895, 1955, and 1915 and an increase in radial growth around 1923 (Figure 2). These chronologies also shared a similar climate signal, with the exception of *C. ovata,* within each site and between sites (Figure 7). PDSI during JJA of the current year appeared to have the greatest effect on these species in this region. The temporal strength of this moisture signal was significant throughout the entire time series of all chronologies and was present until 2000, where we truncated chronologies (Figure 8 and 9). *C. ovata*, the only species that did not share the similar climate signals seen in all other species, is a new species for drought reconstructions; however, it has shown to have a weak climate signal with temperature, precipitation, and PDSI (Pederson et al. 2013). For this study, *C. ovata* was not retained in the models at LD, was the weakest species at other and did not load into any of the best MCOS models (Table 1).

Based on the abundance and explained variance of the species used in MCOS chronologies, *Q. alba and L. tulipifera* were the most important species in this study. In the eastern U.S., *Q. alba* has been widely used in climate reconstructions (Cook & Peters 1997, Cook et al. 1999, Rubion & McCarthy 2000, Cook et al. 2001, Pederson et al. 2004, Cook et al 2007, LeBlanc and Terrell 2009, Copenhearer et al. 2011, Maxwell 2011, Pederson et al. 2012a, Pederson et al. 2013, Maxwell 2014) because of their longevity and

strong climate response. The robust climate response of *Q. alba* continued to be true in this study by being a dominant contributor to the MCOS chronologies for the sites in which it occurred (LD, PM, and DW) and being the SS chronology for PM and DW. *L. tulipifera,* the second most important species, has only recently been recognized as a beneficial species for drought reconstructions (Pederson et al. 2013), which is made evident in the MCOS models.

Because of the presence of *L. tulipifera* at each site and the strong climate signal that it contained, it loaded into all MCOS models. When testing for the best combination of species to include in the MCOS models, the explained variance decreased substantially when *L. tulipifera* was taken out of the assortment. Unlike other species, *L. tulipifera* had a unique moisture signal from the previous year that was derived from its general location in the Eastern Deciduous Forest in the northeast region of the U.S. *L. tulipifera* is commonly found in mesic sites, which explained the lag ($t + 1$) moisture signal captured in the climate analyses.

The topography varied from site to site. At PM there was a visible transition between *Quercus* species that are found on upland xeric locations and *L. tulipifera* in cove mesic locations. At DW, the transition between xeric and mesic sites were less pronounced, but *L. tulipifera* was still generally found in cove-like, mesic locations. The topography at LD and HW exhibited little change in elevation and transitions between xeric and mesic species were not apparent. Having both xeric and mesic species in drought reconstructions appeared to be beneficial because of the way in which species respond differently to moisture.

## 6.2 SS versus MCOS PDSI Models

I compared the SS and MCOS models to determine the model that provided the most accurate results. I found that the MCOS models outperformed the SS models at each site by having higher $r^2$ and adj. $r^2$ values (Table 5 and Figure 10). While the difference between the $r^2$ and adj. $r^2$ values might be minimal; the goal when developing a climate reconstruction is to create a model that explains as much of the variance as possible. Based off the explained variance of these models, the MCOS model does accomplish this goal by having the greatest explained variance at each site.

I calculated the standardized residuals to provide insight into how close the models are to true instrumental data. The standardized residuals indicated that the MCOS models were closer to the true instrumental data by calculating lower residuals. The standardized residuals also measure where the models overestimated drought and pluvial events. By doing this they revealed that the MCOS models captured the more extreme values of drought and pluvial events compared to the SS models (Figure 12).

I have shown that the MCOS model explains more variance and the predicted data is a closer fit to the true data with the $r^2$, adj. $r^2$, and standardized residuals. The skill of the models were tested by the RMSE. The RMSE calculated the error between the observed and predicted PDSI. This metric revealed that all MCOS models had lower RMSE than SS models (Table 5), therefore indicating a more skillful model.

The F statistic and AIC helped provide additional evidence on the performance of the MCOS model compared to the SS model. Both of these metrics proved to be in favor of the MCOS model. When the AIC was used to determine the best model, it revealed that the MCOS models outperform the SS models by having lower AIC values. The AIC

determined that the MCOS model provided a stronger model (e.g. higher variance explained with less predictors, hence less penalties) that has a closer fit to the instrumental JJA PDSI.

### 6.3 The MCOS model

One important aspect to consider about the MCOS method is that it does not produce an all-encompassing model. Every tree in a site cannot be sampled and expected to deliver a highly predicted model. To develop a MCOS model that outperforms a SS model, this study suggests the sampling of all moisture sensitive species and then determining the best combination of species per site. Certain species can be relied on (i.e. *Q. alba and L. tulipifera*) to provide strong moisture signals; however, the overall improvement of the drought signal at a site will require a collection of mixed species to determine the best combination. This study revealed that the combination of species can be similar across sites, but there could be site-specific differences that ultimately result in making it necessary to determine the best combination of species per site. For example, I found that *Q. alba* and *L. tulipifera* always improved site models, but *Q. rubra* and *Q. velutina* only supported the MCOS at one site (Table 1). Therefore, including a species in a model at one may not necessarily improve the performance of the model at other sites. I noticed a pattern in the chronologies that were retained in young forests compared to old forests. LD and HW are younger forests which experienced some degree of logging. PM and DW are older forests that have no evidence of human disturbances. PM and DW retained more species for modeling and had greater signal strengths. LD and HW only included two species in the MCOS model; however, HW did not have *Q. alba* which probably would have been retained in HW_MCOS if it were found in HW.

Another aspect to consider when developing a MCOS model for drought reconstructions is the goal of the study. If the goal is to build the most skillful model in the Eastern U.S., MCOS should be performed. However, if the goal is to produce the longest term of drought and in the event that your longest chronology is not retained, the goal of the study should be considered. The amount of variance explained must be considered when leaving in your longest chronology compared to removing it and a decision must be made whether or not the study benefits from either leaving in the longest chronology and boosting explained variance, or not.

### 6.4 Southern Indiana drought history

I have presented that the MCOS model overall improves drought reconstructions and provides more accurate climate signals from a single forest. Similarities between the four MCOS reconstructions (Figure 11) reveal synchronizing drought and pluvial events between study sites. During the instrumental period (ca. 1895–current), there is a common transition from a dry period in the late 1980s to a wet period in the late 1990s. The late 1950s drought and the 1918 pluvial event are also synchronized across all forests. These pluvial and drought events can be identified in the instrumental data, but not for the pre-observation period (before 1895).

For the pre-observation period, HW, PM and DW provide us with the severity and persistence of past climatic events that instrumental data does not provide. The late 1880s appears to be one of the worst droughts that HW and PM experienced. DW also experienced this drought, but being the oldest site we reconstructed back to 1750. By reconstructing farther back, two prolonged and severe droughts were revealed during the 1810s and 1840s. The 1810s drought is the most severe drought that any site has

experienced. If other sites were older, it would allow us to get a better picture of the regional drought that occurred in Indiana during the 1810s. The most severe and prolonged climate events during the reconstruction period occurred during a period of 100 years. The 100 years of fluctuating climate started with a drought in the 1750s, to a pluvial event in the 1770s, back to a period of drought until the 1850s.

Tree rings are ideal for drought reconstructions because of their ability to provide sub annual records (e.g. season JJA). Other proxies (i.e. stalagmites, ice cores, and sediment cores) are limited on the time frame their record can provide. For example, studies using stalagmites to study global climate variations (Jeffrey et al 1998, Dominik et al. 2003, Fuller et al. (2008) have used isotopes to provide estimated resolutions to determine climate variations (e.g. between 75 to 25 thousand years ago). While studies like these also estimate dry and wet periods, tree rings, unlike any other proxy, can be directly correlated with instrumental PDSI and explain a majority of the variance. Therefore, tree-ring based drought reconstructions are more dependable because of the precise dating and sub annual records they provide compared to other proxies that could be used, which would provide a range of estimated dates and which could not be directly correlated with PDSI.

## 6.5 Conclusion

This study tested a new method (MCOS model) for reconstructing drought in the eastern United States using multiple species from the same location. The main focus of this study was to determine if a MCOS model produces a reconstruction model that is more accurate at reconstructing climate compared to a SS model across multiple sites ($n$ = 4) in Indiana. This study was accomplished by [1] determining PDSI during JJA to be the

best predicted climate variable at each site; [2] developing two drought reconstruction models (SS vs. MCOS) at each site; and [3] comparing different metrics such as $r^2$, adj. $r^2$, model residuals, RMSE, F statistic, and AIC between the two models.

In this study, I was able to suggest that a MCOS model produces a stronger climate response by incorporating climate signals from multiple species that respond differently to climate variables (e.g. lag response of *L. tulipifera*). The MCOS model includes the entire time series of each chronology in the model (via nested approach), allowing for the reconstruction to date as far back as the chronologies will allow. The SS models were limited to how far back they were able to reconstruct with one chronology; hence, the MCOS method produced longer reconstructions backward in time. The MCOS model explains more variance compared to a SS model, and has better standardized residuals, RMSE, F statistic and AIC. Overall, I have demonstrated that a MCOS model is a more accurate model compared to a SS model for drought reconstructions in the eastern United States.

The recent movement towards using multiple species networks in stream flow and drought reconstructions in the Eastern Deciduous Forests is demonstrating the benefits that multiple species bring to the overall improvement of reconstructions (e.g. Maxwell et al. 2011, Pederson et al. 2012a, 2012b, Maxwell et al. 2014). Specifically, this study provided additional evidence on how using the MCOS model creates reconstructions that are more accurate and produce models that explain more variance during the instrumental period, yielding more accurate estimates of drought further backwards in time. Now that this study is complete, this knowledge can contribute to future research focused on drought reconstruction in the Eastern U.S. and in updating chronologies using this method.

By updating more chronologies in the Eastern U.S., the accuracy of the reconstructions could be improved and help in future knowledge of climate conditions across the region.

# APPENDIX A

# COFECHA PROGRAM OUTPUT FOR LILLY DICKEY SITE CHRONOLOGY,

# CARYA OVATA, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                    Version 6.06P    29369                -
-------------------------------------------------------------------------------------------------------------------------------------------------------
File of DATED series:   ldo_dated.txt

Time span of Master dating series is 1876 to 2013   138 years
Continuous time span is              1876 to 2013   138 years
Portion with two or more series is   1876 to 2013   138 years


                                    ***************************************
                                    *C* Number of dated series        18 *C*
                                    *O* Master series 1876 2013  138 yrs *O*
                                    *F* Total rings in all series   2150 *F*
                                    *E* Total dated rings checked   2150 *E*
                                    *C* Series intercorrelation     .625 *C*
                                    *H* Average mean sensitivity    .306 *H*
                                    *A* Segments, possible problems    3 *A*
                                    *** Mean length of series      119.4 ***
                                    ***************************************
ABSENT RINGS listed by SERIES:            (See Master Dating Series for absent rings listed by year)

LDO02B      2 absent rings:   1978 1980

2 absent rings    .093%
```



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PART 2:  TIME PLOT OF TREE-RING SERIES:                                                                                    Page   2
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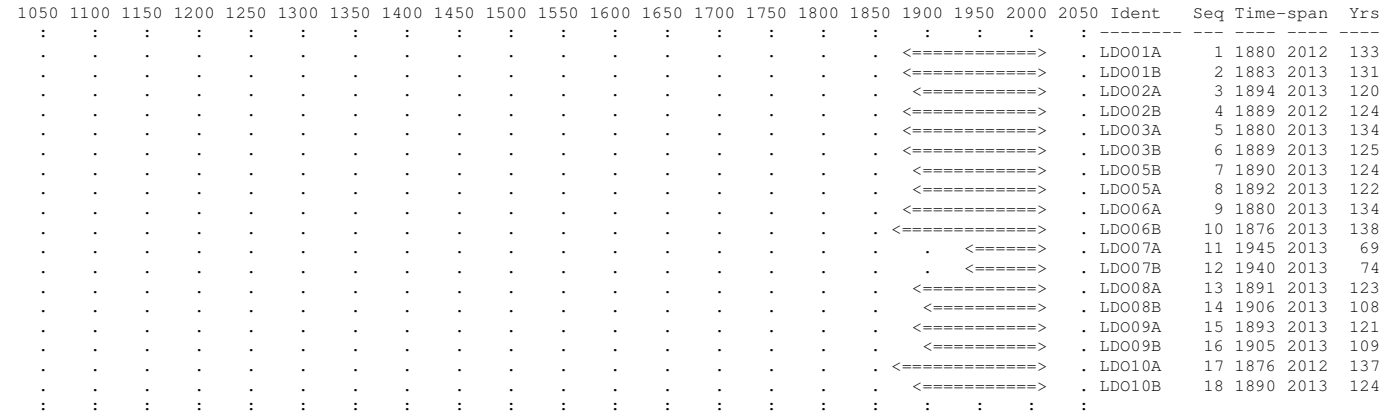



PART 3: Master Dating Series: Page 3

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | -.373 | 14 | 1950 | .678 | 18 | 2000 | 1.587 | 18 | | | | | | |
| | | | 1901 | .248 | 14 | 1951 | .100 | 18 | 2001 | .709 | 18 | | | | | | |
| | | | 1902 | .682 | 14 | 1952 | -.119 | 18 | 2002 | .658 | 18 | | | | | | |
| | | | 1903 | 1.617 | 14 | 1953 | -.833 | 18 | 2003 | -2.165 | 18 | | | | | | |
| | | | 1904 | .653 | 14 | 1954 | .784 | 18 | 2004 | -5.397 | 18 | | | | | | |
| | | | 1905 | .420 | 15 | 1955 | .892 | 18 | 2005 | -.383 | 18 | | | | | | |
| | | | 1906 | .111 | 16 | 1956 | -.845 | 18 | 2006 | .232 | 18 | | | | | | |
| | | | 1907 | .140 | 16 | 1957 | 1.406 | 18 | 2007 | -.018 | 18 | | | | | | |
| | | | 1908 | -.745 | 16 | 1958 | .565 | 18 | 2008 | -.035 | 18 | | | | | | |
| | | | 1909 | -.001 | 16 | 1959 | .756 | 18 | 2009 | 1.135 | 18 | | | | | | |
| | | | 1910 | -.741 | 16 | 1960 | -1.534 | 18 | 2010 | .515 | 18 | | | | | | |
| | | | 1911 | .780 | 16 | 1961 | .414 | 18 | 2011 | .516 | 18 | | | | | | |
| | | | 1912 | -.234 | 16 | 1962 | .748 | 18 | 2012 | -.843 | 18 | | | | | | |
| | | | 1913 | -.744 | 16 | 1963 | -.852 | 18 | 2013 | 1.090 | 15 | | | | | | |
| | | | 1914 | .873 | 16 | 1964 | .767 | 18 | | | | | | | | | |
| | | | 1915 | 1.038 | 16 | 1965 | .048 | 18 | | | | | | | | | |
| | | | 1916 | -.158 | 16 | 1966 | .190 | 18 | | | | | | | | | |
| | | | 1917 | -.733 | 16 | 1967 | -1.136 | 18 | | | | | | | | | |
| | | | 1918 | -1.233 | 16 | 1968 | -.784 | 18 | | | | | | | | | |
| | | | 1919 | -1.043 | 16 | 1969 | -.753 | 18 | | | | | | | | | |
| | | | 1920 | -1.004 | 16 | 1970 | -.097 | 18 | | | | | | | | | |
| | | | 1921 | -1.342 | 16 | 1971 | .387 | 18 | | | | | | | | | |
| | | | 1922 | -.431 | 16 | 1972 | 1.946 | 18 | | | | | | | | | |
| | | | 1923 | .938 | 16 | 1973 | 1.525 | 18 | | | | | | | | | |
| | | | 1924 | -.186 | 16 | 1974 | 1.019 | 18 | | | | | | | | | |
| | | | 1925 | .601 | 16 | 1975 | 1.548 | 18 | | | | | | | | | |
| 1876 | -.731 | 2 | 1926 | 1.869 | 16 | 1976 | .154 | 18 | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1877 | -1.004 | 2 | 1927 | 1.220 | 16 | 1977 | .214 | 18 | | | |
| 1878 | -.264 | 2 | 1928 | .006 | 16 | 1978 | -1.738 | 18 | 1 | | |
| 1879 | -.244 | 2 | 1929 | -.202 | 16 | 1979 | -1.285 | 18 | | | |
| 1880 | -.962 | 5 | 1930 | .328 | 16 | 1980 | -2.052 | 18 | 1 | | |
| 1881 | .333 | 5 | 1931 | 1.243 | 16 | 1981 | .191 | 18 | | | |
| 1882 | 1.620 | 5 | 1932 | -.093 | 16 | 1982 | -.572 | 18 | | | |
| 1883 | 1.631 | 6 | 1933 | -.218 | 16 | 1983 | -1.083 | 18 | | | |
| 1884 | .894 | 6 | 1934 | .235 | 16 | 1984 | -.289 | 18 | | | |
| 1885 | .570 | 6 | 1935 | -.956 | 16 | 1985 | .538 | 18 | | | |
| 1886 | -.325 | 6 | 1936 | -1.484 | 16 | 1986 | -1.029 | 18 | | | |
| 1887 | -1.775 | 6 | 1937 | 1.631 | 16 | 1987 | -.787 | 18 | | | |
| 1888 | -.555 | 6 | 1938 | .447 | 16 | 1988 | .397 | 18 | | | |
| 1889 | .120 | 8 | 1939 | -.057 | 16 | 1989 | .654 | 18 | | | |
| 1890 | .637 | 10 | 1940 | -1.853 | 17 | 1990 | -.393 | 18 | | | |
| 1891 | .108 | 11 | 1941 | .089 | 17 | 1991 | 1.696 | 18 | | | |
| 1892 | .067 | 12 | 1942 | -.861 | 17 | 1992 | 1.547 | 18 | | | |
| 1893 | -.318 | 13 | 1943 | -1.086 | 17 | 1993 | -.086 | 18 | | | |
| 1894 | -1.008 | 14 | 1944 | .297 | 17 | 1994 | -.194 | 18 | | | |
| 1895 | -.677 | 14 | 1945 | .605 | 18 | 1995 | .232 | 18 | | | |
| 1896 | .669 | 14 | 1946 | -1.421 | 18 | 1996 | -.482 | 18 | | | |
| 1897 | -.461 | 14 | 1947 | .393 | 18 | 1997 | .486 | 18 | | | |
| 1898 | -.310 | 14 | 1948 | .238 | 18 | 1998 | .565 | 18 | | | |
| 1899 | -.748 | 14 | 1949 | 1.086 | 18 | 1999 | 1.037 | 18 | | | |

PART 4: Master Bar Plot: 

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1900---a | 1950--------C | 2000----------F | | | | |
| | 1901------A | 1951-----@ | 2001--------C | | | | |
| | 1902--------C | 1952----@ | 2002--------C | | | | |
| | 1903----------F | 1953--c | 2003i | | | | |
| | 1904--------C | 1954--------C | 2004v | | | | |
| | 1905-------B | 1955---------D | 2005---b | | | | |
| | 1906-----@ | 1956--c | 2006------A | | | | |
| | 1907-----A | 1957----------F | 2007-----@ | | | | |
| | 1908--c | 1958-------B | 2008----@ | | | | |
| | 1909-----@ | 1959--------C | 2009---------E | | | | |
| | 1910--c | 1960f | 2010-------B | | | | |
| | 1911--------C | 1961-------B | 2011-------B | | | | |
| | 1912----a | 1962--------C | 2012--c | | | | |
| | 1913--c | 1963--c | 2013---------D | | | | |
| | 1914---------C | 1964--------C | | | | | |
| | 1915---------D | 1965-----@ | | | | | |
| | 1916----a | 1966------A | | | | | |
| | 1917--c | 1967-e | | | | | |
| | 1918-e | 1968--c | | | | | |
| | 1919-d | 1969--c | | | | | |
| | 1920-d | 1970----@ | | | | | |
| | 1921e | 1971-------B | | | | | |
| | 1922---b | 1972----------H | | | | | |
| | 1923---------D | 1973----------F | | | | | |
| | 1924----a | 1974---------D | | | | | |
| | 1925--------B | 1975----------F | | | | | |
| 1876--c | 1926----------G | 1976-----A | | | | | |
| 1877-d | 1927---------E | 1977------A | | | | | |

```
  1878----a       1928-----@      1978g
  1879----a       1929----a       1979e
  1880-d          1930------A     1980h
  1881------A     1931---------E  1981------A
  1882----------F 1932----@       1982--b
  1883----------G 1933----a       1983-d
  1884---------D  1934------A     1984---a
  1885-------B    1935-d          1985-------B
  1886---a        1936f           1986-d
  1887g           1937----------G 1987--c
  1888---b        1938-------B    1988-------B
  1889-----@      1939----@       1989--------C
  1890--------C   1940g           1990---b
  1891-----@      1941-----@      1991----------G
  1892-----@      1942--c         1992----------F
  1893---a        1943-d          1993----@
  1894-d          1944------A     1994----a
  1895--c         1945--------B   1995------A
  1896--------C   1946f           1996---b
  1897---b        1947-------B    1997-------B
  1898---a        1948------A     1998-------B
  1899--c         1949---------D  1999---------D
```

PART 5:  CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags:  A = correlation under   .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1875 1900 1925 1950 1975 |
|---|---|---|---|
| | | | 1924 1949 1974 1999 2024 |
| 1 | LDO01A | 1880 2012 | .47 .64 .50 .45 .50 |
| 2 | LDO01B | 1883 2013 | .58 .68 .70 .63 .75 |
| 3 | LDO02A | 1894 2013 | .50 .63 .63 .53 .62 |
| 4 | LDO02B | 1889 2012 | .56 .65 .71 .52 .47 |
| 5 | LDO03A | 1880 2013 | .60 .61 .58 .68 .86 |
| 6 | LDO03B | 1889 2013 | .62 .71 .76 .70 .80 |
| 7 | LDO05B | 1890 2013 | .53 .62 .55 .61 .75 |
| 8 | LDO05A | 1892 2013 | .49 .54 .63 .72 .79 |
| 9 | LDO06A | 1880 2013 | .45 .57 .71 .62 .68 |
| 10 | LDO06B | 1876 2013 | .49 .51 .53 .54 .77 |
| 11 | LDO07A | 1945 2013 | .54 .49 .72 |
| 12 | LDO07B | 1940 2013 | .57 .54 .80 |
| 13 | LDO08A | 1891 2013 | .43 .52 .53 .68 .85 |
| 14 | LDO08B | 1906 2013 | .39 .27A .47 .85 |
| 15 | LDO09A | 1893 2013 | .47 .57 .71 .73 .87 |
| 16 | LDO09B | 1905 2013 | .48B .65 .66 .83 |
| 17 | LDO10A | 1876 2012 | .54 .73 .68 .66 .32A |
| 18 | LDO10B | 1890 2013 | .51 .51 .56 .62 .51 |
| Av segment correlation | | | .52 .58 .60 .60 .71 |

PART 6: POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

LDO01A 1880 to 2012 133 years Series 1

[B] Entire series, effect on correlation (.479) is:
Lower 1960> -.017 1954< -.014 2012> -.011 1892< -.008 1953> -.008 1991< -.008 Higher 2004 .015 1937 .014

[C] Year-to-year changes diverging by over 4.0 std deviations:
1978 1979 4.2 SD

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1978 -6.6 SD

LDO01B 1883 to 2013 131 years Series 2

[B] Entire series, effect on correlation (.663) is:
Lower 1894< -.022 1960> -.021 1907< -.011 1905< -.009 1938< -.008 1912> -.008 Higher 2004 .032 1937 .010

LDO02A 1894 to 2013 120 years Series 3

[B] Entire series, effect on correlation (.602) is:
Lower 1978> -.019 1894> -.014 1975< -.012 2013< -.012 2003> -.010 1981< -.009 Higher 2004 .103 1946 .013

LDO02B 1889 to 2012 124 years Series 4

[B] Entire series, effect on correlation (.566) is:
Lower 2002< -.018 2004> -.015 1936> -.012 1975< -.012 1901> -.008 1985< -.008 Higher 1960 .019 1980 .012

[D] 2 Absent rings:

| Year | Master | N series | Absent |
|---|---|---|---|
| 1978 | -1.738 | 18 | 1 |
| 1980 | -2.052 | 18 | 1 |

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1978 -5.1 SD

LDO03A 1880 to 2013 134 years Series 5

```
 [B] Entire series, effect on correlation (.705) is:
       Lower   1887> -.019   1947< -.016   1953> -.016   1945< -.014   1888> -.014   1938< -.012 Higher   2004 .052   2003 .026

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1888 +3.4 SD
=============================================================================================================================

 LDO03B    1889 to 2013     125 years                                                                          Series   6

 [B] Entire series, effect on correlation (.736) is:
       Lower   1895> -.016   1991< -.010   1910< -.009   1981< -.009   2009< -.008   1931< -.007 Higher   2004 .059   1960 .012

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

 LDO05B    1890 to 2013     124 years                                                                          Series   7

 [B] Entire series, effect on correlation (.654) is:
       Lower   1890< -.017   1940> -.014   1928> -.013   1894> -.011   1967> -.010   1969< -.008 Higher   2004 .065   2003 .025

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

 LDO05A    1892 to 2013     122 years                                                                          Series   8

 [B] Entire series, effect on correlation (.639) is:
       Lower   1942< -.018   1896< -.014   1956> -.011   1953> -.010   1924> -.008   1908> -.007 Higher   2003 .021   2004 .013

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

 LDO06A    1880 to 2013     134 years                                                                          Series   9

 [B] Entire series, effect on correlation (.624) is:
       Lower   1884< -.018   1920> -.013   1998< -.009   1935> -.008   1996> -.007   1951> -.006 Higher   2003 .029   2004 .022

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

 LDO06B    1876 to 2013     138 years                                                                          Series 10

 [B] Entire series, effect on correlation (.623) is:
       Lower   1929< -.042   1960> -.025   1879> -.012   1878> -.010   1983> -.009   1950< -.007 Higher   2004 .051   2003 .031

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1879 +3.2 SD;    1945 +3.0 SD
=============================================================================================================================

 LDO07A    1945 to 2013      69 years                                                                          Series 11

 [B] Entire series, effect on correlation (.634) is:
       Lower   1953< -.038   1960> -.019   1962< -.019   1956> -.019   1987< -.015   1978> -.012 Higher   2004 .048   2003 .020

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

 LDO07B    1940 to 2013      74 years                                                                          Series 12

 [B] Entire series, effect on correlation (.689) is:
       Lower   1953< -.069   1960> -.020   1964< -.016   2009< -.008   1943> -.007   1993> -.006 Higher   2004 .074   2003 .014

=============================================================================================================================
```

LDO08A  1891 to 2013  123 years  Series 13

[B] Entire series, effect on correlation (.671) is:
Lower 1897> -.021 1896< -.015 1945< -.013 1979> -.011 1967> -.009 1929< -.007 Higher 2004 .061 2003 .028

---

LDO08B  1906 to 2013  108 years  Series 14

[A] Segment High -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1925 1974 | 0 | .18 | .07 | .22 | -.14 | .21 | .02 | -.18 | -.12 | -.11 | .01 | .27*- | .10 | -.01 | -.19 | -.06 | -.01 | -.20 | .11 | -.05 | -.21 | .15 |

[B] Entire series, effect on correlation ( .618) is:
Lower 1960> -.055 1967> -.018 1919> -.013 1955< -.012 1942> -.010 1927< -.010 Higher 2004 .091 2003 .030
1925 to 1974 segment:
Lower 1960> -.120 1967> -.037 1955< -.025 1927< -.021 1942> -.021 1932> -.019 Higher 1937 .060 1972 .044

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1960 +3.5 SD

---

LDO09A  1893 to 2013  121 years  Series 15

[B] Entire series, effect on correlation (.675) is:
Lower 1904< -.034 1894> -.018 1899< -.017 1903< -.010 1953> -.009 1916> -.007 Higher 2004 .038 2003 .027

---

LDO09B  1905 to 2013  109 years  Series 16

[A] Segment High -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1905 1954 | -4 | .00 | -.37 | -.16 | .11 | .08 | .02 | .51* | .12 | -.10 | -.10 | .48\| | .01 | -.41 | -.08 | .03 | -.17 | .01 | -.02 | .18 | -.21 | .03 |

[B] Entire series, effect on correlation (.705) is:
Lower 1950< -.018 1923< -.016 1981< -.014 1953> -.014 2010< -.014 1960> -.010 Higher 2004 .065 2003 .024
1905 to 1954 segment:
Lower 1950< -.046 1923< -.043 1953> -.035 1947< -.024 1938> -.019 1907> -.016 Higher 1926 .048 1946 .033

---

LDO10A  1876 to 2012  137 years  Series 17

[A] Segment High -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1963 2012 | 0 | .10 | -.05 | .01 | .06 | -.19 | -.45 | -.12 | .15 | .12 | -.12 | .32* | .17 | - | - | - | - | - | - | - | - | - |

[B] Entire series, effect on correlation (.496) is:
Lower 2004> -.101 2003> -.018 1954< -.015 2006< -.014 1879< -.011 1878< -.009 Higher 1960 .025 1940 .016
1963 to 2012 segment:
Lower 2004> -.207 2006< -.035 2003> -.020 2002< -.014 1987> -.013 1968> -.011 Higher 1972 .044 1991 .039

[C] Year-to-year changes diverging by over 4.0 STD deviations:
2003 2004 4.3 SD 2004 2005 -4.9 SD

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year

2004 +6.8 SD

LDO10B 1890 to 2013 124 years Series 18

[B] Entire series, effect on correlation (.518) is:
Lower 2004> -.023 1996< -.013 1946> -.011 1937< -.011 2003> -.010 1963> -.010 Higher 1991 .011 1972 .010

[E] Outliers 3 3.0 SD above or -4.5 SD below mean for year
1960 -6.1 SD; 1996 -4.5 SD; 2004 +3.9 SD

PART 7: DESCRIPTIVE STATISTICS:

| | | | | | | Corr | Unfiltered | | | | Filtered | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | with Master | Mean msmt | Max msmt | Std dev | Auto corr | Mean sens | Max value | Std dev | Auto corr | AR () |
| 1 | LDO01A | 1880 2012 | 133 | 5 | 0 | .479 | 1.08 | 7.15 | 1.051 | .878 | .277 | 2.58 | .338 | -.009 | 1 |
| 2 | LDO01B | 1883 2013 | 131 | 5 | 0 | .663 | 1.20 | 5.01 | .627 | .452 | .357 | 2.81 | .486 | .057 | 1 |
| 3 | LDO02A | 1894 2013 | 120 | 5 | 0 | .602 | .96 | 4.11 | .638 | .777 | .283 | 2.52 | .313 | .029 | 1 |
| 4 | LDO02B | 1889 2012 | 124 | 5 | 0 | .566 | 1.05 | 5.01 | .791 | .789 | .330 | 2.66 | .335 | -.047 | 2 |
| 5 | LDO03A | 1880 2013 | 134 | 5 | 0 | .705 | 1.44 | 4.34 | .814 | .692 | .309 | 2.70 | .432 | .116 | 1 |
| 6 | LDO03B | 1889 2013 | 125 | 5 | 0 | .736 | 1.22 | 3.14 | .588 | .592 | .333 | 2.59 | .380 | .033 | 1 |
| 7 | LDO05B | 1890 2013 | 124 | 5 | 0 | .654 | 1.58 | 5.10 | .754 | .496 | .351 | 2.83 | .436 | .102 | 1 |
| 8 | LDO05A | 1892 2013 | 122 | 5 | 0 | .639 | 1.33 | 3.98 | .739 | .625 | .348 | 2.80 | .442 | -.004 | 1 |
| 9 | LDO06A | 1880 2013 | 134 | 5 | 0 | .624 | 1.10 | 7.85 | 1.062 | .873 | .267 | 2.77 | .422 | .013 | 1 |
| 10 | LDO06B | 1876 2013 | 138 | 5 | 0 | .623 | .92 | 3.77 | .739 | .870 | .242 | 2.76 | .469 | .001 | 1 |
| 11 | LDO07A | 1945 2013 | 69 | 3 | 0 | .634 | 1.35 | 5.73 | .829 | .467 | .295 | 2.71 | .520 | -.031 | 1 |
| 12 | LDO07B | 1940 2013 | 74 | 3 | 0 | .689 | .94 | 2.97 | .449 | .353 | .311 | 2.52 | .453 | -.010 | 1 |
| 13 | LDO08A | 1891 2013 | 123 | 5 | 0 | .671 | 1.48 | 3.20 | .592 | .387 | .337 | 2.71 | .442 | .082 | 1 |
| 14 | LDO08B | 1906 2013 | 108 | 4 | 1 | .618 | 1.16 | 3.03 | .566 | .614 | .313 | 2.61 | .392 | .094 | 1 |
| 15 | LDO09A | 1893 2013 | 121 | 5 | 0 | .675 | 1.41 | 3.07 | .549 | .332 | .327 | 2.84 | .557 | .007 | 1 |
| 16 | LDO09B | 1905 2013 | 109 | 4 | 1 | .705 | 1.51 | 3.59 | .622 | .474 | .320 | 2.71 | .425 | .055 | 1 |
| 17 | LDO10A | 1876 2012 | 137 | 5 | 1 | .496 | 1.56 | 3.34 | .537 | .536 | .246 | 2.71 | .494 | -.010 | 1 |
| 18 | LDO10B | 1890 2013 | 124 | 5 | 0 | .518 | 1.43 | 4.53 | .650 | .631 | .282 | 2.57 | .325 | -.041 | 1 |
| Total or mean: | | | 2150 | 84 | 3 | .625 | 1.27 | 7.85 | .707 | .616 | .306 | 2.84 | .423 | .026 | |

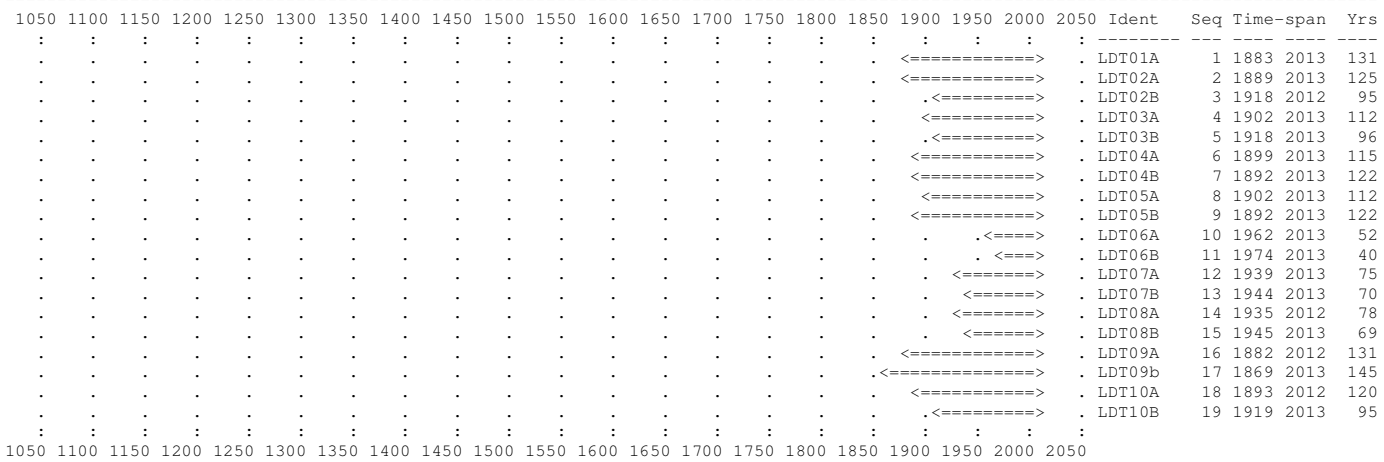
# APPENDIX B

## COFECHA PROGRAM OUTPUT FOR LILLY DICKEY SITE CHRONOLOGY,

## *LIRIODENDRON TULIPIFERA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
-------------------------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   ldt_dated.txt

 Time span of Master dating series is  1869 to  2013   145 years
 Continuous time span is               1869 to  2013   145 years
 Portion with two or more series is    1882 to  2013   132 years


                                     ****************************************
                                     *C* Number of dated series        19 *C*
                                     *O* Master series 1869 2013  145 yrs *O*
                                     *F* Total rings in all series   1905 *F*
                                     *E* Total dated rings checked   1892 *E*
                                     *C* Series intercorrelation     .630 *C*
                                     *H* Average mean sensitivity    .361 *H*
                                     *A* Segments, possible problems    0 *A*
                                     *** Mean length of series      100.3 ***
                                     ****************************************

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

              No ring measurements of zero value
```

PART 2:  TIME PLOT OF TREE-RING SERIES:



PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | .887 | 8 | 1950 | .963 | 17 | 2000 | .380 | 19 | | | | | | |
| | | | 1901 | .988 | 8 | 1951 | 1.598 | 17 | 2001 | 1.088 | 19 | | | | | | |
| | | | 1902 | .613 | 10 | 1952 | .559 | 17 | 2002 | .228 | 19 | | | | | | |
| | | | 1903 | .163 | 10 | 1953 | -2.470 | 17 | 2003 | -.378 | 19 | | | | | | |
| | | | 1904 | .592 | 10 | 1954 | -2.000 | 17 | 2004 | .558 | 19 | | | | | | |
| | | | 1905 | .437 | 10 | 1955 | -.871 | 17 | 2005 | .728 | 19 | | | | | | |
| | | | 1906 | .970 | 10 | 1956 | -.031 | 17 | 2006 | .852 | 19 | | | | | | |
| | | | 1907 | -.144 | 10 | 1957 | 1.158 | 17 | 2007 | -1.891 | 19 | | | | | | |
| | | | 1908 | -.174 | 10 | 1958 | 1.260 | 17 | 2008 | -.376 | 19 | | | | | | |
| | | | 1909 | .620 | 10 | 1959 | .233 | 17 | 2009 | .181 | 19 | | | | | | |
| | | | 1910 | -.764 | 10 | 1960 | 1.296 | 17 | 2010 | .753 | 19 | | | | | | |
| | | | 1911 | -.038 | 10 | 1961 | .348 | 17 | 2011 | -.290 | 19 | | | | | | |
| | | | 1912 | .343 | 10 | 1962 | -.407 | 18 | 2012 | -1.366 | 19 | | | | | | |
| | | | 1913 | -.871 | 10 | 1963 | .892 | 18 | 2013 | -.232 | 15 | | | | | | |
| | | | 1914 | -.793 | 10 | 1964 | -.718 | 18 | | | | | | | | | |
| | | | 1915 | -.261 | 10 | 1965 | -1.490 | 18 | | | | | | | | | |
| | | | 1916 | .223 | 10 | 1966 | -1.341 | 18 | | | | | | | | | |
| | | | 1917 | .001 | 10 | 1967 | -.975 | 18 | | | | | | | | | |
| | | | 1918 | -.454 | 12 | 1968 | .168 | 18 | | | | | | | | | |
| 1869 | 2.680 | 1 | 1919 | -1.256 | 13 | 1969 | .945 | 18 | | | | | | | | | |
| 1870 | -.682 | 1 | 1920 | -.920 | 13 | 1970 | -.792 | 18 | | | | | | | | | |
| 1871 | -1.267 | 1 | 1921 | -.301 | 13 | 1971 | .468 | 18 | | | | | | | | | |
| 1872 | -1.457 | 1 | 1922 | .097 | 13 | 1972 | .417 | 18 | | | | | | | | | |
| 1873 | .129 | 1 | 1923 | .606 | 13 | 1973 | 1.145 | 18 | | | | | | | | | |
| 1874 | -1.039 | 1 | 1924 | 1.386 | 13 | 1974 | 1.143 | 19 | | | | | | | | | |
| 1875 | .074 | 1 | 1925 | .104 | 13 | 1975 | .653 | 19 | | | | | | | | | |
| 1876 | -.272 | 1 | 1926 | -.078 | 13 | 1976 | -.017 | 19 | | | | | | | | | |
| 1877 | -.966 | 1 | 1927 | 1.557 | 13 | 1977 | -.350 | 19 | | | | | | | | | |
| 1878 | .592 | 1 | 1928 | 1.545 | 13 | 1978 | -.392 | 19 | | | | | | | | | |
| 1879 | -.724 | 1 | 1929 | 1.025 | 13 | 1979 | -.675 | 19 | | | | | | | | | |
| 1880 | 1.455 | 1 | 1930 | .038 | 13 | 1980 | 1.176 | 19 | | | | | | | | | |
| 1881 | 1.011 | 1 | 1931 | -.378 | 13 | 1981 | -.342 | 19 | | | | | | | | | |
| 1882 | 1.456 | 2 | 1932 | -.379 | 13 | 1982 | 1.225 | 19 | | | | | | | | | |
| 1883 | 1.404 | 3 | 1933 | -.985 | 13 | 1983 | -.716 | 19 | | | | | | | | | |
| 1884 | 1.541 | 3 | 1934 | -.757 | 13 | 1984 | -2.649 | 19 | | | | | | | | | |
| 1885 | -.606 | 3 | 1935 | .210 | 14 | 1985 | -.153 | 19 | | | | | | | | | |
| 1886 | -.611 | 3 | 1936 | -2.636 | 14 | 1986 | .785 | 19 | | | | | | | | | |
| 1887 | -1.420 | 3 | 1937 | -.423 | 14 | 1987 | .907 | 19 | | | | | | | | | |
| 1888 | -1.433 | 3 | 1938 | 1.448 | 14 | 1988 | -2.864 | 19 | | | | | | | | | |
| 1889 | -1.908 | 4 | 1939 | 1.163 | 15 | 1989 | -.525 | 19 | | | | | | | | | |
| 1890 | -.342 | 4 | 1940 | -.424 | 15 | 1990 | .825 | 19 | | | | | | | | | |
| 1891 | .635 | 4 | 1941 | -1.337 | 15 | 1991 | .074 | 19 | | | | | | | | | |
| 1892 | .583 | 6 | 1942 | -.487 | 15 | 1992 | .718 | 19 | | | | | | | | | |
| 1893 | -.773 | 7 | 1943 | -.015 | 15 | 1993 | 1.197 | 19 | | | | | | | | | |
| 1894 | -1.345 | 7 | 1944 | -1.220 | 16 | 1994 | -.913 | 19 | | | | | | | | | |
| 1895 | -1.654 | 7 | 1945 | .176 | 17 | 1995 | .026 | 19 | | | | | | | | | |
| 1896 | .201 | 7 | 1946 | .029 | 17 | 1996 | -.305 | 19 | | | | | | | | | |
| 1897 | .823 | 7 | 1947 | .797 | 17 | 1997 | -1.243 | 19 | | | | | | | | | |
| 1898 | -.028 | 7 | 1948 | .736 | 17 | 1998 | 1.318 | 19 | | | | | | | | | |
| 1899 | 1.440 | 8 | 1949 | .618 | 17 | 1999 | .729 | 19 | | | | | | | | | |

PART 4: Master Bar Plot:

| Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1900 | --------D | 1950 | --------D | 2000 | ------B | | | | | | | | |
| | | 1901 | ---------D | 1951 | ----------F | 2001 | ---------D | | | | | | | | |
| | | 1902 | -------B | 1952 | -------B | 2002 | ------A | | | | | | | | |
| | | 1903 | ------A | 1953 | j | 2003 | ---b | | | | | | | | |
| | | 1904 | -------B | 1954 | h | 2004 | -------B | | | | | | | | |
| | | 1905 | -------B | 1955 | --c | 2005 | --------C | | | | | | | | |
| | | 1906 | --------D | 1956 | -----@ | 2006 | --------C | | | | | | | | |
| | | 1907 | ----a | 1957 | ---------E | 2007 | h | | | | | | | | |
| | | 1908 | ----a | 1958 | ---------E | 2008 | ---b | | | | | | | | |
| | | 1909 | -------B | 1959 | ------A | 2009 | ------A | | | | | | | | |
| | | 1910 | --c | 1960 | ---------E | 2010 | --------C | | | | | | | | |
| | | 1911 | -----@ | 1961 | ------A | 2011 | ----a | | | | | | | | |
| | | 1912 | ------A | 1962 | ---b | 2012 | e | | | | | | | | |
| | | 1913 | --c | 1963 | --------D | 2013 | ----a | | | | | | | | |
| | | 1914 | --c | 1964 | --c | | | | | | | | | | |
| | | 1915 | ----a | 1965 | f | | | | | | | | | | |
| | | 1916 | ------A | 1966 | -e | | | | | | | | | | |
| | | 1917 | -----@ | 1967 | -d | | | | | | | | | | |
| | | 1918 | ---b | 1968 | ------A | | | | | | | | | | |
| 1869 | ----------K | 1919 | -e | 1969 | --------D | | | | | | | | | | |
| 1870 | --c | 1920 | -d | 1970 | --c | | | | | | | | | | |
| 1871 | -e | 1921 | ----a | 1971 | -------B | | | | | | | | | | |
| 1872 | f | 1922 | -----@ | 1972 | ------B | | | | | | | | | | |
| 1873 | -----A | 1923 | -------B | 1973 | ---------E | | | | | | | | | | |
| 1874 | -d | 1924 | ----------F | 1974 | ---------E | | | | | | | | | | |
| 1875 | -----@ | 1925 | -----@ | 1975 | -------C | | | | | | | | | | |
| 1876 | ----a | 1926 | -----@ | 1976 | -----@ | | | | | | | | | | |
| 1877 | -d | 1927 | ----------F | 1977 | ---a | | | | | | | | | | |
| 1878 | -------B | 1928 | ----------F | 1978 | ---b | | | | | | | | | | |
| 1879 | --c | 1929 | ---------D | 1979 | --c | | | | | | | | | | |
| 1880 | ----------F | 1930 | -----@ | 1980 | ---------E | | | | | | | | | | |
| 1881 | ---------D | 1931 | ---b | 1981 | ---a | | | | | | | | | | |
| 1882 | ----------F | 1932 | ---b | 1982 | ---------E | | | | | | | | | | |
| 1883 | ----------F | 1933 | -d | 1983 | --c | | | | | | | | | | |
| 1884 | ----------F | 1934 | --c | 1984 | k | | | | | | | | | | |
| 1885 | --b | 1935 | ------A | 1985 | ----a | | | | | | | | | | |
| 1886 | --b | 1936 | k | 1986 | --------C | | | | | | | | | | |
| 1887 | f | 1937 | ---b | 1987 | --------D | | | | | | | | | | |
| 1888 | f | 1938 | ----------F | 1988 | k | | | | | | | | | | |
| 1889 | h | 1939 | ---------E | 1989 | ---b | | | | | | | | | | |
| 1890 | ---a | 1940 | ---b | 1990 | --------C | | | | | | | | | | |
| 1891 | -------C | 1941 | -e | 1991 | -----@ | | | | | | | | | | |
| 1892 | -------B | 1942 | ---b | 1992 | -------C | | | | | | | | | | |
| 1893 | --c | 1943 | -----@ | 1993 | ---------E | | | | | | | | | | |
| 1894 | -e | 1944 | -e | 1994 | -d | | | | | | | | | | |
| 1895 | g | 1945 | ------A | 1995 | -----@ | | | | | | | | | | |
| 1896 | ------A | 1946 | -----@ | 1996 | ----a | | | | | | | | | | |
| 1897 | --------C | 1947 | --------C | 1997 | -e | | | | | | | | | | |
| 1898 | -----@ | 1948 | --------C | 1998 | ----------E | | | | | | | | | | |
| 1899 | ----------F | 1949 | -------B | 1999 | --------C | | | | | | | | | | |

PART 5:  CORRELATION OF SERIES BY SEGMENTS:

Correlations of  50-year dated segments, lagged  25 years
Flags:  A = correlation under   .3281 but highest as dated;  B = correlation higher at other than dated position

| Seq | Series | Time_span | 1875 1900 1925 1950 1975<br>1924 1949 1974 1999 2024 | | | | |
|---|---|---|---|---|---|---|---|
| 1 | LDT01A | 1883 2013 | .47 | .61 | .67 | .75 | .79 |
| 2 | LDT02A | 1889 2013 | .65 | .65 | .51 | .50 | .58 |
| 3 | LDT02B | 1918 2012 | | .43 | .48 | .51 | .58 |
| 4 | LDT03A | 1902 2013 | | .39 | .57 | .70 | .67 |
| 5 | LDT03B | 1918 2013 | | .73 | .63 | .65 | .63 |
| 6 | LDT04A | 1899 2013 | .44 | .43 | .65 | .71 | .77 |
| 7 | LDT04B | 1892 2013 | .70 | .67 | .73 | .56 | .59 |
| 8 | LDT05A | 1902 2013 | | .40 | .55 | .81 | .77 |
| 9 | LDT05B | 1892 2013 | .60 | .74 | .90 | .84 | .81 |
| 10 | LDT06A | 1962 2013 | | | | .51 | .53 |
| 11 | LDT06B | 1974 2013 | | | | .71 | |
| 12 | LDT07A | 1939 2013 | | | .78 | .84 | .75 |
| 13 | LDT07B | 1944 2013 | | | .77 | .78 | .69 |
| 14 | LDT08A | 1935 2012 | | | .76 | .73 | .64 |
| 15 | LDT08B | 1945 2013 | | | .87 | .86 | .79 |
| 16 | LDT09A | 1882 2012 | .48 | .61 | .82 | .84 | .80 |
| 17 | LDT09b | 1869 2013 | .42 | .61 | .83 | .74 | .71 |
| 18 | LDT10A | 1893 2012 | .37 | .42 | .69 | .46 | .42 |
| 19 | LDT10B | 1919 2013 | | .66 | .60 | .56 | .40 |
| Av segment correlation | | | .52 | .56 | .69 | .69 | .66 |

PART 6:  POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

LDT01A    1883 to  2013     131 years  Series  1

[B] Entire series, effect on correlation (  .667) is:
      Lower   1970> -.015   1898< -.013   1904< -.011   1894> -.010   1907> -.009   1883< -.009  Higher   1988  .030   2007  .018

LDT02A    1889 to  2013     125 years  Series  2

[B] Entire series, effect on correlation (  .572) is:
      Lower   1956< -.019   2009< -.013   1981> -.010   1958< -.009   1965> -.009   1966> -.009  Higher   1936  .049   1988  .023

LDT02B    1918 to  2012      95 years  Series  3

[B] Entire series, effect on correlation (  .509) is:
      Lower   1948< -.017   1925> -.011   1934< -.011   1965> -.011   1924< -.010   1929< -.010  Higher   1936  .036   2007  .027

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      2007 -5.6 SD

LDT03A    1902 to  2013     112 years  Series  4

[B] Entire series, effect on correlation (  .600) is:
      Lower   1936> -.025   1944> -.018   1945< -.010   1994> -.009   1979< -.009   1903< -.008  Higher   2007  .016   1953  .016

LDT03B    1918 to  2013      96 years  Series  5

[B] Entire series, effect on correlation (  .669) is:
      Lower   1973< -.035   1970< -.020   1979< -.019   2008< -.012   1962> -.011   1996> -.010  Higher   2007  .017   1988  .017

LDT04A    1899 to  2013     115 years  Series  6

[B] Entire series, effect on correlation (  .626) is:

```
      Lower   1910> -.034   1913> -.020   1999< -.012   1934> -.009   1954< -.008   1906< -.007  Higher   1936  .027   1988  .024

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1910 +3.8 SD
================================================================================================================================================

 LDT04B    1892 to  2013     122 years                                                                                          Series   7

 [B] Entire series, effect on correlation (  .642) is:
      Lower   1991< -.037   1926< -.018   1993< -.014   1994> -.009   1905< -.008   1975< -.008  Higher   1936  .032   2007  .016

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

 LDT05A    1902 to  2013     112 years                                                                                          Series   8

 [B] Entire series, effect on correlation (  .636) is:
      Lower   1936> -.025   1939< -.017   1916< -.012   2007> -.011   1970> -.011   1940> -.010  Higher   1988  .044   1984  .012

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1937 +3.0 SD
================================================================================================================================================

 LDT05B    1892 to  2013     122 years                                                                                          Series   9

 [B] Entire series, effect on correlation (  .730) is:
      Lower   1894< -.029   1898> -.020   1912< -.014   1900< -.013   1976< -.007   1893> -.005  Higher   1936  .020   1988  .019

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

 LDT06A    1962 to  2013      52 years                                                                                          Series  10

 [B] Entire series, effect on correlation (  .517) is:
      Lower   1970> -.053   1968< -.038   1969< -.033   1964> -.024   2007> -.023   1979> -.023  Higher   1988  .123   1983  .023

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

 LDT06B    1974 to  2013      40 years                                                                                          Series  11

 [B] Entire series, effect on correlation (  .706) is:
      Lower   1999< -.039   1979> -.019   2013< -.019   1996< -.016   1978< -.015   1998< -.013  Higher   1988  .064   1984  .021

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

 LDT07A    1939 to  2013      75 years                                                                                          Series  12

 [B] Entire series, effect on correlation (  .708) is:
      Lower   2011> -.019   2005< -.019   2006< -.014   1979> -.014   1954> -.014   2004< -.012  Higher   1988  .057   1953  .020

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

 LDT07B    1944 to  2013      70 years                                                                                          Series  13

 [B] Entire series, effect on correlation (  .708) is:
      Lower   2006< -.031   1979> -.021   2011> -.020   1970> -.018   1981> -.014   1974< -.013  Higher   1988  .062   1953  .024

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

 LDT08A    1935 to  2012      78 years                                                                                          Series  14
```

```
 [B] Entire series, effect on correlation (  .688) is:
       Lower   2010< -.018   1992< -.016   1993< -.013   1970< -.012   2009< -.011   1990< -.007  Higher   1953  .020   1988  .016

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

 LDT08B    1945 to  2013      69 years                                                                                    Series  15

 [B] Entire series, effect on correlation (  .794) is:
       Lower   1997> -.013   2010< -.013   2007> -.012   1979> -.012   2012> -.009   2009< -.009  Higher   1988  .046   1953  .016

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

 LDT09A    1882 to  2012     131 years                                                                                    Series  16

 [B] Entire series, effect on correlation (  .708) is:
       Lower   1910> -.015   2006< -.014   1917> -.012   1907> -.009   2002< -.009   1896< -.008  Higher   1936  .028   1988  .022

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

 LDT09b    1869 to  2013     145 years                                                                                    Series  17

 [*] Early part of series cannot be checked from 1869 to 1881 -- not matched by another series

 [B] Entire series, effect on correlation (  .649) is:
       Lower   1897< -.030   1914> -.013   1986< -.012   1898> -.007   1917< -.007   1954> -.006  Higher   1953  .020   2007  .019

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

 LDT10A    1893 to  2012     120 years                                                                                    Series  18

 [B] Entire series, effect on correlation (  .420) is:
       Lower   1915< -.033   1894> -.020   1995< -.019   1960< -.015   1893< -.014   1913> -.012  Higher   1936  .025   1953  .020

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1893 1894   4.7 SD    1914 1915  -4.4 SD

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1893 -4.6 SD;    1894 +3.2 SD;    1915 -7.4 SD
==========================================================================================================================================

 LDT10B    1919 to  2013      95 years                                                                                    Series  19

 [B] Entire series, effect on correlation (  .498) is:
       Lower   2007> -.058   1970> -.019   1953> -.012   1973< -.011   1928< -.010   2004< -.010  Higher   1988  .046   1936  .029

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1994 -4.8 SD;    2007 +4.2 SD
==========================================================================================================================================

 [*] All segments correlate highest as dated with correlation with master series over   .3281
```

PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LDT01A | 1883 2013 | 131 | 5 | 0 | .667 | 2.48 | 6.96 | 1.239 | .536 | .365 | 2.82 | .512 | -.049 | 2 |
| 2 | LDT02A | 1889 2013 | 125 | 5 | 0 | .572 | 3.25 | 8.91 | 1.366 | .462 | .319 | 2.60 | .381 | -.058 | 2 |
| 3 | LDT02B | 1918 2012 | 95 | 4 | 0 | .509 | 3.82 | 9.23 | 1.897 | .478 | .367 | 2.51 | .357 | -.110 | 1 |
| 4 | LDT03A | 1902 2013 | 112 | 4 | 0 | .600 | 2.33 | 5.87 | 1.001 | .599 | .283 | 2.67 | .408 | -.035 | 1 |
| 5 | LDT03B | 1918 2013 | 96 | 4 | 0 | .669 | 2.89 | 6.25 | 1.179 | .457 | .329 | 2.62 | .416 | -.037 | 2 |
| 6 | LDT04A | 1899 2013 | 115 | 5 | 0 | .626 | 3.29 | 6.87 | 1.522 | .322 | .421 | 2.85 | .562 | -.036 | 2 |
| 7 | LDT04B | 1892 2013 | 122 | 5 | 0 | .642 | 3.04 | 7.94 | 1.526 | .475 | .386 | 2.74 | .477 | -.058 | 2 |
| 8 | LDT05A | 1902 2013 | 112 | 4 | 0 | .636 | 2.69 | 8.10 | 1.276 | .468 | .373 | 2.67 | .506 | -.018 | 2 |
| 9 | LDT05B | 1892 2013 | 122 | 5 | 0 | .730 | 2.97 | 9.52 | 1.318 | .473 | .353 | 2.77 | .492 | -.020 | 2 |
| 10 | LDT06A | 1962 2013 | 52 | 2 | 0 | .517 | 4.95 | 10.21 | 2.455 | .408 | .446 | 2.53 | .568 | -.005 | 2 |
| 11 | LDT06B | 1974 2013 | 40 | 1 | 0 | .706 | 6.32 | 12.51 | 2.798 | .398 | .383 | 2.71 | .728 | -.047 | 2 |
| 12 | LDT07A | 1939 2013 | 75 | 3 | 0 | .708 | 2.82 | 6.44 | 1.493 | .609 | .389 | 2.62 | .453 | .018 | 1 |
| 13 | LDT07B | 1944 2013 | 70 | 3 | 0 | .708 | 3.18 | 7.52 | 1.711 | .637 | .390 | 2.51 | .480 | -.010 | 1 |
| 14 | LDT08A | 1935 2012 | 78 | 3 | 0 | .688 | 3.16 | 9.31 | 1.943 | .622 | .392 | 2.66 | .484 | -.034 | 2 |
| 15 | LDT08B | 1945 2013 | 69 | 3 | 0 | .794 | 3.58 | 7.53 | 1.816 | .619 | .366 | 2.68 | .501 | .056 | 1 |
| 16 | LDT09A | 1882 2012 | 131 | 5 | 0 | .708 | 2.02 | 6.13 | 1.001 | .631 | .323 | 2.64 | .421 | -.017 | 2 |
| 17 | LDT09b | 1869 2013 | 145 | 5 | 0 | .649 | 2.10 | 5.94 | 1.032 | .661 | .304 | 2.82 | .555 | -.039 | 2 |
| 18 | LDT10A | 1893 2012 | 120 | 5 | 0 | .420 | 2.23 | 5.78 | 1.113 | .489 | .400 | 2.59 | .417 | -.040 | 2 |
| 19 | LDT10B | 1919 2013 | 95 | 4 | 0 | .498 | 3.12 | 7.59 | 1.547 | .525 | .388 | 2.54 | .403 | .000 | 2 |
| Total or mean: | | | 1905 | 75 | 0 | .630 | 2.95 | 12.51 | 1.424 | .522 | .361 | 2.85 | .470 | -.032 | |

# APPENDIX C

## COFECHA PROGRAM OUTPUT FOR LILLY DICKEY SITE CHRONOLOGY, *QUERCUS MONTANA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
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 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   Ldm_dated.txt

 Time span of Master dating series is  1867 to  2013   147 years
 Continuous time span is               1867 to  2013   147 years
 Portion with two or more series is    1877 to  2013   137 years


                                     ***************************************
                                     *C* Number of dated series        20 *C*
                                     *O* Master series 1867 2013  147 yrs *O*
                                     *F* Total rings in all series   2084 *F*
                                     *E* Total dated rings checked   2074 *E*
                                     *C* Series intercorrelation     .607 *C*
                                     *H* Average mean sensitivity    .222 *H*
                                     *A* Segments, possible problems    4 *A*
                                     *** Mean length of series      104.2 ***
                                     ***************************************

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

              No ring measurements of zero value
```
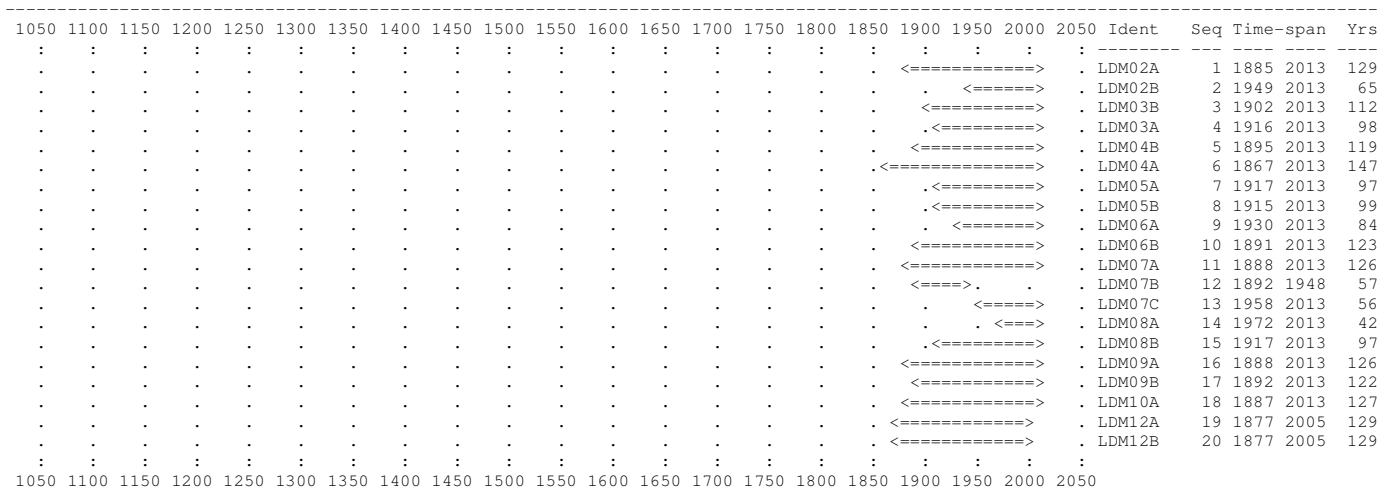

PART 2:  TIME PLOT OF TREE-RING SERIES:



PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | -1.087 | 11 | 1950 | 1.217 | 17 | 2000 | 1.166 | 19 | | | | | | |
| | | | 1901 | -.730 | 11 | 1951 | 1.490 | 17 | 2001 | .970 | 19 | | | | | | |
| | | | 1902 | -.700 | 12 | 1952 | .866 | 17 | 2002 | -.188 | 19 | | | | | | |
| | | | 1903 | .823 | 12 | 1953 | -.637 | 17 | 2003 | -.979 | 19 | | | | | | |
| | | | 1904 | 1.134 | 12 | 1954 | -1.623 | 17 | 2004 | -2.009 | 19 | | | | | | |
| | | | 1905 | .101 | 12 | 1955 | .301 | 17 | 2005 | .309 | 19 | | | | | | |
| | | | 1906 | .507 | 12 | 1956 | .919 | 17 | 2006 | .924 | 17 | | | | | | |
| | | | 1907 | .391 | 12 | 1957 | 1.866 | 17 | 2007 | -2.087 | 17 | | | | | | |
| | | | 1908 | -.461 | 12 | 1958 | 1.688 | 18 | 2008 | .547 | 17 | | | | | | |
| | | | 1909 | -.067 | 12 | 1959 | -.220 | 18 | 2009 | .658 | 17 | | | | | | |
| | | | 1910 | -.515 | 12 | 1960 | .197 | 18 | 2010 | 1.352 | 17 | | | | | | |
| | | | 1911 | -1.264 | 12 | 1961 | -.035 | 18 | 2011 | -.127 | 17 | | | | | | |
| | | | 1912 | -.186 | 12 | 1962 | -.052 | 18 | 2012 | -1.314 | 17 | | | | | | |
| | | | 1913 | -.326 | 12 | 1963 | -.970 | 18 | 2013 | .904 | 17 | | | | | | |
| | | | 1914 | -1.954 | 12 | 1964 | -1.884 | 18 | | | | | | | | | |
| | | | 1915 | .098 | 13 | 1965 | -.999 | 18 | | | | | | | | | |
| | | | 1916 | 1.588 | 14 | 1966 | -1.142 | 18 | | | | | | | | | |
| 1867 | 1.308 | 1 | 1917 | 1.284 | 16 | 1967 | -1.218 | 18 | | | | | | | | | |
| 1868 | .240 | 1 | 1918 | -.222 | 16 | 1968 | -.296 | 18 | | | | | | | | | |
| 1869 | 2.782 | 1 | 1919 | -.909 | 16 | 1969 | .105 | 18 | | | | | | | | | |
| 1870 | -1.574 | 1 | 1920 | -.445 | 16 | 1970 | -.892 | 18 | | | | | | | | | |
| 1871 | .389 | 1 | 1921 | -.908 | 16 | 1971 | .550 | 18 | | | | | | | | | |
| 1872 | 1.643 | 1 | 1922 | -.324 | 16 | 1972 | -.238 | 19 | | | | | | | | | |
| 1873 | .788 | 1 | 1923 | .265 | 16 | 1973 | 1.564 | 19 | | | | | | | | | |
| 1874 | -.730 | 1 | 1924 | .928 | 16 | 1974 | 1.189 | 19 | | | | | | | | | |
| 1875 | -1.855 | 1 | 1925 | -.839 | 16 | 1975 | .695 | 19 | | | | | | | | | |
| 1876 | -.868 | 1 | 1926 | .342 | 16 | 1976 | .740 | 19 | | | | | | | | | |
| 1877 | 2.287 | 3 | 1927 | 1.705 | 16 | 1977 | .177 | 19 | | | | | | | | | |
| 1878 | .362 | 3 | 1928 | 1.808 | 16 | 1978 | .662 | 19 | | | | | | | | | |
| 1879 | -.195 | 3 | 1929 | .520 | 16 | 1979 | -.224 | 19 | | | | | | | | | |
| 1880 | .380 | 3 | 1930 | .157 | 17 | 1980 | -.088 | 19 | | | | | | | | | |
| 1881 | -.626 | 3 | 1931 | -.003 | 17 | 1981 | -.705 | 19 | | | | | | | | | |
| 1882 | -.497 | 3 | 1932 | 1.038 | 17 | 1982 | .718 | 19 | | | | | | | | | |
| 1883 | -.388 | 3 | 1933 | -.842 | 17 | 1983 | -.253 | 19 | | | | | | | | | |
| 1884 | -.804 | 3 | 1934 | -1.032 | 17 | 1984 | -1.582 | 19 | | | | | | | | | |
| 1885 | -.419 | 4 | 1935 | -.024 | 17 | 1985 | -.230 | 19 | | | | | | | | | |
| 1886 | -1.424 | 4 | 1936 | -2.550 | 17 | 1986 | -.464 | 19 | | | | | | | | | |
| 1887 | -1.247 | 5 | 1937 | -.539 | 17 | 1987 | -.248 | 19 | | | | | | | | | |
| 1888 | -.327 | 7 | 1938 | 1.157 | 17 | 1988 | -1.768 | 19 | | | | | | | | | |
| 1889 | -1.019 | 7 | 1939 | 1.195 | 17 | 1989 | 1.649 | 19 | | | | | | | | | |
| 1890 | .086 | 7 | 1940 | -.836 | 17 | 1990 | .774 | 19 | | | | | | | | | |
| 1891 | .475 | 8 | 1941 | -1.641 | 17 | 1991 | .088 | 19 | | | | | | | | | |
| 1892 | 1.142 | 10 | 1942 | -.052 | 17 | 1992 | 1.214 | 19 | | | | | | | | | |
| 1893 | .285 | 10 | 1943 | -.162 | 17 | 1993 | 1.342 | 19 | | | | | | | | | |
| 1894 | -.143 | 10 | 1944 | -2.032 | 17 | 1994 | -.916 | 19 | | | | | | | | | |
| 1895 | -.252 | 11 | 1945 | -.684 | 17 | 1995 | -.085 | 19 | | | | | | | | | |
| 1896 | .316 | 11 | 1946 | .167 | 17 | 1996 | -.884 | 19 | | | | | | | | | |
| 1897 | 1.394 | 11 | 1947 | .169 | 17 | 1997 | -.943 | 19 | | | | | | | | | |
| 1898 | .261 | 11 | 1948 | .160 | 17 | 1998 | .624 | 19 | | | | | | | | | |
| 1899 | .175 | 11 | 1949 | .946 | 17 | 1999 | .744 | 19 | | | | | | | | | |

PART 4: Master Bar Plot:

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1900-d | 1950---------E | 2000---------E | | | | |
| | 1901--c | 1951----------F | 2001--------D | | | | |
| | 1902--c | 1952--------C | 2002----a | | | | |
| | 1903--------C | 1953---c | 2003-d | | | | |
| | 1904---------E | 1954f | 2004h | | | | |
| | 1905------@ | 1955------A | 2005------A | | | | |
| | 1906-------B | 1956--------D | 2006--------D | | | | |
| | 1907-------B | 1957----------G | 2007h | | | | |
| | 1908---b | 1958----------G | 2008-------B | | | | |
| | 1909-----@ | 1959----a | 2009--------C | | | | |
| | 1910---b | 1960------A | 2010---------E | | | | |
| | 1911-e | 1961-----@ | 2011-----a | | | | |
| | 1912----a | 1962-----@ | 2012-e | | | | |
| | 1913----a | 1963-d | 2013--------D | | | | |
| | 1914h | 1964h | | | | | |
| | 1915------@ | 1965-d | | | | | |
| | 1916----------F | 1966-e | | | | | |
| 1867---------E | 1917---------E | 1967-e | | | | | |
| 1868------A | 1918----a | 1968----a | | | | | |
| 1869----------K | 1919--d | 1969------@ | | | | | |
| 1870f | 1920---b | 1970--d | | | | | |
| 1871-------B | 1921--d | 1971-------B | | | | | |
| 1872----------G | 1922----a | 1972----a | | | | | |
| 1873--------C | 1923------A | 1973----------F | | | | | |
| 1874--c | 1924--------D | 1974---------E | | | | | |
| 1875g | 1925--c | 1975--------C | | | | | |
| 1876--c | 1926-------A | 1976--------C | | | | | |
| 1877----------I | 1927----------G | 1977------A | | | | | |
| 1878-------A | 1928----------G | 1978--------C | | | | | |
| 1879----a | 1929-------B | 1979----a | | | | | |
| 1880-------B | 1930------A | 1980-----@ | | | | | |
| 1881---c | 1931-----@ | 1981--c | | | | | |
| 1882---b | 1932---------D | 1982--------C | | | | | |
| 1883---b | 1933--c | 1983----a | | | | | |
| 1884--c | 1934-d | 1984f | | | | | |
| 1885---b | 1935-----@ | 1985----a | | | | | |
| 1886f | 1936j | 1986---b | | | | | |
| 1887-e | 1937---b | 1987----a | | | | | |
| 1888----a | 1938---------E | 1988g | | | | | |
| 1889-d | 1939---------E | 1989----------G | | | | | |
| 1890------@ | 1940--c | 1990--------C | | | | | |
| 1891-------B | 1941g | 1991------@ | | | | | |
| 1892---------E | 1942-----@ | 1992---------E | | | | | |
| 1893------A | 1943----a | 1993---------E | | | | | |
| 1894----a | 1944h | 1994--d | | | | | |
| 1895----a | 1945--c | 1995-----@ | | | | | |
| 1896------A | 1946------A | 1996--d | | | | | |
| 1897---------F | 1947------A | 1997-d | | | | | |
| 1898------A | 1948------A | 1998-------B | | | | | |
| 1899------A | 1949--------D | 1999--------C | | | | | |

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|
| 1 | LDM02A | 1885 2013 | .40 | .53 | .72 | .80 | .84 |
| 2 | LDM02B | 1949 2013 | | | .76 | .76 | .76 |
| 3 | LDM03B | 1902 2013 | | .81 | .83 | .71 | .72 |
| 4 | LDM03A | 1916 2013 | | .68 | .74 | .74 | .84 |
| 5 | LDM04B | 1895 2013 | .18B | .23B | .46 | .66 | .75 |
| 6 | LDM04A | 1867 2013 | .40 | .61 | .74 | .64 | .75 |
| 7 | LDM05A | 1917 2013 | | .69 | .67 | .49 | .56 |
| 8 | LDM05B | 1915 2013 | | .64 | .58 | .42 | .51 |
| 9 | LDM06A | 1930 2013 | | | .73 | .68 | .67 |
| 10 | LDM06B | 1891 2013 | .72 | .65 | .70 | .66 | .66 |
| 11 | LDM07A | 1888 2013 | .37 | .63 | .71 | .64 | .68 |
| 12 | LDM07B | 1892 1948 | .42 | .37 | | | |
| 13 | LDM07C | 1958 2013 | | | | .28A | .37 |
| 14 | LDM08A | 1972 2013 | | | | .46 | |
| 15 | LDM08B | 1917 2013 | | .77 | .78 | .67 | .63 |
| 16 | LDM09A | 1888 2013 | .33B | .55 | .76 | .71 | .70 |
| 17 | LDM09B | 1892 2013 | .76 | .70 | .69 | .61 | .64 |
| 18 | LDM10A | 1887 2013 | .68 | .67 | .65 | .56 | .47 |
| 19 | LDM12A | 1877 2005 | .43 | .58 | .72 | .65 | .66 |
| 20 | LDM12B | 1877 2005 | .49 | .67 | .73 | .69 | .68 |
| Av segment correlation | | | .47 | .61 | .70 | .62 | .66 |

PART 6: POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

LDM02A 1885 to 2013 129 years Series 1

[B] Entire series, effect on correlation ( .634) is:
Lower 1902< -.060 1942< -.023 1901< -.018 1949< -.015 1895> -.015 1888> -.010 Higher 2007 .029 1936 .027

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1895 +3.7 SD; 1902 -5.8 SD

LDM02B  1949 to  2013  65 years  Series  2

[B] Entire series, effect on correlation (  .761) is:
Lower  2004> -.022  1964> -.019  1979< -.019  1984> -.013  2005< -.013  1959< -.010  Higher  2007  .047  1994  .011

---

LDM03B  1902 to  2013  112 years  Series  3

[B] Entire series, effect on correlation (  .758) is:
Lower  1910> -.013  2007> -.012  1984> -.011  1902> -.008  1905< -.007  1981< -.007  Higher  1914  .010  2004  .010

---

LDM03A  1916 to  2013  98 years  Series  4

[B] Entire series, effect on correlation (  .760) is:
Lower  1924< -.014  1921> -.014  1954> -.010  1933< -.009  2011> -.008  1955< -.008  Higher  2007  .021  2004  .011

---

LDM04B  1895 to  2013  119 years  Series  5

[A] Segment  High  -10  -9  -8  -7  -6  -5  -4  -3  -2  -1  +0  +1  +2  +3  +4  +5  +6  +7  +8  +9  +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1895 1944 | 10 | -.05 | -.28 | .08 | .09 | -.08 | .08 | .06 | -.14 | -.24 | -.02 | .18\| | .08 | -.10 | .00 | .20 | -.04 | -.30 | .14 | .14 | .01 | .21* |
| 1900 1949 | 4 | -.08 | -.27 | .09 | .15 | -.05 | .03 | .02 | -.16 | -.25 | .01 | .23\| | .06 | -.13 | -.02 | .24* | .01 | -.23 | .15 | .11 | .03 | .22 |

[B] Entire series, effect on correlation (  .483) is:
Lower  1926< -.082  1914> -.035  1925> -.020  1897< -.017  1927< -.011  1902> -.008  Higher  1936  .033  2007  .026
1895 to 1944 segment:
Lower  1926< -.143  1914> -.062  1925> -.036  1897< -.030  1927< -.014  1902> -.013  Higher  1936  .124  1944  .038
1900 to 1949 segment:
Lower  1926< -.166  1914> -.065  1925> -.037  1927< -.018  1902> -.014  1917< -.011  Higher  1936  .123  1944  .038

[C] Year-to-year changes diverging by over 4.0 std deviations:
1925 1926  -4.4 SD

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
1914 +3.5 SD;  1926 -4.6 SD

---

LDM04A  1867 to  2013  147 years  Series  6

[*] Early part of series cannot be checked from 1867 to 1876 -- not matched by another series

[B] Entire series, effect on correlation (  .625) is:
Lower  1905< -.022  1886> -.011  1955< -.011  1921> -.008  1959> -.008  2003> -.008  Higher  2007  .027  2004  .012

---

LDM05A  1917 to  2013  97 years  Series  7

[B] Entire series, effect on correlation (  .614) is:
Lower  2003> -.018  1981> -.018  1993< -.015  1959> -.012  1928< -.011  1926> -.011  Higher  1944  .018  2007  .017

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
1926 +3.4 SD;  1981 +3.8 SD

LDM05B 1915 to 2013 99 years Series 8

[B] Entire series, effect on correlation ( .553) is:
Lower 1991< -.018 2003> -.016 1970< -.014 1963> -.013 1987< -.012 1965> -.010 Higher 2007 .024 1944 .022

LDM06A 1930 to 2013 84 years Series 9

[B] Entire series, effect on correlation ( .690) is:
Lower 2004> -.027 2010< -.017 2002> -.014 1963> -.013 1959> -.011 1979> -.008 Higher 2007 .047 1944 .015

LDM06B 1891 to 2013 123 years Series 10

[B] Entire series, effect on correlation ( .653) is:
Lower 2009< -.023 1943< -.015 1952< -.012 1920< -.010 1941> -.009 1984> -.008 Higher 1936 .033 1914 .014

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1985 +3.1 SD

LDM07A 1888 to 2013 126 years Series 11

[B] Entire series, effect on correlation ( .582) is:
Lower 1889> -.044 1970> -.014 1900> -.011 1978< -.009 1890< -.009 1924< -.009 Higher 2007 .040 1936 .017

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1889 +4.4 SD

LDM07B 1892 to 1948 57 years Series 12

[B] Entire series, effect on correlation ( .398) is:
Lower 1899< -.094 1941> -.035 1921< -.016 1944> -.015 1919> -.014 1942< -.012 Higher 1940 .030 1925 .021

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1899 -5.2 SD

LDM07C 1958 to 2013 56 years Series 13

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1958 2007 | 0 | -.04 | .25 | -.05 | .26 | .08 | -.04 | -.03 | .10 | -.10 | -.20 | .28* | -.11 | -.18 | -.29 | .01 | -.10 | -.06 | - | - | - | - |

[B] Entire series, effect on correlation ( .334) is:
Lower 1964> -.067 1975< -.036 2004> -.026 1981> -.019 1972< -.017 1958< -.017 Higher 2007 .051 1994 .040
1958 to 2007 segment:
Lower 1964> -.071 1975< -.039 2004> -.027 1981> -.020 1958< -.017 1972< -.017 Higher 2007 .063 1994 .047

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1964 +5.2 SD; 1965 +3.8 SD

```
LDM08A    1972 to  2013      42 years                                                                                                  Series  14

[B] Entire series, effect on correlation (  .461) is:
      Lower   1972< -.089   2004> -.023   1981> -.021   1998< -.018   1983> -.015   2009< -.015  Higher   2007  .066   1984  .045

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

LDM08B    1917 to  2013      97 years                                                                                                  Series  15

[B] Entire series, effect on correlation (  .699) is:
      Lower   1997> -.012   2011< -.010   1986< -.010   1940< -.010   2012> -.010   1979> -.009  Higher   1936  .031   1944  .013

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

LDM09A    1888 to  2013     126 years                                                                                                  Series  16

[A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
   ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1888 1937   -1    .10  .01 -.05  .14 -.08 -.08 -.25 -.04  .10  .34* .33|-.19 -.11 -.01  .22  .04 -.01  .00 -.09 -.30 -.08

[B] Entire series, effect on correlation (  .571) is:
      Lower   1896< -.041   1903< -.021   2003> -.016   1981< -.011   1913> -.010   2013< -.009  Higher   2007  .046   1914  .016
    1888 to 1937 segment:
      Lower   1896< -.113   1903< -.056   1913> -.021   1898> -.019   1905> -.017   1915< -.016  Higher   1914  .080   1936  .069

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1896 -4.6 SD
================================================================================================================================================

LDM09B    1892 to  2013     122 years                                                                                                  Series  17

[B] Entire series, effect on correlation (  .660) is:
      Lower   1944> -.020   1984< -.015   1979< -.013   1987> -.007   1950< -.007   1975< -.006  Higher   1936  .030   1914  .009

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

LDM10A    1887 to  2013     127 years                                                                                                  Series  18

[B] Entire series, effect on correlation (  .559) is:
      Lower   1988> -.017   2007> -.013   1889> -.011   1980< -.011   2004> -.010   1998< -.007  Higher   1914  .018   1936  .013

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

LDM12A    1877 to  2005     129 years                                                                                                  Series  19

[B] Entire series, effect on correlation (  .554) is:
      Lower   1889< -.026   1945< -.018   1915< -.012   1879> -.012   1988> -.011   1899> -.010  Higher   1936  .034   2004  .015

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1899 +3.6 SD
================================================================================================================================================

LDM12B    1877 to  2005     129 years                                                                                                  Series  20

[B] Entire series, effect on correlation (  .594) is:
      Lower   1889< -.019   1899> -.018   1881> -.015   1909< -.012   1933> -.009   1888< -.009  Higher   1936  .029   1914  .014

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
```

1889 -5.1 SD;  1899 +4.5 SD

PART 7:  DESCRIPTIVE STATISTICS:

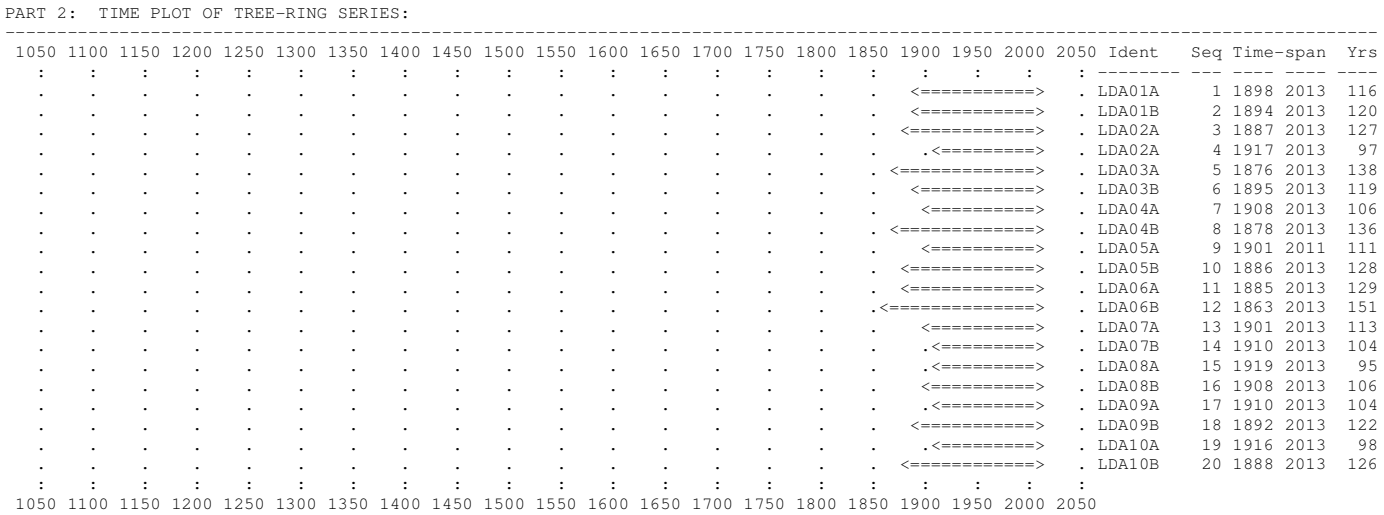
| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LDM02A | 1885 2013 | 129 | 5 | 0 | .634 | 1.83 | 3.83 | .505 | .451 | .220 | 2.61 | .410 | .040 | 1 |
| 2 | LDM02B | 1949 2013 | 65 | 3 | 0 | .761 | 2.28 | 3.60 | .596 | .508 | .202 | 2.63 | .559 | -.082 | 1 |
| 3 | LDM03B | 1902 2013 | 112 | 4 | 0 | .758 | 2.14 | 3.65 | .592 | .443 | .243 | 2.65 | .503 | .046 | 1 |
| 4 | LDM03A | 1916 2013 | 98 | 4 | 0 | .760 | 2.00 | 3.95 | .659 | .535 | .251 | 2.65 | .563 | .011 | 1 |
| 5 | LDM04B | 1895 2013 | 119 | 5 | 2 | .483 | 2.31 | 4.40 | .837 | .705 | .210 | 2.64 | .428 | -.044 | 1 |
| 6 | LDM04A | 1867 2013 | 147 | 5 | 0 | .625 | 1.53 | 3.25 | .667 | .768 | .209 | 2.71 | .527 | -.050 | 1 |
| 7 | LDM05A | 1917 2013 | 97 | 4 | 0 | .614 | 2.79 | 6.76 | 1.117 | .703 | .216 | 2.82 | .430 | -.109 | 1 |
| 8 | LDM05B | 1915 2013 | 99 | 4 | 0 | .553 | 2.30 | 5.04 | .897 | .694 | .223 | 2.61 | .522 | -.064 | 1 |
| 9 | LDM06A | 1930 2013 | 84 | 3 | 0 | .690 | 3.84 | 9.98 | 1.572 | .599 | .308 | 2.58 | .472 | -.028 | 2 |
| 10 | LDM06B | 1891 2013 | 123 | 5 | 0 | .653 | 2.11 | 5.22 | .948 | .652 | .263 | 2.67 | .507 | -.073 | 2 |
| 11 | LDM07A | 1888 2013 | 126 | 5 | 0 | .582 | 2.22 | 3.95 | .659 | .553 | .208 | 2.73 | .485 | .005 | 1 |
| 12 | LDM07B | 1892 1948 | 57 | 2 | 0 | .398 | 1.91 | 3.03 | .404 | .495 | .166 | 2.65 | .541 | .037 | 2 |
| 13 | LDM07C | 1958 2013 | 56 | 2 | 1 | .334 | 2.10 | 3.47 | .651 | .638 | .217 | 2.70 | .674 | -.067 | 1 |
| 14 | LDM08A | 1972 2013 | 42 | 1 | 0 | .461 | 3.80 | 6.76 | 1.411 | .507 | .243 | 2.71 | .509 | -.014 | 1 |
| 15 | LDM08B | 1917 2013 | 97 | 4 | 0 | .699 | 2.54 | 7.15 | 1.024 | .623 | .243 | 2.66 | .512 | -.056 | 2 |
| 16 | LDM09A | 1888 2013 | 126 | 5 | 1 | .571 | 1.75 | 3.72 | .749 | .836 | .194 | 2.63 | .483 | -.023 | 1 |
| 17 | LDM09B | 1892 2013 | 122 | 5 | 0 | .660 | 2.12 | 4.16 | .665 | .684 | .193 | 2.54 | .405 | -.021 | 1 |
| 18 | LDM10A | 1887 2013 | 127 | 5 | 0 | .559 | 1.78 | 5.05 | .797 | .770 | .224 | 2.65 | .457 | -.020 | 2 |
| 19 | LDM12A | 1877 2005 | 129 | 5 | 0 | .554 | 1.30 | 2.91 | .505 | .756 | .211 | 2.70 | .435 | -.051 | 2 |
| 20 | LDM12B | 1877 2005 | 129 | 5 | 0 | .594 | 1.31 | 3.00 | .552 | .748 | .206 | 2.93 | .477 | -.046 | 2 |
| Total or mean: | | | 2084 | 81 | 4 | .607 | 2.09 | 9.98 | .764 | .649 | .222 | 2.93 | .485 | -.030 | |

# APPENDIX D

# COFECHA PROGRAM OUTPUT FOR LILLY DICKEY SITE CHRONOLOGY, *QUERCUS ALBA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
------------------------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   lda_dated.txt

 Time span of Master dating series is  1863 to  2013   151 years
 Continuous time span is               1863 to  2013   151 years
 Portion with two or more series is    1876 to  2013   138 years


                                      ***************************************
                                      *C* Number of dated series        20 *C*
                                      *O* Master series 1863 2013  151 yrs *O*
                                      *F* Total rings in all series   2346 *F*
                                      *E* Total dated rings checked   2333 *E*
                                      *C* Series intercorrelation     .717 *C*
                                      *H* Average mean sensitivity    .245 *H*
                                      *A* Segments, possible problems    2 *A*
                                      *** Mean length of series      117.3 ***
                                      ***************************************

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

              No ring measurements of zero value
```

PART 2:  TIME PLOT OF TREE-RING SERIES:



PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | .000 | 11 | 1950 | 1.806 | 20 | 2000 | .642 | 20 | | | | | | |
| | | | 1901 | -1.116 | 13 | 1951 | 1.709 | 20 | 2001 | 1.738 | 20 | | | | | | |
| | | | 1902 | -.842 | 13 | 1952 | .182 | 20 | 2002 | .044 | 20 | | | | | | |
| | | | 1903 | .822 | 13 | 1953 | -1.024 | 20 | 2003 | -1.076 | 20 | | | | | | |
| | | | 1904 | .452 | 13 | 1954 | -1.897 | 20 | 2004 | -2.422 | 20 | | | | | | |
| | | | 1905 | .166 | 13 | 1955 | -.178 | 20 | 2005 | -.197 | 20 | | | | | | |
| | | | 1906 | .197 | 13 | 1956 | -.170 | 20 | 2006 | .623 | 20 | | | | | | |
| | | | 1907 | .435 | 13 | 1957 | 1.107 | 20 | 2007 | -1.515 | 20 | | | | | | |
| | | | 1908 | -.327 | 15 | 1958 | 1.037 | 20 | 2008 | .718 | 20 | | | | | | |
| | | | 1909 | .178 | 15 | 1959 | .198 | 20 | 2009 | .784 | 20 | | | | | | |
| | | | 1910 | .123 | 17 | 1960 | -.930 | 20 | 2010 | .847 | 20 | | | | | | |
| | | | 1911 | -1.745 | 17 | 1961 | .241 | 20 | 2011 | -.071 | 20 | | | | | | |
| | | | 1912 | .718 | 17 | 1962 | .155 | 20 | 2012 | -1.525 | 19 | | | | | | |
| 1863 | 1.838 | 1 | 1913 | -.729 | 17 | 1963 | -1.229 | 20 | 2013 | .711 | 19 | | | | | | |
| 1864 | -.410 | 1 | 1914 | -2.845 | 17 | 1964 | -1.752 | 20 | | | | | | | | | |
| 1865 | .669 | 1 | 1915 | 1.069 | 17 | 1965 | -.455 | 20 | | | | | | | | | |
| 1866 | -.626 | 1 | 1916 | 1.354 | 18 | 1966 | -1.511 | 20 | | | | | | | | | |
| 1867 | .192 | 1 | 1917 | 1.024 | 19 | 1967 | -.676 | 20 | | | | | | | | | |
| 1868 | -2.311 | 1 | 1918 | .254 | 19 | 1968 | .505 | 20 | | | | | | | | | |
| 1869 | 1.301 | 1 | 1919 | -.915 | 20 | 1969 | .298 | 20 | | | | | | | | | |
| 1870 | 1.609 | 1 | 1920 | -.632 | 20 | 1970 | -.890 | 20 | | | | | | | | | |
| 1871 | .860 | 1 | 1921 | -1.104 | 20 | 1971 | .499 | 20 | | | | | | | | | |
| 1872 | .658 | 1 | 1922 | -.722 | 20 | 1972 | -.027 | 20 | | | | | | | | | |
| 1873 | .042 | 1 | 1923 | .852 | 20 | 1973 | 1.407 | 20 | | | | | | | | | |
| 1874 | -.637 | 1 | 1924 | .780 | 20 | 1974 | .979 | 20 | | | | | | | | | |
| 1875 | -.919 | 1 | 1925 | -1.233 | 20 | 1975 | .710 | 20 | | | | | | | | | |
| 1876 | .099 | 2 | 1926 | .807 | 20 | 1976 | .840 | 20 | | | | | | | | | |
| 1877 | -.417 | 2 | 1927 | 1.318 | 20 | 1977 | -.078 | 20 | | | | | | | | | |
| 1878 | -.351 | 3 | 1928 | 1.556 | 20 | 1978 | -.091 | 20 | | | | | | | | | |
| 1879 | -.583 | 3 | 1929 | .851 | 20 | 1979 | .787 | 20 | | | | | | | | | |
| 1880 | -1.738 | 3 | 1930 | -.001 | 20 | 1980 | -1.537 | 20 | | | | | | | | | |
| 1881 | -.442 | 3 | 1931 | -.236 | 20 | 1981 | -1.190 | 20 | | | | | | | | | |
| 1882 | 1.088 | 3 | 1932 | .413 | 20 | 1982 | 1.474 | 20 | | | | | | | | | |
| 1883 | 1.371 | 3 | 1933 | -1.193 | 20 | 1983 | -.465 | 20 | | | | | | | | | |
| 1884 | 1.244 | 3 | 1934 | -.958 | 20 | 1984 | -1.480 | 20 | | | | | | | | | |
| 1885 | -.174 | 4 | 1935 | .778 | 20 | 1985 | .607 | 20 | | | | | | | | | |
| 1886 | -.078 | 5 | 1936 | -2.139 | 20 | 1986 | .844 | 20 | | | | | | | | | |
| 1887 | -1.150 | 6 | 1937 | .782 | 20 | 1987 | .126 | 20 | | | | | | | | | |
| 1888 | -1.437 | 7 | 1938 | .821 | 20 | 1988 | -2.245 | 20 | | | | | | | | | |
| 1889 | .020 | 7 | 1939 | .764 | 20 | 1989 | .756 | 20 | | | | | | | | | |
| 1890 | .596 | 7 | 1940 | -.787 | 20 | 1990 | -.535 | 20 | | | | | | | | | |
| 1891 | 1.587 | 7 | 1941 | -1.687 | 20 | 1991 | -.758 | 20 | | | | | | | | | |
| 1892 | .918 | 8 | 1942 | .064 | 20 | 1992 | 1.069 | 20 | | | | | | | | | |
| 1893 | -.594 | 8 | 1943 | -.332 | 20 | 1993 | 1.198 | 20 | | | | | | | | | |
| 1894 | .232 | 9 | 1944 | -1.521 | 20 | 1994 | -.299 | 20 | | | | | | | | | |
| 1895 | -.562 | 10 | 1945 | -.130 | 20 | 1995 | .253 | 20 | | | | | | | | | |
| 1896 | 1.264 | 10 | 1946 | .063 | 20 | 1996 | -.410 | 20 | | | | | | | | | |
| 1897 | 1.641 | 10 | 1947 | .041 | 20 | 1997 | -.385 | 20 | | | | | | | | | |
| 1898 | -.694 | 11 | 1948 | .664 | 20 | 1998 | .553 | 20 | | | | | | | | | |
| 1899 | -.110 | 11 | 1949 | 1.211 | 20 | 1999 | .206 | 20 | | | | | | | | | |

PART 4:  Master Bar Plot:

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1900-----@ | 1950----------G | 2000-------C | | | | |
| | 1901-d | 1951----------G | 2001----------G | | | | |
| | 1902--c | 1952------A | 2002-----@ | | | | |
| | 1903--------C | 1953-d | 2003-d | | | | |
| | 1904------B | 1954h | 2004j | | | | |
| | 1905------A | 1955----a | 2005----a | | | | |
| | 1906------A | 1956----a | 2006-------B | | | | |
| | 1907------B | 1957---------D | 2007f | | | | |
| | 1908---a | 1958---------D | 2008-------C | | | | |
| | 1909------A | 1959------A | 2009--------C | | | | |
| | 1910-----@ | 1960--d | 2010--------C | | | | |
| | 1911g | 1961------A | 2011----@ | | | | |
| | 1912-------C | 1962-----A | 2012f | | | | |
| 1863----------G | 1913--c | 1963-e | 2013-------C | | | | |
| 1864---b | 1914k | 1964g | | | | | |
| 1865-------C | 1915---------D | 1965---b | | | | | |
| 1866--c | 1916----------E | 1966f | | | | | |
| 1867------A | 1917---------D | 1967--c | | | | | |
| 1868i | 1918------A | 1968-------B | | | | | |
| 1869---------E | 1919--d | 1969------A | | | | | |
| 1870----------F | 1920--c | 1970--d | | | | | |
| 1871--------C | 1921-d | 1971-------B | | | | | |
| 1872-------C | 1922--c | 1972----@ | | | | | |
| 1873-----@ | 1923--------C | 1973----------F | | | | | |
| 1874--c | 1924--------C | 1974---------D | | | | | |
| 1875--d | 1925-e | 1975-------C | | | | | |
| 1876-----@ | 1926--------C | 1976--------C | | | | | |
| 1877---b | 1927---------E | 1977----@ | | | | | |
| 1878---a | 1928----------F | 1978----@ | | | | | |
| 1879--b | 1929--------C | 1979--------C | | | | | |
| 1880g | 1930-----@ | 1980f | | | | | |
| 1881---b | 1931----a | 1981-e | | | | | |
| 1882---------D | 1932------B | 1982----------F | | | | | |
| 1883----------E | 1933-e | 1983---b | | | | | |
| 1884---------E | 1934-d | 1984f | | | | | |
| 1885----a | 1935--------C | 1985-------B | | | | | |
| 1886----@ | 1936i | 1986--------C | | | | | |
| 1887-e | 1937--------C | 1987-----A | | | | | |
| 1888-f | 1938--------C | 1988i | | | | | |
| 1889-----@ | 1939--------C | 1989--------C | | | | | |
| 1890-------B | 1940--c | 1990---b | | | | | |
| 1891----------F | 1941g | 1991--c | | | | | |
| 1892--------D | 1942-----@ | 1992---------D | | | | | |
| 1893--b | 1943---a | 1993---------E | | | | | |
| 1894------A | 1944f | 1994---a | | | | | |
| 1895---b | 1945----a | 1995------A | | | | | |
| 1896---------E | 1946-----@ | 1996---b | | | | | |
| 1897----------G | 1947-----@ | 1997---b | | | | | |
| 1898--c | 1948-------C | 1998-------B | | | | | |
| 1899----@ | 1949---------E | 1999------A | | | | | |

PART 5:  CORRELATION OF SERIES BY SEGMENTS:

Correlations of  50-year dated segments, lagged  25 years

Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1875 1900 1925 1950 1975<br>1924 1949 1974 1999 2024 |
|---|---|---|---|
| 1 | LDA01A | 1898 2013 | .80 .83 .83 .75 .73 |
| 2 | LDA01B | 1894 2013 | .83 .82 .83 .78 .83 |
| 3 | LDA02A | 1887 2013 | .84 .83 .84 .72 .70 |
| 4 | LDA02A | 1917 2013 | .30B .28B .57 .77 |
| 5 | LDA03A | 1876 2013 | .54 .68 .56 .46 .63 |
| 6 | LDA03B | 1895 2013 | .75 .77 .82 .78 .70 |
| 7 | LDA04A | 1908 2013 | .79 .71 .69 .76 |
| 8 | LDA04B | 1878 2013 | .62 .80 .81 .73 .77 |
| 9 | LDA05A | 1901 2011 | .74 .76 .75 .84 |
| 10 | LDA05B | 1886 2013 | .64 .77 .77 .69 .70 |
| 11 | LDA06A | 1885 2013 | .77 .76 .59 .57 .64 |
| 12 | LDA06B | 1863 2013 | .63 .70 .69 .70 .71 |
| 13 | LDA07A | 1901 2013 | .66 .66 .55 .53 |
| 14 | LDA07B | 1910 2013 | .75 .66 .66 .68 |
| 15 | LDA08A | 1919 2013 | .87 .87 .80 .75 |
| 16 | LDA08B | 1908 2013 | .82 .83 .65 .68 |
| 17 | LDA09A | 1910 2013 | .81 .76 .67 .65 |
| 18 | LDA09B | 1892 2013 | .76 .79 .76 .69 .69 |
| 19 | LDA10A | 1916 2013 | .77 .76 .77 .76 |
| 20 | LDA10B | 1888 2013 | .76 .79 .82 .83 .77 |
| Av segment correlation | | | .72 .75 .73 .69 .71 |

PART 6: POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

LDA01A 1898 to 2013 116 years Series 1

[B] Entire series, effect on correlation ( .775) is:
Lower 1898> -.016 2003< -.012 1979< -.011 1988> -.011 1974< -.005 1981< -.005 Higher 1936 .016 1911 .008

LDA01B 1894 to 2013 120 years Series 2

[B] Entire series, effect on correlation ( .818) is:
Lower 1914> -.017 1988> -.014 1960< -.007 2003< -.006 1940> -.005 1895> -.005 Higher 1936 .018 2004 .008

LDA02A  1887 to  2013  127 years  Series  3

[B] Entire series, effect on correlation (  .778) is:
Lower  2007> -.013  1990> -.008  1984> -.008  1999< -.007  1974< -.006  1904< -.006  Higher  2004  .011  1936  .008

---

LDA02A  1917 to  2013  97 years  Series  4

[A] Segment  High  -10  -9  -8  -7  -6  -5  -4  -3  -2  -1  +0  +1  +2  +3  +4  +5  +6  +7  +8  +9  +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1917 1966 | 1 | -.06 | .19 | .24 | .13 | -.01 | -.15 | -.24 | -.12 | -.04 | -.05 | .30\| | .40* | .27 | .11 | .16 | -.06 | -.12 | -.11 | -.17 | -.29 | -.20 |
| 1925 1974 | 1 | -.04 | .21 | .10 | -.01 | .02 | -.16 | -.21 | -.07 | -.03 | -.12 | .28\| | .44* | .37 | .07 | .15 | -.05 | -.13 | -.12 | -.06 | -.25 | -.21 |

[B] Entire series, effect on correlation (  .554) is:
Lower  1936> -.059  1962< -.054  1944> -.020  1964> -.014  1939< -.012  1956> -.010  Higher  2004  .039  1988  .036
1917 to 1966 segment:
Lower  1962< -.094  1936> -.091  1944> -.034  1964> -.022  1939< -.021  1956> -.016  Higher  1950  .039  1966  .034
1925 to 1974 segment:
Lower  1962< -.090  1936> -.084  1944> -.032  1939< -.021  1964> -.020  1956> -.016  Higher  1966  .037  1950  .037

[E] Outliers  4  3.0 SD above or -4.5 SD below mean for year
1936 +4.3 SD;  1944 +3.2 SD;  1956 +3.2 SD;  1962 -4.5 SD

---

LDA03A  1876 to  2013  138 years  Series  5

[B] Entire series, effect on correlation (  .579) is:
Lower  1951< -.024  1878> -.021  1880> -.019  1903< -.014  1954> -.013  1985< -.012  Higher  1988  .020  1914  .015

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1878 +4.3 SD

---

LDA03B  1895 to  2013  119 years  Series  6

[B] Entire series, effect on correlation (  .733) is:
Lower  2011< -.014  1903< -.013  1938< -.011  2004> -.011  1896< -.010  1993< -.007  Higher  1936  .027  1911  .009

---

LDA04A  1908 to  2013  106 years  Series  7

[B] Entire series, effect on correlation (  .756) is:
Lower  1987< -.013  1971< -.010  1960> -.008  1977> -.007  2003> -.006  1945< -.006  Higher  1914  .017  2004  .017

---

LDA04B  1878 to  2013  136 years  Series  8

[B] Entire series, effect on correlation (  .726) is:
Lower  1880< -.016  1879> -.014  1961< -.013  1902< -.011  1886> -.009  1924< -.006  Higher  1936  .027  1914  .014

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1879 +3.0 SD

---

LDA05A  1901 to  2011  111 years  Series  9

```
 [B] Entire series, effect on correlation (  .769) is:
       Lower   1908< -.012   1960< -.010   1902> -.010   1975< -.006   1911> -.005   1972> -.005  Higher   2004  .015   1988  .009

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

 LDA05B    1886 to  2013     128 years                                                                                    Series  10

 [B] Entire series, effect on correlation (  .704) is:
       Lower   1900< -.026   1888> -.018   1886< -.012   1999< -.010   1975< -.009   1994> -.007  Higher   1936  .016   1914  .015

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1888 +3.6 SD;    2008 +3.0 SD
==========================================================================================================================================

 LDA06A    1885 to  2013     129 years                                                                                    Series  11

 [B] Entire series, effect on correlation (  .708) is:
       Lower   1972< -.016   1969< -.015   1998< -.011   1971< -.008   1973< -.007   1919> -.006  Higher   1914  .014   1988  .012

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

 LDA06B    1863 to  2013     151 years                                                                                    Series  12

 [*] Early part of series cannot be checked from 1863 to 1875 -- not matched by another series

 [B] Entire series, effect on correlation (  .679) is:
       Lower   2004> -.011   1879< -.010   1911> -.010   1878< -.009   1953> -.008   1972< -.007  Higher   1936  .020   1914  .019

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       2003 -4.6 SD
==========================================================================================================================================

 LDA07A    1901 to  2013     113 years                                                                                    Series  13

 [B] Entire series, effect on correlation (  .613) is:
       Lower   1966> -.022   1984< -.022   1988> -.018   1973< -.010   1901> -.010   2013< -.009  Higher   2004  .019   1936  .009

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1966 +3.4 SD;    1988 +3.5 SD
==========================================================================================================================================

 LDA07B    1910 to  2013     104 years                                                                                    Series  14

 [B] Entire series, effect on correlation (  .706) is:
       Lower   1936> -.015   1923< -.009   1973< -.009   1970> -.009   1962< -.009   1966> -.008  Higher   1914  .025   1988  .018

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

 LDA08A    1919 to  2013      95 years                                                                                    Series  15

 [B] Entire series, effect on correlation (  .808) is:
       Lower   1980> -.021   2004> -.014   2009< -.012   1960> -.008   2008< -.007   2003> -.004  Higher   1936  .022   1988  .012

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

 LDA08B    1908 to  2013     106 years                                                                                    Series  16

 [B] Entire series, effect on correlation (  .750) is:
```

```
      Lower   1980> -.034   2009< -.019   1997< -.013   1953< -.006   1981> -.005   1959< -.004  Higher   1936  .023   2004  .014

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1980 +3.6 SD
================================================================================================================================================

 LDA09A    1910 to  2013     104 years                                                                                          Series  17

 [B] Entire series, effect on correlation (  .697) is:
      Lower   1963> -.020   2005< -.015   2012> -.014   1960> -.007   1911> -.006   1948< -.006  Higher   1936  .036   1954  .008

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1963 +3.0 SD
================================================================================================================================================

 LDA09B    1892 to  2013     122 years                                                                                          Series  18

 [B] Entire series, effect on correlation (  .691) is:
      Lower   1963> -.024   2004> -.018   1911> -.010   1960> -.010   2002< -.009   1906< -.007  Higher   1936  .033   1980  .012

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1963 +3.5 SD
================================================================================================================================================

 LDA10A    1916 to  2013      98 years                                                                                          Series  19

 [B] Entire series, effect on correlation (  .753) is:
      Lower   2003> -.011   1991> -.010   2007> -.009   1963> -.008   1934> -.008   1935< -.008  Higher   2004  .016   1980  .012

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

 LDA10B    1888 to  2013     126 years                                                                                          Series  20

 [B] Entire series, effect on correlation (  .765) is:
      Lower   2004< -.011   2003> -.011   1909< -.007   1912< -.006   1888< -.005   1986< -.005  Higher   1911  .008   1980  .008

================================================================================================================================================
PART 7:  DESCRIPTIVE STATISTICS:
------------------------------------------------------------------------------------------------------------------------------------------------

                                                 Corr   //-------- Unfiltered --------\\  //---- Filtered -----\\
                          No.    No.    No.      with   Mean    Max     Std    Auto   Mean   Max     Std    Auto   AR
 Seq Series   Interval   Years  Segmt  Flags    Master  msmt    msmt    dev    corr   sens   value   dev    corr   ()
 --- -------- ---------  -----  -----  -----    ------ -----   -----   -----  -----  -----  -----  -----  -----  --
   1 LDA01A   1898 2013    116      5      0     .775   1.79    3.25    .566   .556   .243   2.55   .371   -.012   2
   2 LDA01B   1894 2013    120      5      0     .818   1.54    3.90    .555   .670   .229   2.57   .536    .002   2
   3 LDA02A   1887 2013    127      5      0     .778   2.28    5.37    .814   .505   .280   2.64   .470   -.036   2
   4 LDA02A   1917 2013     97      4      2     .554   1.94    3.42    .631   .523   .249   2.62   .519    .010   1
   5 LDA03A   1876 2013    138      5      0     .579   1.88    3.95    .557   .523   .226   2.59   .395   -.056   4
   6 LDA03B   1895 2013    119      5      0     .733   1.73    3.47    .594   .646   .217   2.70   .500   -.047   1
   7 LDA04A   1908 2013    106      4      0     .756   2.90    7.42   1.336   .804   .234   2.58   .457    .009   1
   8 LDA04B   1878 2013    136      5      0     .726   2.48    9.21   1.248   .728   .251   2.65   .450   -.039   1
   9 LDA05A   1901 2011    111      4      0     .769   1.90    3.11    .564   .593   .230   2.62   .515   -.049   1
  10 LDA05B   1886 2013    128      5      0     .704   2.23    4.03    .697   .545   .236   2.87   .549   -.037   2
  11 LDA06A   1885 2013    129      5      0     .708   1.88    3.98    .569   .450   .257   2.55   .382    .000   2
  12 LDA06B   1863 2013    151      5      0     .679   1.55    3.02    .507   .518   .264   2.65   .393   -.066   2
  13 LDA07A   1901 2013    113      4      0     .613   2.28    5.06    .781   .696   .188   2.67   .432   -.018   1
  14 LDA07B   1910 2013    104      4      0     .706   2.38    6.01    .862   .622   .225   2.79   .506   -.066   1
```

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 | LDA08A | 1919 | 2013 | 95 | 4 | 0 | .808 | 2.28 | 4.29 | .742 | .432 | .279 | 2.76 | .535 | -.045 | 1 |
| 16 | LDA08B | 1908 | 2013 | 106 | 4 | 0 | .750 | 1.67 | 4.87 | .752 | .581 | .279 | 2.98 | .615 | -.029 | 1 |
| 17 | LDA09A | 1910 | 2013 | 104 | 4 | 0 | .697 | 1.86 | 4.45 | .746 | .535 | .278 | 2.73 | .450 | -.027 | 2 |
| 18 | LDA09B | 1892 | 2013 | 122 | 5 | 0 | .691 | 1.21 | 2.86 | .550 | .627 | .290 | 2.69 | .461 | -.034 | 2 |
| 19 | LDA10A | 1916 | 2013 | 98 | 4 | 0 | .753 | 1.91 | 3.72 | .504 | .348 | .223 | 2.72 | .443 | -.024 | 1 |
| 20 | LDA10B | 1888 | 2013 | 126 | 5 | 0 | .765 | 2.08 | 3.40 | .525 | .427 | .212 | 2.43 | .346 | -.045 | 1 |
| Total or mean: | | | | 2346 | 91 | 2 | .717 | 1.98 | 9.21 | .702 | .567 | .245 | 2.98 | .462 | -.031 | |

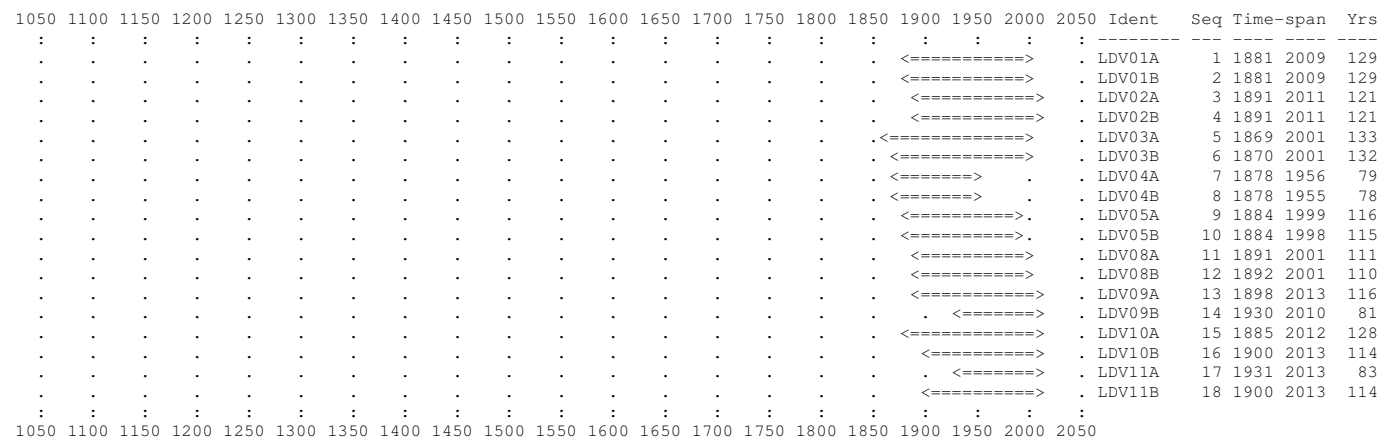
# APPENDIX E

## COFECHA PROGRAM OUTPUT FOR LILLY DICKEY SITE CHRONOLOGY,

## *QUERCUS VELATINA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
------------------------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   ldv_dated.txt

 Time span of Master dating series is  1869 to  2013   145 years
 Continuous time span is               1869 to  2013   145 years
 Portion with two or more series is    1870 to  2013   144 years


                                     ****************************************
                                     *C* Number of dated series        18 *C*
                                     *O* Master series 1869 2013  145 yrs *O*
                                     *F* Total rings in all series   2010 *F*
                                     *E* Total dated rings checked   2009 *E*
                                     *C* Series intercorrelation     .638 *C*
                                     *H* Average mean sensitivity    .199 *H*
                                     *A* Segments, possible problems    0 *A*
                                     *** Mean length of series      111.7 ***
                                     ****************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | .023 | 16 | 1950 | 1.762 | 18 | 2000 | .320 | 14 | | | | | | |
| | | | 1901 | -.690 | 16 | 1951 | 1.665 | 18 | 2001 | 1.254 | 14 | | | | | | |
| | | | 1902 | .114 | 16 | 1952 | .560 | 18 | 2002 | .128 | 10 | | | | | | |
| | | | 1903 | .466 | 16 | 1953 | -.570 | 18 | 2003 | -.562 | 10 | | | | | | |
| | | | 1904 | .940 | 16 | 1954 | -1.359 | 18 | 2004 | -2.522 | 10 | | | | | | |
| | | | 1905 | .112 | 16 | 1955 | -.832 | 18 | 2005 | -.204 | 10 | | | | | | |
| | | | 1906 | .303 | 16 | 1956 | -.463 | 17 | 2006 | 1.199 | 10 | | | | | | |
| | | | 1907 | 1.055 | 16 | 1957 | 1.288 | 16 | 2007 | -1.122 | 10 | | | | | | |
| | | | 1908 | -.016 | 16 | 1958 | 1.218 | 16 | 2008 | .132 | 10 | | | | | | |
| | | | 1909 | .135 | 16 | 1959 | .642 | 16 | 2009 | .122 | 10 | | | | | | |
| | | | 1910 | .035 | 16 | 1960 | -1.005 | 16 | 2010 | 1.470 | 8 | | | | | | |
| | | | 1911 | -1.332 | 16 | 1961 | -.248 | 16 | 2011 | .133 | 7 | | | | | | |
| | | | 1912 | .320 | 16 | 1962 | -.318 | 16 | 2012 | -1.556 | 5 | | | | | | |
| | | | 1913 | -1.192 | 16 | 1963 | .335 | 16 | 2013 | -.173 | 4 | | | | | | |
| | | | 1914 | -2.327 | 16 | 1964 | -1.308 | 16 | | | | | | | | | |
| | | | 1915 | .854 | 16 | 1965 | -.152 | 16 | | | | | | | | | |
| | | | 1916 | 1.650 | 16 | 1966 | -.668 | 16 | | | | | | | | | |
| | | | 1917 | 1.021 | 16 | 1967 | -.671 | 16 | | | | | | | | | |
| | | | 1918 | .387 | 16 | 1968 | -.283 | 16 | | | | | | | | | |
| 1869 | .943 | 1 | 1919 | -.695 | 16 | 1969 | .542 | 16 | | | | | | | | | |
| 1870 | -4.363 | 2 | 1920 | -.941 | 16 | 1970 | -.405 | 16 | | | | | | | | | |
| 1871 | .299 | 2 | 1921 | -.516 | 16 | 1971 | .913 | 16 | | | | | | | | | |
| 1872 | -.782 | 2 | 1922 | -.698 | 16 | 1972 | -.226 | 16 | | | | | | | | | |
| 1873 | 1.228 | 2 | 1923 | -.363 | 16 | 1973 | .883 | 16 | | | | | | | | | |
| 1874 | -.162 | 2 | 1924 | .717 | 16 | 1974 | 1.204 | 16 | | | | | | | | | |
| 1875 | -.257 | 2 | 1925 | -.520 | 16 | 1975 | 1.566 | 16 | | | | | | | | | |
| 1876 | 1.419 | 2 | 1926 | .646 | 16 | 1976 | 1.347 | 16 | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1877 | .850 | 2 | 1927 | 1.779 | 16 | 1977 | .249 | 16 |
| 1878 | .424 | 4 | 1928 | 2.132 | 16 | 1978 | .356 | 16 |
| 1879 | -.669 | 4 | 1929 | 1.210 | 16 | 1979 | .053 | 16 |
| 1880 | .940 | 4 | 1930 | .016 | 17 | 1980 | -1.723 | 16 |
| 1881 | .820 | 6 | 1931 | -.427 | 18 | 1981 | -1.960 | 16 |
| 1882 | .732 | 6 | 1932 | -.192 | 18 | 1982 | .810 | 16 |
| 1883 | -.049 | 6 | 1933 | -.828 | 18 | 1983 | -.824 | 16 |
| 1884 | .232 | 8 | 1934 | -1.092 | 18 | 1984 | -1.545 | 16 |
| 1885 | .461 | 9 | 1935 | .496 | 18 | 1985 | .062 | 16 |
| 1886 | -.592 | 9 | 1936 | -1.786 | 18 | 1986 | 1.010 | 16 |
| 1887 | -1.803 | 9 | 1937 | -.313 | 18 | 1987 | .545 | 16 |
| 1888 | -1.083 | 9 | 1938 | 1.575 | 18 | 1988 | -1.657 | 16 |
| 1889 | -.907 | 9 | 1939 | 1.112 | 18 | 1989 | .633 | 16 |
| 1890 | .381 | 9 | 1940 | -.543 | 18 | 1990 | -.443 | 16 |
| 1891 | .936 | 12 | 1941 | -1.268 | 18 | 1991 | -.817 | 16 |
| 1892 | .799 | 13 | 1942 | -.375 | 18 | 1992 | 1.123 | 16 |
| 1893 | -.009 | 13 | 1943 | -.290 | 18 | 1993 | .787 | 16 |
| 1894 | -.092 | 13 | 1944 | -1.353 | 18 | 1994 | -.723 | 16 |
| 1895 | -1.361 | 13 | 1945 | -.274 | 18 | 1995 | .563 | 16 |
| 1896 | .474 | 13 | 1946 | -.665 | 18 | 1996 | -.149 | 16 |
| 1897 | 1.180 | 13 | 1947 | .348 | 18 | 1997 | -.946 | 16 |
| 1898 | -1.086 | 14 | 1948 | .621 | 18 | 1998 | .667 | 16 |
| 1899 | -.065 | 14 | 1949 | .902 | 18 | 1999 | .779 | 15 |

PART 4: Master Bar Plot:

```
   Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value
                   1900-----@      1950----------G 2000------A
                   1901--c         1951----------G 2001---------E
                   1902-----@      1952-------B    2002-----A
                   1903-------B    1953--b         2003--b
                   1904--------D   1954-e          2004j
                   1905-----@      1955--c         2005----a
                   1906------A     1956---b        2006---------E
                   1907---------D  1957---------E  2007-d
                   1908-----@      1958---------E  2008-----A
                   1909-----A      1959-------C    2009-----@
                   1910-----@      1960-d          2010----------F
                   1911-e          1961----a       2011-----A
                   1912------A     1962---a        2012f
                   1913-e          1963------A     2013----a
                   1914i           1964-e
                   1915--------C   1965----a
                   1916----------G 1966--c
                   1917---------D  1967--c
                   1918------B     1968----a
   1869--------D   1919--c         1969-------B
   1870q           1920-d          1970---b
   1871------A     1921---b        1971--------D
   1872--c         1922--c         1972----a
   1873---------E  1923---a        1973--------D
   1874----a       1924--------C   1974---------E
   1875----a       1925---b        1975----------F
   1876----------F 1926-------C    1976----------E
   1877--------C   1927----------G 1977------A
   1878------B     1928----------I 1978------A
```

```
1879--c          1929----------E  1979-----@
1880--------D    1930-----@       1980g
1881--------C    1931---b         1981h
1882--------C    1932----a        1982--------C
1883-----@       1933--c          1983--c
1884------A      1934-d           1984f
1885-------B     1935-------B     1985-----@
1886--b          1936g            1986----------D
1887g            1937---a         1987-------B
1888-d           1938----------F  1988g
1889-d           1939----------D  1989-------C
1890------B      1940---b         1990---b
1891--------D    1941-e           1991--c
1892--------C    1942---a         1992----------D
1893-----@       1943----a        1993--------C
1894----@        1944-e           1994--c
1895-e           1945----a        1995-------B
1896--------B    1946--c          1996----a
1897---------E   1947------A      1997-d
1898-d           1948-------B     1998-------C
1899-----@       1949--------D    1999--------C
```

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|
| 1 | LDV01A | 1881 2009 | | .48 | .76 | .75 | .73 | .69 |
| 2 | LDV01B | 1881 2009 | | .47 | .70 | .72 | .53 | .53 |
| 3 | LDV02A | 1891 2011 | | .77 | .75 | .60 | .56 | .51 |
| 4 | LDV02B | 1891 2011 | | .79 | .77 | .55 | .50 | .48 |
| 5 | LDV03A | 1869 2001 | .70 | .50 | .67 | .61 | .54 | .53 |
| 6 | LDV03B | 1870 2001 | .77 | .53 | .64 | .65 | .53 | .53 |
| 7 | LDV04A | 1878 1956 | | .58 | .68 | .67 | | |
| 8 | LDV04B | 1878 1955 | | .61 | .74 | .70 | | |
| 9 | LDV05A | 1884 1999 | | .62 | .68 | .65 | .54 | |
| 10 | LDV05B | 1884 1998 | | .59 | .60 | .47 | .50 | |
| 11 | LDV08A | 1891 2001 | | .47 | .70 | .70 | .73 | .72 |
| 12 | LDV08B | 1892 2001 | | .67 | .70 | .66 | .65 | .63 |
| 13 | LDV09A | 1898 2013 | | .82 | .80 | .74 | .62 | .66 |
| 14 | LDV09B | 1930 2010 | | | | .74 | .74 | .75 |
| 15 | LDV10A | 1885 2012 | | .79 | .78 | .76 | .73 | .74 |
| 16 | LDV10B | 1900 2013 | | | .70 | .64 | .62 | .68 |
| 17 | LDV11A | 1931 2013 | | | | .60 | .63 | .70 |
| 18 | LDV11B | 1900 2013 | | | .51 | .65 | .69 | .71 |
| Av segment correlation | | | .74 | .62 | .70 | .66 | .61 | .63 |

PART 6: POTENTIAL PROBLEMS:

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

```
 [B] Effect of those data values which most lower or raise correlation with master series
     Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

 [C] Year-to-year changes very different from the mean change in other series

 [D] Absent rings (zero values)

 [E] Values which are statistical outliers from mean for the year
=============================================================================================================================================

 LDV01A    1881 to  2009     129 years                                                                                        Series   1

 [B] Entire series, effect on correlation (  .650) is:
       Lower   1898> -.029   1882< -.018   1960> -.015   1883> -.015   1889> -.010   1983> -.008  Higher   1988  .013   1964  .012

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1898 +3.3 SD;    1899 +3.8 SD
=============================================================================================================================================

 LDV01B    1881 to  2009     129 years                                                                                        Series   2

 [B] Entire series, effect on correlation (  .559) is:
       Lower   1993< -.052   1898> -.033   1960> -.017   1883> -.014   1912< -.012   1909< -.011  Higher   1980  .020   1964  .013

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1898 +4.2 SD
=============================================================================================================================================

 LDV02A    1891 to  2011     121 years                                                                                        Series   3

 [B] Entire series, effect on correlation (  .598) is:
       Lower   1960< -.023   2005< -.014   1900< -.012   1997> -.012   2006< -.010   2010< -.009  Higher   1898  .014   1936  .013

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

 LDV02B    1891 to  2011     121 years                                                                                        Series   4

 [B] Entire series, effect on correlation (  .569) is:
       Lower   1960< -.051   2005< -.014   1964> -.013   2006< -.011   1994> -.008   2004> -.008  Higher   1936  .016   1914  .011

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1960 1961   4.1 SD

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1960 -6.2 SD
=============================================================================================================================================

 LDV03A    1869 to  2001     133 years                                                                                        Series   5

 [*] Early part of series cannot be checked from 1869 to 1869 -- not matched by another series

 [B] Entire series, effect on correlation (  .644) is:
       Lower   1883< -.064   1960> -.017   1981> -.016   1998< -.012   1936> -.009   1997> -.007  Higher   1870  .092   1898  .008

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1883 -4.8 SD;    1960 +3.1 SD;    1981 +3.0 SD
=============================================================================================================================================
```

```
 LDV03B    1870 to  2001     132 years                                                                                  Series   6

 [B] Entire series, effect on correlation (  .688) is:
       Lower   1883< -.020   1981> -.015   1997> -.011   1998< -.010   1911> -.007   1908> -.007  Higher   1870  .101   1988  .011

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1883 -4.5 SD;    1885 +3.1 SD
================================================================================================================================

 LDV04A    1878 to  1956      79 years                                                                                  Series   7

 [B] Entire series, effect on correlation (  .596) is:
       Lower   1883> -.021   1896< -.019   1956< -.015   1892< -.011   1944> -.010   1937> -.009  Higher   1914  .032   1898  .019

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

 LDV04B    1878 to  1955      78 years                                                                                  Series   8

 [B] Entire series, effect on correlation (  .610) is:
       Lower   1883> -.028   1892< -.024   1953> -.022   1896< -.021   1880< -.015   1952< -.012  Higher   1914  .037   1898  .026

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1883 +3.0 SD;    1937 +3.0 SD
================================================================================================================================

 LDV05A    1884 to  1999     116 years                                                                                  Series   9

 [B] Entire series, effect on correlation (  .595) is:
       Lower   1991< -.035   1960> -.018   1898> -.016   1952< -.011   1984> -.009   1997> -.009  Higher   1936  .025   1988  .024

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1896 +3.3 SD
================================================================================================================================

 LDV05B    1884 to  1998     115 years                                                                                  Series  10

 [B] Entire series, effect on correlation (  .532) is:
       Lower   1952< -.024   1955< -.020   1960> -.018   1937< -.014   1944> -.012   1914> -.011  Higher   1988  .028   1936  .023

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1896 +3.7 SD
================================================================================================================================

 LDV08A    1891 to  2001     111 years                                                                                  Series  11

 [B] Entire series, effect on correlation (  .617) is:
       Lower   1891< -.059   1897< -.035   1925> -.011   1990> -.008   1972> -.008   1979> -.008  Higher   1980  .021   1914  .019

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1891 -4.6 SD
================================================================================================================================

 LDV08B    1892 to  2001     110 years                                                                                  Series  12

 [B] Entire series, effect on correlation (  .667) is:
       Lower   1997< -.010   1979> -.008   1984> -.008   1971< -.007   1974< -.007   1936> -.007  Higher   1980  .018   1914  .018

================================================================================================================================
```

LDV09A  1898 to  2013  116 years  Series 13

[B] Entire series, effect on correlation (  .730) is:
Lower  1981< -.031  1980> -.016  1946< -.012  1964> -.009  1987< -.009  1900> -.006  Higher  1936  .014  2004  .012

---

LDV09B  1930 to  2010  81 years  Series 14

[B] Entire series, effect on correlation (  .735) is:
Lower  1988> -.021  1998< -.018  1977< -.011  1997< -.009  1930> -.009  1991> -.006  Higher  2004  .025  1964  .011

---

LDV10A  1885 to  2012  128 years  Series 15

[B] Entire series, effect on correlation (  .747) is:
Lower  2004< -.013  1939< -.008  1895> -.007  1976< -.007  1942< -.007  1983> -.006  Higher  1936  .009  2007  .008

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
2004 -4.6 SD

---

LDV10B  1900 to  2013  114 years  Series 16

[B] Entire series, effect on correlation (  .690) is:
Lower  1964> -.023  1988> -.018  1921> -.011  1900> -.011  1965< -.010  1954< -.010  Higher  2004  .020  1936  .018

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
1900 +3.2 SD;  1921 +3.3 SD

---

LDV11A  1931 to  2013  83 years  Series 17

[B] Entire series, effect on correlation (  .651) is:
Lower  1963< -.031  1964> -.013  1951< -.012  1947< -.011  1981> -.010  1965< -.007  Higher  1936  .030  1980  .023

---

LDV11B  1900 to  2013  114 years  Series 18

[B] Entire series, effect on correlation (  .617) is:
Lower  1902< -.049  1901> -.022  1929< -.016  1963< -.015  1980> -.010  1967< -.009  Higher  1936  .025  2007  .015

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1901 +4.0 SD

---

[*] All segments correlate highest as dated with correlation with master series over  .3281

PART 7:  DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | LDV01A | 1881 | 2009 | 129 | 5 | 0 | .650 | 1.89 | 7.13 | .785 | .677 | .187 | 2.72 | .452 | .007 | 1 |
| 2 | LDV01B | 1881 | 2009 | 129 | 5 | 0 | .559 | 1.90 | 6.86 | .772 | .690 | .184 | 2.68 | .477 | -.086 | 2 |
| 3 | LDV02A | 1891 | 2011 | 121 | 5 | 0 | .598 | 2.02 | 4.50 | .790 | .801 | .198 | 2.56 | .396 | .011 | 1 |
| 4 | LDV02B | 1891 | 2011 | 121 | 5 | 0 | .569 | 2.00 | 4.29 | .805 | .806 | .199 | 2.42 | .327 | -.030 | 1 |
| 5 | LDV03A | 1869 | 2001 | 133 | 6 | 0 | .644 | 2.16 | 4.72 | .770 | .768 | .174 | 2.58 | .410 | -.074 | 1 |
| 6 | LDV03B | 1870 | 2001 | 132 | 6 | 0 | .688 | 2.17 | 4.58 | .756 | .765 | .167 | 2.52 | .350 | -.021 | 2 |
| 7 | LDV04A | 1878 | 1956 | 79 | 3 | 0 | .596 | 1.72 | 3.08 | .605 | .611 | .232 | 2.70 | .450 | -.046 | 1 |
| 8 | LDV04B | 1878 | 1955 | 78 | 3 | 0 | .610 | 1.70 | 2.95 | .558 | .549 | .254 | 2.70 | .536 | -.055 | 1 |
| 9 | LDV05A | 1884 | 1999 | 116 | 4 | 0 | .595 | 1.41 | 2.29 | .410 | .762 | .155 | 2.75 | .462 | -.011 | 1 |
| 10 | LDV05B | 1884 | 1998 | 115 | 4 | 0 | .532 | 1.40 | 2.47 | .430 | .729 | .176 | 2.82 | .469 | .007 | 1 |
| 11 | LDV08A | 1891 | 2001 | 111 | 5 | 0 | .617 | 3.61 | 8.50 | 1.714 | .849 | .187 | 2.53 | .475 | -.022 | 1 |
| 12 | LDV08B | 1892 | 2001 | 110 | 5 | 0 | .667 | 3.61 | 8.86 | 1.747 | .852 | .186 | 2.70 | .498 | -.006 | 1 |
| 13 | LDV09A | 1898 | 2013 | 116 | 5 | 0 | .730 | 2.30 | 4.61 | .856 | .798 | .192 | 2.56 | .402 | -.043 | 2 |
| 14 | LDV09B | 1930 | 2010 | 81 | 3 | 0 | .735 | 1.71 | 3.00 | .461 | .461 | .227 | 2.71 | .483 | .007 | 2 |
| 15 | LDV10A | 1885 | 2012 | 128 | 5 | 0 | .747 | 1.66 | 4.93 | .658 | .738 | .210 | 2.55 | .340 | -.028 | 2 |
| 16 | LDV10B | 1900 | 2013 | 114 | 4 | 0 | .690 | 1.76 | 5.17 | .761 | .748 | .226 | 2.71 | .547 | -.010 | 1 |
| 17 | LDV11A | 1931 | 2013 | 83 | 3 | 0 | .651 | 2.81 | 5.30 | .850 | .450 | .257 | 2.58 | .528 | -.046 | 2 |
| 18 | LDV11B | 1900 | 2013 | 114 | 4 | 0 | .617 | 2.50 | 4.88 | .749 | .528 | .230 | 2.75 | .553 | -.079 | 1 |
| Total or mean: | | | | 2010 | 80 | 0 | .638 | 2.13 | 8.86 | .811 | .713 | .199 | 2.82 | .447 | -.029 | |

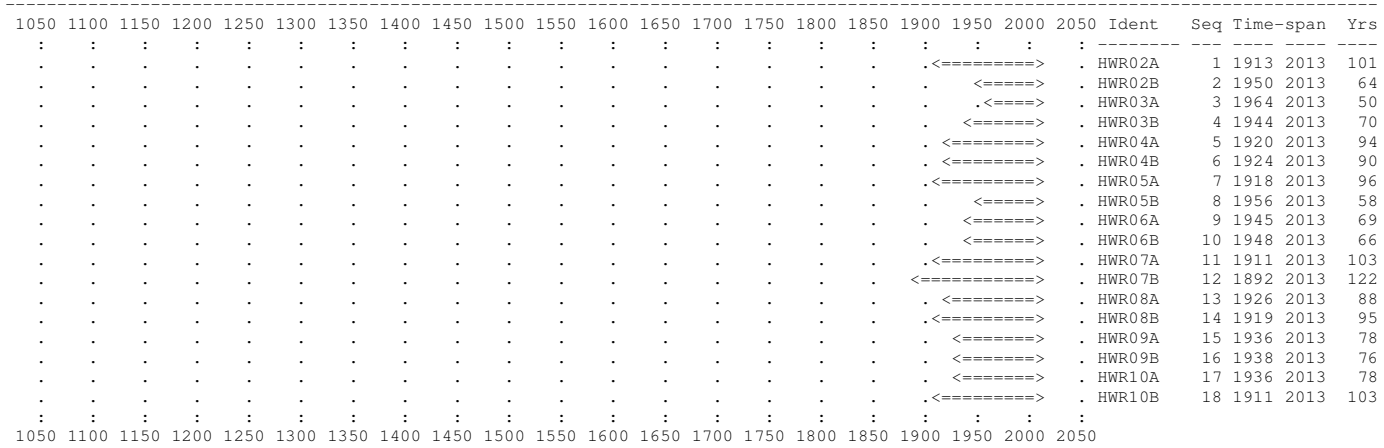
# APPENDIX F

# COFECHA PROGRAM OUTPUT FOR HOOT WOODS SITE CHRONOLOGY,

# QUERCUS RUBRA, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                    Version 6.06P    29368
------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   hwr_dated.txt

 Time span of Master dating series is  1892 to  2013   122 years
 Continuous time span is               1892 to  2013   122 years
 Portion with two or more series is    1911 to  2013   103 years


                                    ****************************************
                                    *C* Number of dated series        18 *C*
                                    *O* Master series 1892 2013  122 yrs *O*
                                    *F* Total rings in all series   1501 *F*
                                    *E* Total dated rings checked   1482 *E*
                                    *C* Series intercorrelation     .606 *C*
                                    *H* Average mean sensitivity    .189 *H*
                                    *A* Segments, possible problems    1 *A*
                                    *** Mean length of series       83.4 ***
                                    ****************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | .572 | 1 | 1950 | .892 | 16 | 2000 | .010 | 18 | | | | | | |
| | | | 1901 | 1.187 | 1 | 1951 | .258 | 16 | 2001 | 1.131 | 18 | | | | | | |
| | | | 1902 | .923 | 1 | 1952 | -.624 | 16 | 2002 | 1.141 | 18 | | | | | | |
| | | | 1903 | 2.890 | 1 | 1953 | -1.526 | 16 | 2003 | 1.400 | 18 | | | | | | |
| | | | 1904 | .666 | 1 | 1954 | -1.481 | 16 | 2004 | .905 | 18 | | | | | | |
| | | | 1905 | .518 | 1 | 1955 | .518 | 16 | 2005 | .364 | 18 | | | | | | |
| | | | 1906 | -.916 | 1 | 1956 | 1.196 | 17 | 2006 | -.171 | 18 | | | | | | |
| | | | 1907 | -1.362 | 1 | 1957 | 1.945 | 17 | 2007 | -.410 | 18 | | | | | | |
| | | | 1908 | -1.653 | 1 | 1958 | .491 | 17 | 2008 | .132 | 18 | | | | | | |
| | | | 1909 | .289 | 1 | 1959 | -.556 | 17 | 2009 | -.023 | 18 | | | | | | |
| | | | 1910 | .494 | 1 | 1960 | .552 | 17 | 2010 | .727 | 18 | | | | | | |
| | | | 1911 | -.285 | 3 | 1961 | .064 | 17 | 2011 | .012 | 18 | | | | | | |
| | | | 1912 | .497 | 3 | 1962 | -.185 | 17 | 2012 | -1.982 | 18 | | | | | | |
| | | | 1913 | -2.136 | 4 | 1963 | -.624 | 17 | 2013 | -.102 | 18 | | | | | | |
| | | | 1914 | -1.913 | 4 | 1964 | -.019 | 18 | | | | | | | | | |
| | | | 1915 | 1.253 | 4 | 1965 | 1.185 | 18 | | | | | | | | | |
| | | | 1916 | 1.663 | 4 | 1966 | -.612 | 18 | | | | | | | | | |
| | | | 1917 | -.015 | 4 | 1967 | -1.423 | 18 | | | | | | | | | |
| | | | 1918 | .708 | 5 | 1968 | 1.085 | 18 | | | | | | | | | |
| | | | 1919 | -.944 | 6 | 1969 | .442 | 18 | | | | | | | | | |
| | | | 1920 | .250 | 7 | 1970 | -1.149 | 18 | | | | | | | | | |
| | | | 1921 | -.030 | 7 | 1971 | -.587 | 18 | | | | | | | | | |
| | | | 1922 | .505 | 7 | 1972 | -.718 | 18 | | | | | | | | | |
| | | | 1923 | .082 | 7 | 1973 | .080 | 18 | | | | | | | | | |
| | | | 1924 | .748 | 8 | 1974 | .519 | 18 | | | | | | | | | |
| | | | 1925 | .512 | 8 | 1975 | .125 | 18 | | | | | | | | | |
| | | | 1926 | .795 | 9 | 1976 | -.147 | 18 | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 1927 | -1.169 | 9 | | 1977 | -.558 | 18 | |
| | | | | 1928 | .740 | 9 | | 1978 | 1.202 | 18 | |
| | | | | 1929 | .599 | 9 | | 1979 | .924 | 18 | |
| | | | | 1930 | -1.558 | 9 | | 1980 | .614 | 18 | |
| | | | | 1931 | -.497 | 9 | | 1981 | -1.374 | 18 | |
| | | | | 1932 | .410 | 9 | | 1982 | .178 | 18 | |
| | | | | 1933 | -1.602 | 9 | | 1983 | -.879 | 18 | |
| | | | | 1934 | .416 | 9 | | 1984 | -.597 | 18 | |
| | | | | 1935 | 1.192 | 9 | | 1985 | 1.174 | 18 | |
| | | | | 1936 | -1.795 | 11 | | 1986 | .390 | 18 | |
| | | | | 1937 | 1.481 | 11 | | 1987 | 1.207 | 18 | |
| | | | | 1938 | 1.670 | 12 | | 1988 | -.925 | 18 | |
| | | | | 1939 | .376 | 12 | | 1989 | .312 | 18 | |
| | | | | 1940 | -.450 | 12 | | 1990 | .626 | 18 | |
| | | | | 1941 | -.447 | 12 | | 1991 | .346 | 18 | |
| 1892 | .076 | 1 | | 1942 | .445 | 12 | | 1992 | .876 | 18 | |
| 1893 | -.395 | 1 | | 1943 | -.875 | 12 | | 1993 | -1.348 | 18 | |
| 1894 | -3.309 | 1 | | 1944 | -1.238 | 13 | | 1994 | -1.133 | 18 | |
| 1895 | -.531 | 1 | | 1945 | -.070 | 14 | | 1995 | -.409 | 18 | |
| 1896 | -1.744 | 1 | | 1946 | -.987 | 14 | | 1996 | -1.478 | 18 | |
| 1897 | -.461 | 1 | | 1947 | 1.260 | 14 | | 1997 | -1.280 | 18 | |
| 1898 | 1.258 | 1 | | 1948 | .267 | 15 | | 1998 | .010 | 18 | |
| 1899 | .554 | 1 | | 1949 | .342 | 15 | | 1999 | .033 | 18 | |

PART 4: Master Bar Plot:

| Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1900 | -------B | 1950 | --------D | 2000 | ----@ | | | | | | | | |
| | | 1901 | ---------E | 1951 | ------A | 2001 | ---------E | | | | | | | | |
| | | 1902 | --------D | 1952 | --b | 2002 | ---------E | | | | | | | | |
| | | 1903 | ----------L | 1953 | f | 2003 | ----------F | | | | | | | | |
| | | 1904 | --------C | 1954 | f | 2004 | --------D | | | | | | | | |
| | | 1905 | -------B | 1955 | -------B | 2005 | ------A | | | | | | | | |
| | | 1906 | --d | 1956 | ---------E | 2006 | ----a | | | | | | | | |
| | | 1907 | -e | 1957 | ----------H | 2007 | ---b | | | | | | | | |
| | | 1908 | g | 1958 | -------B | 2008 | -----A | | | | | | | | |
| | | 1909 | ------A | 1959 | --b | 2009 | ----@ | | | | | | | | |
| | | 1910 | -------B | 1960 | -------B | 2010 | --------C | | | | | | | | |
| | | 1911 | ---a | 1961 | -----@ | 2011 | ----@ | | | | | | | | |
| | | 1912 | -------B | 1962 | ----a | 2012 | h | | | | | | | | |
| | | 1913 | i | 1963 | --b | 2013 | ----@ | | | | | | | | |
| | | 1914 | h | 1964 | ----@ | | | | | | | | | | |
| | | 1915 | ---------E | 1965 | ---------E | | | | | | | | | | |
| | | 1916 | ----------G | 1966 | --b | | | | | | | | | | |
| | | 1917 | ----@ | 1967 | -f | | | | | | | | | | |
| | | 1918 | --------C | 1968 | ---------D | | | | | | | | | | |
| | | 1919 | -d | 1969 | ------B | | | | | | | | | | |
| | | 1920 | -----A | 1970 | -e | | | | | | | | | | |
| | | 1921 | ----@ | 1971 | --b | | | | | | | | | | |
| | | 1922 | -------B | 1972 | --c | | | | | | | | | | |
| | | 1923 | -----@ | 1973 | -----@ | | | | | | | | | | |
| | | 1924 | --------C | 1974 | -------B | | | | | | | | | | |
| | | 1925 | -------B | 1975 | -----@ | | | | | | | | | | |
| | | 1926 | --------C | 1976 | ----a | | | | | | | | | | |
| | | 1927 | -e | 1977 | --b | | | | | | | | | | |

```
                  1928--------C   1978---------E
                  1929-------B    1979--------D
                  1930f           1980-------B
                  1931---b        1981-e
                  1932------B     1982-----A
                  1933f           1983--d
                  1934------B     1984--b
                  1935---------E  1985---------E
                  1936g           1986------B
                  1937----------F 1987---------E
                  1938----------G 1988--d
                  1939------B     1989------A
                  1940---b        1990--------C
                  1941---b        1991------A
   1892-----@     1942------B     1992--------D
   1893---b       1943--c         1993-e
   1894m          1944-e          1994-e
   1895---b       1945----@       1995---b
   1896g          1946-d          1996f
   1897---b       1947---------E  1997-e
   1898---------E 1948------A     1998----@
   1899-------B   1949------A     1999----@
```

PART 5:  CORRELATION OF SERIES BY SEGMENTS:

Correlations of  50-year dated segments, lagged  25 years
Flags:  A = correlation under   .3281 but highest as dated;  B = correlation higher at other than dated position

| Seq | Series | Time_span | 1900 1925 1950 1975 1949 1974 1999 2024 | | | |
|---|---|---|---|---|---|---|
| 1 | HWR02A | 1913 2013 | .80 | .83 | .76 | .75 |
| 2 | HWR02B | 1950 2013 | | | .49 | .44 |
| 3 | HWR03A | 1964 2013 | | | .63 | |
| 4 | HWR03B | 1944 2013 | | .44 | .36 | .37 |
| 5 | HWR04A | 1920 2013 | .58 | .52 | .46 | .54 |
| 6 | HWR04B | 1924 2013 | .67 | .67 | .72 | .78 |
| 7 | HWR05A | 1918 2013 | .65 | .63 | .57 | .47 |
| 8 | HWR05B | 1956 2013 | | | .66 | .72 |
| 9 | HWR06A | 1945 2013 | | .66 | .64 | .71 |
| 10 | HWR06B | 1948 2013 | | .52 | .51 | .56 |
| 11 | HWR07A | 1911 2013 | .57 | .47 | .45 | .34 |
| 12 | HWR07B | 1892 2013 | .66 | .61 | .43 | .41 |
| 13 | HWR08A | 1926 2013 | | .60 | .50 | .48 |
| 14 | HWR08B | 1919 2013 | .69 | .74 | .69 | .76 |
| 15 | HWR09A | 1936 2013 | | .32A | .61 | .43 |
| 16 | HWR09B | 1938 2013 | | .64 | .61 | .72 |
| 17 | HWR10A | 1936 2013 | | .76 | .77 | .85 |
| 18 | HWR10B | 1911 2013 | .70 | .73 | .73 | .79 |
| Av segment correlation | | | .66 | .61 | .59 | .60 |

PART 6:  POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

HWR02A  1913 to  2013  101 years  Series  1

[B] Entire series, effect on correlation (  .775) is:
  Lower  1988< -.014  1914> -.012  1921> -.010  1967> -.009  1923< -.008  2013< -.006  Higher  1936  .019  1913  .014

HWR02B  1950 to  2013  64 years  Series  2

[B] Entire series, effect on correlation (  .459) is:
  Lower  1970> -.053  2004< -.043  2011< -.032  1954> -.030  1992< -.018  2007> -.015  Higher  1993  .060  2012  .036

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
  1970 +4.0 SD;  1971 +4.0 SD

HWR03A  1964 to  2013  50 years  Series  3

[B] Entire series, effect on correlation (  .628) is:
  Lower  2012> -.037  1993> -.033  1998< -.014  2011< -.008  2009> -.008  1967> -.006  Higher  1996  .019  1970  .017

HWR03B  1944 to  2013  70 years  Series  4

[B] Entire series, effect on correlation (  .461) is:
  Lower  1988> -.090  1989< -.032  1998< -.027  2003< -.019  2009> -.011  1994> -.011  Higher  2012  .059  1996  .026

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
  1988 +4.9 SD

HWR04A  1920 to  2013  94 years  Series  5

[B] Entire series, effect on correlation (  .546) is:
  Lower  1970> -.034  1978< -.020  1952< -.014  2003< -.014  1926< -.013  1927> -.012  Higher  2012  .044  1930  .018

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
  1962 +3.2 SD;  1970 +4.4 SD

```
HWR04B    1924 to  2013      90 years                                                                                                  Series   6

[B] Entire series, effect on correlation (  .729) is:
      Lower   1933< -.013   1970> -.012   1955< -.011   1935< -.010   1971< -.009   1952< -.008  Higher   1981  .010   1957  .007

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

HWR05A    1918 to  2013      96 years                                                                                                  Series   7

[B] Entire series, effect on correlation (  .591) is:
      Lower   1974< -.026   2007< -.021   1924< -.019   2012> -.017   1966> -.017   1973< -.010  Higher   1936  .044   1993  .014

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1920 +3.4 SD
================================================================================================================================================

HWR05B    1956 to  2013      58 years                                                                                                  Series   8

[B] Entire series, effect on correlation (  .688) is:
      Lower   1988> -.028   1971< -.027   1959< -.016   1960< -.013   2007< -.009   1996> -.008  Higher   2012  .060   1981  .019

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

HWR06A    1945 to  2013      69 years                                                                                                  Series   9

[B] Entire series, effect on correlation (  .673) is:
      Lower   1993> -.034   1952> -.018   1963< -.015   1959> -.011   1978< -.007   1994> -.006  Higher   1981  .019   1988  .018

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

HWR06B    1948 to  2013      66 years                                                                                                  Series  10

[B] Entire series, effect on correlation (  .553) is:
      Lower   1953> -.030   1986< -.027   1993> -.020   2011> -.011   1987< -.011   2009< -.010  Higher   2012  .059   1970  .015

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

HWR07A    1911 to  2013     103 years                                                                                                  Series  11

[B] Entire series, effect on correlation (  .455) is:
      Lower   2012> -.039   1969< -.022   1933> -.016   1995> -.012   1954> -.011   1945< -.010  Higher   1993  .032   1913  .022

[E] Outliers     4   3.0 SD above or -4.5 SD below mean for year
      1971 +3.2 SD;    1995 +4.7 SD;    1996 +3.1 SD;    2012 +4.0 SD
================================================================================================================================================

HWR07B    1892 to  2013     122 years                                                                                                  Series  12

[*] Early part of series cannot be checked from 1892 to 1910 -- not matched by another series

[B] Entire series, effect on correlation (  .546) is:
      Lower   1945< -.025   1988> -.022   1987< -.021   1946> -.020   1952> -.015   1986< -.013  Higher   1993  .025   1933  .023

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1952 +3.6 SD;    1971 +3.8 SD
================================================================================================================================================

HWR08A    1926 to  2013      88 years                                                                                                  Series  13
```

```
 [B] Entire series, effect on correlation (  .554) is:
       Lower   2009< -.051   1961< -.017   1968< -.016   1943> -.013   1965< -.012   1945< -.011  Higher   1936  .025   2012  .018

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

 HWR08B    1919 to  2013      95 years                                                                                    Series  14

 [B] Entire series, effect on correlation (  .705) is:
       Lower   1921< -.019   1920< -.013   1919> -.010   1961< -.010   1963> -.009   1952> -.009  Higher   1936  .028   1993  .015

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

 HWR09A    1936 to  2013      78 years                                                                                    Series  15

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1936 1985    0    .06 -.07  .08  .13 -.12 -.20  .03 -.17 -.17  .21  .32* .16  .13  .07 -.17 -.17 -.29  .18 -.10  .14  .02

 [B] Entire series, effect on correlation (  .331) is:
       Lower   1936> -.069   1937< -.036   2012> -.028   2001< -.022   1968< -.019   2008< -.018  Higher   1988  .046   1993  .026
     1936 to 1985 segment:
       Lower   1936> -.120   1937< -.065   1968< -.034   1946> -.023   1953> -.014   1942< -.010  Higher   1970  .040   1978  .030

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1936 1937  -4.7 SD

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1936 +4.1 SD;    2012 +3.3 SD
==========================================================================================================================================

 HWR09B    1938 to  2013      76 years                                                                                    Series  16

 [B] Entire series, effect on correlation (  .648) is:
       Lower   1993> -.031   1954> -.027   1953> -.019   2001< -.018   1962< -.017   1942< -.014  Higher   2012  .050   1988  .023

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

 HWR10A    1936 to  2013      78 years                                                                                    Series  17

 [B] Entire series, effect on correlation (  .791) is:
       Lower   1952< -.019   1955< -.014   1945> -.010   2000> -.009   1953> -.009   2009> -.006  Higher   1936  .022   2012  .018

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

 HWR10B    1911 to  2013     103 years                                                                                    Series  18

 [B] Entire series, effect on correlation (  .722) is:
       Lower   1933> -.017   1911> -.015   1976< -.015   1928< -.014   1963> -.012   1921> -.010  Higher   1913  .018   1936  .016

==========================================================================================================================================
```

PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HWR02A | 1913 2013 | 101 | 4 | 0 | .775 | 3.02 | 6.33 | 1.178 | .661 | .216 | 2.69 | .456 | -.055 | 1 |
| 2 | HWR02B | 1950 2013 | 64 | 2 | 0 | .459 | 4.09 | 7.17 | 1.196 | .707 | .191 | 2.61 | .590 | .075 | 1 |
| 3 | HWR03A | 1964 2013 | 50 | 1 | 0 | .628 | 5.31 | 8.86 | 1.882 | .772 | .193 | 2.51 | .456 | -.025 | 1 |
| 4 | HWR03B | 1944 2013 | 70 | 3 | 0 | .461 | 3.57 | 7.00 | 1.442 | .876 | .155 | 2.71 | .501 | .019 | 1 |
| 5 | HWR04A | 1920 2013 | 94 | 4 | 0 | .546 | 3.11 | 5.69 | 1.012 | .751 | .180 | 2.57 | .416 | -.009 | 1 |
| 6 | HWR04B | 1924 2013 | 90 | 4 | 0 | .729 | 3.16 | 5.70 | 1.121 | .741 | .207 | 2.56 | .411 | -.062 | 2 |
| 7 | HWR05A | 1918 2013 | 96 | 4 | 0 | .591 | 2.87 | 5.35 | .685 | .560 | .172 | 2.80 | .505 | -.057 | 1 |
| 8 | HWR05B | 1956 2013 | 58 | 2 | 0 | .688 | 4.38 | 7.02 | 1.187 | .665 | .166 | 2.55 | .485 | .028 | 1 |
| 9 | HWR06A | 1945 2013 | 69 | 3 | 0 | .673 | 3.80 | 6.22 | .981 | .535 | .202 | 2.62 | .574 | -.045 | 2 |
| 10 | HWR06B | 1948 2013 | 66 | 3 | 0 | .553 | 3.47 | 5.95 | 1.028 | .764 | .172 | 2.56 | .472 | -.103 | 3 |
| 11 | HWR07A | 1911 2013 | 103 | 4 | 0 | .455 | 2.91 | 5.32 | .758 | .548 | .179 | 2.78 | .491 | -.035 | 2 |
| 12 | HWR07B | 1892 2013 | 122 | 4 | 0 | .546 | 2.58 | 4.14 | .670 | .576 | .184 | 2.66 | .511 | .052 | 1 |
| 13 | HWR08A | 1926 2013 | 88 | 3 | 0 | .554 | 3.15 | 6.42 | 1.161 | .795 | .158 | 2.76 | .512 | -.010 | 1 |
| 14 | HWR08B | 1919 2013 | 95 | 4 | 0 | .705 | 3.08 | 5.85 | 1.274 | .793 | .199 | 2.64 | .452 | -.029 | 2 |
| 15 | HWR09A | 1936 2013 | 78 | 3 | 1 | .331 | 3.55 | 7.86 | 1.873 | .928 | .148 | 2.76 | .527 | -.060 | 1 |
| 16 | HWR09B | 1938 2013 | 76 | 3 | 0 | .648 | 3.45 | 6.96 | 1.384 | .858 | .169 | 2.55 | .473 | -.068 | 1 |
| 17 | HWR10A | 1936 2013 | 78 | 3 | 0 | .791 | 3.56 | 8.53 | 1.561 | .541 | .283 | 2.68 | .526 | -.022 | 2 |
| 18 | HWR10B | 1911 2013 | 103 | 4 | 0 | .722 | 2.75 | 4.89 | .717 | .405 | .216 | 2.73 | .572 | -.017 | 2 |
| Total or mean: | | | 1501 | 58 | 1 | .606 | 3.31 | 8.86 | 1.124 | .681 | .189 | 2.80 | .495 | -.023 | |

# APPENDIX G

## COFECHA PROGRAM OUTPUT FOR HOOT WOODS SITE CHRONOLOGY,

## *FRAXINUS AMERICANA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
------------------------------------------------------------------------------------------------------------------------------------------

QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

File of DATED series:   hwf_dated.txt

Time span of Master dating series is  1854 to  2013   160 years
Continuous time span is               1854 to  2013   160 years
Portion with two or more series is    1890 to  2013   124 years


                                    ****************************************
                                    *C* Number of dated series        20 *C*
                                    *O* Master series 1854 2013  160 yrs *O*
                                    *F* Total rings in all series   1910 *F*
                                    *E* Total dated rings checked   1874 *E*
                                    *C* Series intercorrelation     .529 *C*
                                    *H* Average mean sensitivity    .240 *H*
                                    *A* Segments, possible problems    6 *A*
                                    *** Mean length of series       95.5 ***
                                    ****************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:

```
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 Ident    Seq Time-span  Yrs
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <========>    . HWF01A     1 1923 2013   91
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>    . HWF01B     2 1906 2013  108
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>   . HWF02A     3 1854 2013  160
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>    . HWF02B     4 1909 2013  105
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>    . HWF04A     5 1903 2013  111
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <===========>    . HWF04B     6 1892 2013  122
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>    . HWF05A     7 1900 2013  114
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <===========>    . HWF05B     8 1893 2013  121
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <===========>    . HWF06A     9 1890 2013  124
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <=======>    . HWF06B    10 1930 2013   84
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=========>    . HWF07A    11 1916 2013   98
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=========>    . HWF07B    12 1915 2013   99
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<====>    . HWF08A    13 1968 2013   46
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>    . HWF08B    14 1949 2013   65
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>    . HWF09A    15 1941 2013   73
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=========>    . HWF10A    16 1914 2013  100
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>    . HWF10B    17 1940 2013   74
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>    . HWF11A    18 1905 2013  109
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<====>    . HWF12A    19 1960 2013   54
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<====>    . HWF12B    20 1962 2013   52
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050
```

PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | -.203 | 5 | 1950 | .755 | 17 | 2000 | -.379 | 20 | | | | | | |
| | | | 1901 | -.422 | 5 | 1951 | 1.276 | 17 | 2001 | .185 | 20 | | | | | | |
| | | | 1902 | .711 | 5 | 1952 | 1.004 | 17 | 2002 | 1.486 | 20 | | | | | | |
| | | | 1903 | -.186 | 6 | 1953 | -.321 | 17 | 2003 | .063 | 20 | | | | | | |
| 1854 | -.300 | 1 | 1904 | 1.522 | 6 | 1954 | -.673 | 17 | 2004 | -.118 | 20 | | | | | | |
| 1855 | .623 | 1 | 1905 | 1.415 | 7 | 1955 | .422 | 17 | 2005 | -.130 | 20 | | | | | | |
| 1856 | -1.278 | 1 | 1906 | .558 | 8 | 1956 | .880 | 17 | 2006 | .749 | 20 | | | | | | |
| 1857 | 1.773 | 1 | 1907 | .023 | 8 | 1957 | .365 | 17 | 2007 | -.597 | 20 | | | | | | |
| 1858 | -.284 | 1 | 1908 | .199 | 8 | 1958 | 1.262 | 17 | 2008 | -.644 | 20 | | | | | | |
| 1859 | 1.476 | 1 | 1909 | .476 | 9 | 1959 | .459 | 17 | 2009 | -.592 | 20 | | | | | | |
| 1860 | 2.225 | 1 | 1910 | -.534 | 9 | 1960 | .371 | 18 | 2010 | .931 | 20 | | | | | | |
| 1861 | -1.246 | 1 | 1911 | -1.841 | 9 | 1961 | -.981 | 18 | 2011 | -.058 | 20 | | | | | | |
| 1862 | -.214 | 1 | 1912 | 1.343 | 9 | 1962 | -.805 | 19 | 2012 | -1.787 | 20 | | | | | | |
| 1863 | -.800 | 1 | 1913 | -.106 | 9 | 1963 | -.281 | 19 | 2013 | 1.215 | 20 | | | | | | |
| 1864 | -1.864 | 1 | 1914 | -1.582 | 10 | 1964 | .002 | 19 | | | | | | | | | |
| 1865 | -2.523 | 1 | 1915 | 1.175 | 11 | 1965 | -.624 | 19 | | | | | | | | | |
| 1866 | 2.180 | 1 | 1916 | .894 | 12 | 1966 | -.008 | 19 | | | | | | | | | |
| 1867 | 1.115 | 1 | 1917 | -.058 | 12 | 1967 | -1.087 | 19 | | | | | | | | | |
| 1868 | .319 | 1 | 1918 | -.227 | 12 | 1968 | .327 | 20 | | | | | | | | | |
| 1869 | .819 | 1 | 1919 | -.667 | 12 | 1969 | .283 | 20 | | | | | | | | | |
| 1870 | 1.325 | 1 | 1920 | .589 | 12 | 1970 | -1.414 | 20 | | | | | | | | | |
| 1871 | -1.189 | 1 | 1921 | -.846 | 12 | 1971 | .881 | 20 | | | | | | | | | |
| 1872 | 2.205 | 1 | 1922 | -.381 | 12 | 1972 | -.626 | 20 | | | | | | | | | |
| 1873 | -.225 | 1 | 1923 | -.736 | 13 | 1973 | 2.132 | 20 | | | | | | | | | |
| 1874 | -1.399 | 1 | 1924 | .643 | 13 | 1974 | 1.297 | 20 | | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1875 | .033 | 1 | 1925 | -.427 | 13 | 1975 | .192 | 20 |
| 1876 | 1.007 | 1 | 1926 | .193 | 13 | 1976 | .238 | 20 |
| 1877 | -.288 | 1 | 1927 | .962 | 13 | 1977 | -.375 | 20 |
| 1878 | -.431 | 1 | 1928 | 1.689 | 13 | 1978 | -.339 | 20 |
| 1879 | 1.163 | 1 | 1929 | -.348 | 13 | 1979 | -.135 | 20 |
| 1880 | -.805 | 1 | 1930 | -1.076 | 14 | 1980 | 1.069 | 20 |
| 1881 | -.831 | 1 | 1931 | -.236 | 14 | 1981 | .133 | 20 |
| 1882 | -1.227 | 1 | 1932 | .601 | 14 | 1982 | .731 | 20 |
| 1883 | 3.326 | 1 | 1933 | -.535 | 14 | 1983 | -.392 | 20 |
| 1884 | .274 | 1 | 1934 | -1.078 | 14 | 1984 | -.560 | 20 |
| 1885 | -.248 | 1 | 1935 | .539 | 14 | 1985 | -.777 | 20 |
| 1886 | -1.135 | 1 | 1936 | -1.346 | 14 | 1986 | -.468 | 20 |
| 1887 | -1.436 | 1 | 1937 | .900 | 14 | 1987 | -1.012 | 20 |
| 1888 | -2.510 | 1 | 1938 | 1.600 | 14 | 1988 | -2.000 | 20 |
| 1889 | -.655 | 1 | 1939 | .822 | 14 | 1989 | -.922 | 20 |
| 1890 | -2.010 | 2 | 1940 | .298 | 15 | 1990 | 1.094 | 20 |
| 1891 | .022 | 2 | 1941 | -.544 | 16 | 1991 | -1.169 | 20 |
| 1892 | .241 | 3 | 1942 | .797 | 16 | 1992 | .833 | 20 |
| 1893 | -.321 | 4 | 1943 | -.021 | 16 | 1993 | 1.091 | 20 |
| 1894 | -.249 | 4 | 1944 | -.927 | 16 | 1994 | -.096 | 20 |
| 1895 | -1.618 | 4 | 1945 | .098 | 16 | 1995 | -.437 | 20 |
| 1896 | .108 | 4 | 1946 | -1.448 | 16 | 1996 | .093 | 20 |
| 1897 | .700 | 4 | 1947 | -.783 | 16 | 1997 | -.021 | 20 |
| 1898 | -.329 | 4 | 1948 | -.972 | 16 | 1998 | 1.598 | 20 |
| 1899 | .228 | 4 | 1949 | -.730 | 17 | 1999 | .875 | 20 |

PART 4: Master Bar Plot:

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1900----a | 1950--------C | 2000---b | | | | |
| | 1901---b | 1951---------E | 2001------A | | | | |
| | 1902--------C | 1952---------D | 2002----------F | | | | |
| | 1903----a | 1953----a | 2003-----@ | | | | |
| 1854----a | 1904----------F | 1954--c | 2004-----@ | | | | |
| 1855-------B | 1905----------F | 1955-------B | 2005-----a | | | | |
| 1856-e | 1906-------B | 1956--------D | 2006--------C | | | | |
| 1857----------G | 1907-----@ | 1957-------A | 2007--b | | | | |
| 1858----a | 1908------A | 1958---------E | 2008--c | | | | |
| 1859----------F | 1909-------B | 1959-------B | 2009--b | | | | |
| 1860----------I | 1910---b | 1960-------A | 2010--------D | | | | |
| 1861-e | 1911g | 1961-d | 2011-----@ | | | | |
| 1862----a | 1912---------E | 1962--c | 2012g | | | | |
| 1863--c | 1913-----@ | 1963----a | 2013---------E | | | | |
| 1864g | 1914f | 1964-----@ | | | | | |
| 1865j | 1915---------E | 1965--b | | | | | |
| 1866----------I | 1916--------D | 1966-----@ | | | | | |
| 1867---------D | 1917-----@ | 1967-d | | | | | |
| 1868------A | 1918----a | 1968-------A | | | | | |
| 1869--------C | 1919--c | 1969------A | | | | | |
| 1870---------E | 1920-------B | 1970f | | | | | |
| 1871-e | 1921--c | 1971--------D | | | | | |
| 1872----------I | 1922---b | 1972--c | | | | | |
| 1873----a | 1923--c | 1973----------I | | | | | |
| 1874f | 1924--------C | 1974---------E | | | | | |
| 1875-----@ | 1925---b | 1975------A | | | | | |
| 1876---------D | 1926------A | 1976------A | | | | | |

```
  1877----a       1927--------D   1977---a
  1878---b        1928----------G 1978----a
  1879---------E  1929----a       1979-----a
  1880--c         1930-d          1980---------D
  1881--c         1931----a       1981------A
  1882-e          1932-------B    1982--------C
  1883----------M 1933---b        1983---b
  1884------A     1934-d          1984---b
  1885----a       1935-------B    1985--c
  1886-e          1936-e          1986---b
  1887f           1937--------D   1987-d
  1888j           1938----------F 1988h
  1889--c         1939--------C   1989-d
  1890h           1940------A     1990---------D
  1891-----@      1941---b        1991-e
  1892------A     1942--------C   1992--------C
  1893----a       1943-----@      1993---------D
  1894----a       1944-d          1994-----@
  1895f           1945------@     1995---b
  1896------@     1946f           1996------@
  1897--------C   1947--c         1997-----@
  1898----a       1948-d          1998----------F
  1899------A     1949--c         1999--------C
```

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|
| 1 | HWF01A | 1923 2013 | | .27B | .27B | .33B | .43 |
| 2 | HWF01B | 1906 2013 | | .37 | .39 | .51 | .49 |
| 3 | HWF02A | 1854 2013 | .47 | .58 | .58 | .68 | .62 |
| 4 | HWF02B | 1909 2013 | | .67 | .58 | .50 | .54 |
| 5 | HWF04A | 1903 2013 | | .74 | .80 | .61 | .46 |
| 6 | HWF04B | 1892 2013 | .61 | .68 | .74 | .68 | .59 |
| 7 | HWF05A | 1900 2013 | | .60 | .46 | .24B | .40 |
| 8 | HWF05B | 1893 2013 | .35 | .51 | .48 | .24A | .37 |
| 9 | HWF06A | 1890 2013 | .37 | .58 | .68 | .64 | .65 |
| 10 | HWF06B | 1930 2013 | | | .70 | .70 | .68 |
| 11 | HWF07A | 1916 2013 | | .46 | .57 | .56 | .70 |
| 12 | HWF07B | 1915 2013 | | .53 | .68 | .69 | .77 |
| 13 | HWF08A | 1968 2013 | | | | .60 | |
| 14 | HWF08B | 1949 2013 | | | .51 | .52 | .49 |
| 15 | HWF09A | 1941 2013 | | | .56 | .60 | .64 |
| 16 | HWF10A | 1914 2013 | | .75 | .59 | .46B | .44 |
| 17 | HWF10B | 1940 2013 | | | .70 | .65 | .62 |
| 18 | HWF11A | 1905 2013 | | .41 | .50 | .52 | .44 |
| 19 | HWF12A | 1960 2013 | | | | .36 | .53 |
| 20 | HWF12B | 1962 2013 | | | | .54 | .58 |
| Av segment correlation | | | .45 | .55 | .58 | .53 | .55 |

PART 6: POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

HWF01A 1923 to 2013 91 years Series 1

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1923 1972 | 7 | -.14 | .07 | .20 | -.08 | -.04 | -.23 | -.08 | -.23 | -.17 | -.20 | .27\|-.11 | .14 | -.09 | -.06 | .32 | .09 | .34*-.01 | | -.05 | | -.05 |
| 1925 1974 | 5 | -.09 | .02 | .18 | -.08 | -.06 | -.20 | -.11 | -.22 | -.15 | -.17 | .27\|-.08 | .13 | -.13 | -.12 | .36* | .14 | .35 | -.03 | -.02 | | -.03 |
| 1950 1999 | 2 | .07 | -.11 | .16 | -.09 | -.22 | .02 | -.23 | .15 | -.15 | .00 | .33\|-.06 | .45*-.03 | | -.21 | .26 | .10 | -.04 | -.02 | .12 | | -.25 |

[B] Entire series, effect on correlation ( .339) is:
Lower 1946> -.039 1998< -.034 1967> -.028 1986< -.021 1942< -.017 1982< -.013 Higher 2012 .032 1970 .027
1923 to 1972 segment:
Lower 1946> -.076 1967> -.054 1942< -.036 1930> -.023 1938< -.021 1960< -.019 Higher 1970 .066 1928 .038
1925 to 1974 segment:
Lower 1946> -.075 1967> -.055 1942< -.032 1930> -.023 1938< -.018 1960< -.017 Higher 1970 .064 1928 .035
1950 to 1999 segment:
Lower 1998< -.057 1967> -.054 1986< -.030 1995> -.023 1982< -.021 1981> -.017 Higher 1970 .050 1991 .042

[E] Outliers 3 3.0 SD above or -4.5 SD below mean for year
1946 +3.7 SD; 1967 +4.1 SD; 2001 +3.2 SD

HWF01B 1906 to 2013 108 years Series 2

[B] Entire series, effect on correlation ( .440) is:
Lower 1939< -.022 1915< -.021 1921> -.013 1965< -.013 2004> -.013 1932< -.013 Higher 1991 .026 1911 .023

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1921 +3.1 SD; 2004 +4.3 SD

HWF02A 1854 to 2013 160 years Series 3

[*] Early part of series cannot be checked from 1854 to 1889 -- not matched by another series

[B] Entire series, effect on correlation ( .527) is:
Lower 1890> -.042 1898> -.025 2003< -.015 1948> -.012 1970> -.011 1897> -.011 Higher 1988 .023 1991 .017

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1898 +4.1 SD; 1949 +3.2 SD

HWF02B  1909 to  2013  105 years  Series  4

[B] Entire series, effect on correlation (  .586) is:
Lower  1995< -.023  1970> -.019  1987> -.015  1948> -.013  1988> -.012  1932< -.011  Higher  2012  .020  1991  .019

---

HWF04A  1903 to  2013  111 years  Series  5

[B] Entire series, effect on correlation (  .595) is:
Lower  1988> -.023  2008< -.021  2012> -.020  2006< -.017  1975< -.014  1964< -.009  Higher  1946  .015  1973  .013

---

HWF04B  1892 to  2013  122 years  Series  6

[B] Entire series, effect on correlation (  .618) is:
Lower  1970> -.012  1894< -.011  1893> -.010  2007> -.010  1902< -.009  1898> -.008  Higher  1911  .016  1895  .013

---

HWF05A  1900 to  2013  114 years  Series  7

[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  -8  .00  .06  .33* .09  .08  .02 -.37 -.20 -.03 -.15  .24|-.14 -.14 -.12 -.28 -.05 -.05  .25  .20  .14  .30

[B] Entire series, effect on correlation (  .449) is:
Lower  1988> -.039  1951< -.024  1954< -.022  1991> -.018  1948> -.015  1946> -.011  Higher  2012  .023  1914  .021
1950 to 1999 segment:
Lower  1988> -.078  1951< -.043  1991> -.034  1986> -.018  1996< -.016  1985> -.015  Higher  1973  .064  1992  .029

[E] Outliers  3  3.0 SD above or -4.5 SD below mean for year
1948 +3.2 SD;  1988 +4.0 SD;  1992 +3.0 SD

---

HWF05B  1893 to  2013  121 years  Series  8

[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  0  -.29  .06  .17  .10 -.04 -.03 -.09 -.01  .06 -.09  .24*-.11  .09 -.04 -.02  .00 -.09  .03 -.08 -.02  .23

[B] Entire series, effect on correlation (  .354) is:
Lower  1897< -.037  1898< -.035  1914> -.029  1957< -.026  1988> -.024  1987> -.024  Higher  1895  .022  2002  .014
1950 to 1999 segment:
Lower  1957< -.071  1987> -.057  1988> -.050  1990< -.038  1962> -.021  1968< -.019  Higher  1973  .040  1998  .039

[E] Outliers  5  3.0 SD above or -4.5 SD below mean for year
1898 -4.9 SD;  1914 +3.9 SD;  1962 +3.1 SD;  1987 +4.1 SD;  1988 +4.0 SD

---

HWF06A  1890 to  2013  124 years  Series  9

[B] Entire series, effect on correlation (  .500) is:
Lower  1895> -.049  1963< -.022  2000< -.014  1912< -.012  1890< -.012  1894> -.009  Higher  1988  .020  1973  .018

[E] Outliers  3  3.0 SD above or -4.5 SD below mean for year
1895 +4.5 SD;  1902 +3.1 SD;  1963 -4.5 SD

```
================================================================================================================================================

 HWF06B    1930 to  2013      84 years                                                                                          Series  10

 [B] Entire series, effect on correlation (  .686) is:
       Lower   2013< -.017   1963< -.014   2003> -.013   2008> -.012   1958< -.011   1964> -.011  Higher   1988  .020   1973  .017

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

 HWF07A    1916 to  2013      98 years                                                                                          Series  11

 [B] Entire series, effect on correlation (  .601) is:
       Lower   1977< -.035   1950< -.017   1951< -.015   1919> -.014   1957> -.010   1928< -.009  Higher   2012  .024   1988  .023

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

 HWF07B    1915 to  2013      99 years                                                                                          Series  12

 [B] Entire series, effect on correlation (  .671) is:
       Lower   1916< -.022   1950< -.019   1928< -.014   1919< -.011   1962> -.010   1918> -.010  Higher   1988  .021   1991  .016

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

 HWF08A    1968 to  2013      46 years                                                                                          Series  13

 [B] Entire series, effect on correlation (  .603) is:
       Lower   2001< -.036   1983> -.022   1992< -.018   1985> -.013   1973< -.010   2005< -.010  Higher   2012  .048   1998  .020

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1982 +3.0 SD
================================================================================================================================================

 HWF08B    1949 to  2013      65 years                                                                                          Series  14

 [B] Entire series, effect on correlation (  .472) is:
       Lower   2000> -.052   1951< -.021   1981< -.020   2006< -.014   1969< -.010   1998< -.009  Higher   1973  .032   2013  .017

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       2000 +4.6 SD
================================================================================================================================================

 HWF09A    1941 to  2013      73 years                                                                                          Series  15

 [B] Entire series, effect on correlation (  .588) is:
       Lower   1956< -.038   2008> -.030   1971< -.019   1974< -.018   1961> -.017   1965> -.015  Higher   1988  .024   1970  .023

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       2008 +3.4 SD
================================================================================================================================================

 HWF10A    1914 to  2013     100 years                                                                                          Series  16

 [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    6   -.12 -.21 -.13 -.08 -.16 -.07 -.19  .07  .03  .03  .46| .17 -.04  .06  .16 -.02  .48*-.17  .14  .01 -.33

 [B] Entire series, effect on correlation (  .569) is:
       Lower   1964< -.082   1982< -.026   2012> -.012   1966< -.011   2001< -.009   1920< -.008  Higher   1936  .017   1973  .017
```

```
     1950 to 1999 segment:
       Lower   1964< -.135   1982< -.045   1966< -.016   1955< -.014   1965> -.013   1962> -.012  Higher   1973  .038   1998  .033

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1964 -4.9 SD
================================================================================================================================================

 HWF10B    1940 to  2013      74 years                                                                                          Series  17

 [B] Entire series, effect on correlation (  .653) is:
       Lower   1993< -.019   2001< -.012   1943> -.009   1956< -.009   2010< -.009   1978> -.008  Higher   1946  .018   1973  .014

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

 HWF11A    1905 to  2013     109 years                                                                                          Series  18

 [B] Entire series, effect on correlation (  .440) is:
       Lower   1990< -.033   1944> -.017   1935< -.014   1937< -.014   2007> -.014   1907< -.012  Higher   1991  .024   1946  .022

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

 HWF12A    1960 to  2013      54 years                                                                                          Series  19

 [B] Entire series, effect on correlation (  .406) is:
       Lower   1960< -.082   1987> -.033   1961> -.026   1965> -.019   1994> -.018   2008> -.013  Higher   1988  .045   2012  .032

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1965 +3.1 SD;    1994 +3.4 SD
================================================================================================================================================

 HWF12B    1962 to  2013      52 years                                                                                          Series  20

 [B] Entire series, effect on correlation (  .568) is:
       Lower   2000> -.031   1969< -.024   1962< -.015   1991> -.013   1965> -.012   1967> -.010  Higher   1988  .024   2012  .018

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1970 -4.5 SD
================================================================================================================================================
```

PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HWF01A | 1923 2013 | 91 | 4 | 3 | .339 | 2.39 | 5.55 | .976 | .779 | .201 | 2.80 | .536 | -.008 | 1 |
| 2 | HWF01B | 1906 2013 | 108 | 4 | 0 | .440 | 2.93 | 5.88 | 1.278 | .790 | .219 | 2.82 | .503 | -.026 | 1 |
| 3 | HWF02A | 1854 2013 | 160 | 5 | 0 | .527 | 1.99 | 4.95 | 1.250 | .848 | .270 | 3.02 | .566 | -.037 | 1 |
| 4 | HWF02B | 1909 2013 | 105 | 4 | 0 | .586 | 2.43 | 5.91 | 1.305 | .817 | .260 | 2.75 | .547 | -.048 | 1 |
| 5 | HWF04A | 1903 2013 | 111 | 4 | 0 | .595 | 2.13 | 3.98 | .639 | .532 | .217 | 2.75 | .522 | .032 | 1 |
| 6 | HWF04B | 1892 2013 | 122 | 5 | 0 | .618 | 2.89 | 5.38 | .918 | .531 | .236 | 2.68 | .503 | .015 | 1 |
| 7 | HWF05A | 1900 2013 | 114 | 4 | 1 | .449 | 2.33 | 5.55 | 1.071 | .752 | .195 | 2.74 | .461 | .034 | 1 |
| 8 | HWF05B | 1893 2013 | 121 | 5 | 1 | .354 | 2.68 | 8.16 | 1.214 | .759 | .217 | 2.81 | .552 | .034 | 1 |
| 9 | HWF06A | 1890 2013 | 124 | 5 | 0 | .500 | 2.82 | 7.42 | 1.209 | .635 | .258 | 2.81 | .497 | -.038 | 1 |
| 10 | HWF06B | 1930 2013 | 84 | 3 | 0 | .686 | 3.47 | 6.30 | .988 | .327 | .235 | 2.73 | .456 | .021 | 1 |
| 11 | HWF07A | 1916 2013 | 98 | 4 | 0 | .601 | 2.02 | 4.14 | .886 | .589 | .315 | 2.74 | .518 | -.016 | 1 |
| 12 | HWF07B | 1915 2013 | 99 | 4 | 0 | .671 | 2.24 | 5.54 | 1.321 | .776 | .315 | 2.69 | .531 | -.083 | 1 |
| 13 | HWF08A | 1968 2013 | 46 | 1 | 0 | .603 | 4.71 | 10.86 | 2.047 | .367 | .327 | 2.84 | .505 | -.036 | 1 |
| 14 | HWF08B | 1949 2013 | 65 | 3 | 0 | .472 | 3.40 | 8.66 | 1.204 | .599 | .225 | 2.93 | .553 | .002 | 1 |
| 15 | HWF09A | 1941 2013 | 73 | 3 | 0 | .588 | 3.65 | 7.46 | 1.295 | .370 | .275 | 2.70 | .512 | .046 | 1 |
| 16 | HWF10A | 1914 2013 | 100 | 4 | 1 | .569 | 2.87 | 6.13 | 1.012 | .677 | .195 | 2.70 | .427 | -.023 | 1 |
| 17 | HWF10B | 1940 2013 | 74 | 3 | 0 | .653 | 3.46 | 5.99 | .732 | .439 | .174 | 2.50 | .366 | -.008 | 1 |
| 18 | HWF11A | 1905 2013 | 109 | 4 | 0 | .440 | 1.79 | 6.08 | 1.096 | .761 | .251 | 2.83 | .479 | -.009 | 1 |
| 19 | HWF12A | 1960 2013 | 54 | 2 | 0 | .406 | 3.51 | 6.12 | 1.071 | .639 | .217 | 2.75 | .607 | -.100 | 1 |
| 20 | HWF12B | 1962 2013 | 52 | 2 | 0 | .568 | 4.70 | 6.97 | 1.055 | .453 | .180 | 2.47 | .438 | .064 | 1 |
| Total or mean: | | | 1910 | 73 | 6 | .529 | 2.73 | 10.86 | 1.110 | .651 | .240 | 3.02 | .506 | -.009 | |

# APPENDIX H

## COFECHA PROGRAM OUTPUT FOR HOOT WOODS SITE CHRONOLOGY,

## *CARYA OVATA*, INDIANA, U.S.A.

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P R O G R A M     C O F E C H A                                                                    Version 6.06P    29368
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 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   hwo_dated.txt

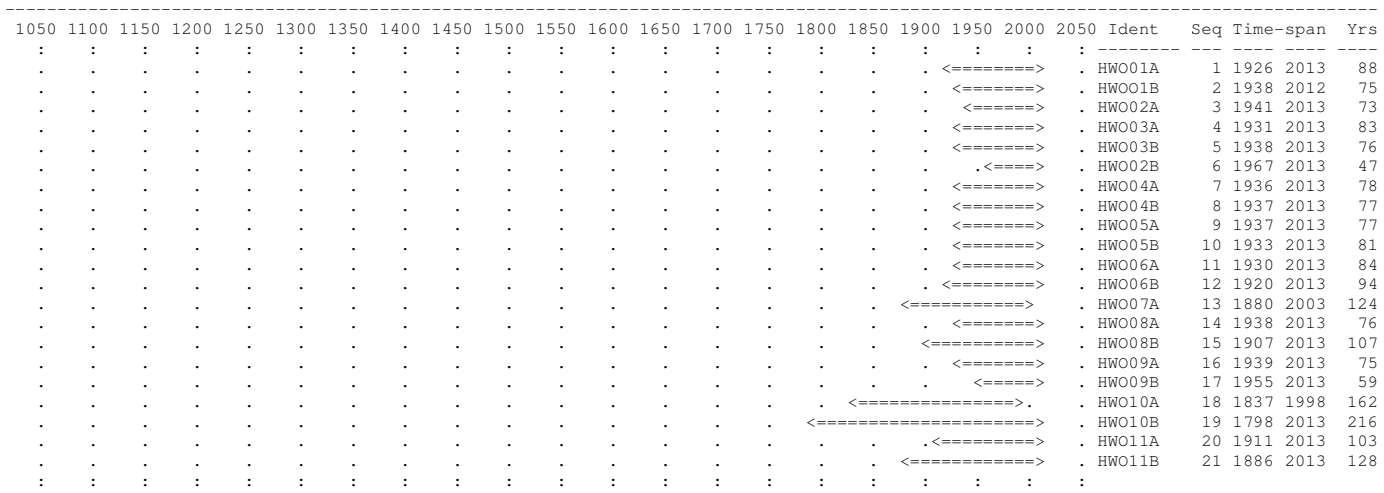

 Time span of Master dating series is  1798 to  2013   216 years
 Continuous time span is               1798 to  2013   216 years
 Portion with two or more series is    1837 to  2013   177 years


                                    ***************************************
                                    *C* Number of dated series        21 *C*
                                    *O* Master series 1798 2013  216 yrs *O*
                                    *F* Total rings in all series   1983 *F*
                                    *E* Total dated rings checked   1944 *E*
                                    *C* Series intercorrelation     .590 *C*
                                    *H* Average mean sensitivity    .289 *H*
                                    *A* Segments, possible problems    1 *A*
                                    *** Mean length of series       94.4 ***
                                    ***************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1800 | .210 | 1 | 1850 | -1.284 | 2 | 1900 | .934 | 4 | 1950 | .428 | 19 | 2000 | .703 | 20 |
| | | | 1801 | .561 | 1 | 1851 | -.418 | 2 | 1901 | -.610 | 4 | 1951 | .383 | 19 | 2001 | .087 | 20 |
| | | | 1802 | 1.577 | 1 | 1852 | -.447 | 2 | 1902 | .813 | 4 | 1952 | -.509 | 19 | 2002 | .157 | 20 |
| | | | 1803 | -1.000 | 1 | 1853 | .704 | 2 | 1903 | -.050 | 4 | 1953 | -.402 | 19 | 2003 | -.345 | 20 |
| | | | 1804 | .247 | 1 | 1854 | .248 | 2 | 1904 | .585 | 4 | 1954 | -1.916 | 19 | 2004 | 1.119 | 19 |
| | | | 1805 | -.208 | 1 | 1855 | -2.970 | 2 | 1905 | 1.421 | 4 | 1955 | .977 | 20 | 2005 | -.307 | 19 |
| | | | 1806 | 2.235 | 1 | 1856 | -.957 | 2 | 1906 | -.500 | 4 | 1956 | .855 | 20 | 2006 | .231 | 19 |
| | | | 1807 | .784 | 1 | 1857 | -.484 | 2 | 1907 | .289 | 5 | 1957 | -.029 | 20 | 2007 | -.654 | 19 |
| | | | 1808 | 1.459 | 1 | 1858 | -.484 | 2 | 1908 | -.472 | 5 | 1958 | .283 | 20 | 2008 | .261 | 19 |
| | | | 1809 | 1.095 | 1 | 1859 | -1.916 | 2 | 1909 | -1.941 | 5 | 1959 | .346 | 20 | 2009 | .092 | 19 |
| | | | 1810 | -.792 | 1 | 1860 | 1.271 | 2 | 1910 | .096 | 5 | 1960 | .902 | 20 | 2010 | .199 | 19 |
| | | | 1811 | -.068 | 1 | 1861 | .484 | 2 | 1911 | -.664 | 6 | 1961 | .021 | 20 | 2011 | .395 | 19 |
| | | | 1812 | -1.363 | 1 | 1862 | .756 | 2 | 1912 | 1.656 | 6 | 1962 | .168 | 20 | 2012 | -1.746 | 19 |
| | | | 1813 | -.277 | 1 | 1863 | -1.032 | 2 | 1913 | -1.193 | 6 | 1963 | -.056 | 20 | 2013 | .504 | 18 |
| | | | 1814 | -1.133 | 1 | 1864 | -.985 | 2 | 1914 | -1.901 | 6 | 1964 | -.021 | 20 | | | |
| | | | 1815 | -2.115 | 1 | 1865 | -1.734 | 2 | 1915 | 1.416 | 6 | 1965 | .715 | 20 | | | |
| | | | 1816 | -1.893 | 1 | 1866 | 1.652 | 2 | 1916 | 1.948 | 6 | 1966 | -.010 | 20 | | | |
| | | | 1817 | .225 | 1 | 1867 | -1.002 | 2 | 1917 | .381 | 6 | 1967 | -.566 | 21 | | | |
| | | | 1818 | 2.091 | 1 | 1868 | .592 | 2 | 1918 | -.512 | 6 | 1968 | .424 | 21 | | | |
| | | | 1819 | .661 | 1 | 1869 | 2.203 | 2 | 1919 | -.011 | 6 | 1969 | -.466 | 21 | | | |
| | | | 1820 | 1.710 | 1 | 1870 | .459 | 2 | 1920 | -.228 | 7 | 1970 | -1.590 | 21 | | | |
| | | | 1821 | .360 | 1 | 1871 | -.473 | 2 | 1921 | -.782 | 7 | 1971 | -.578 | 21 | | | |
| | | | 1822 | .990 | 1 | 1872 | 1.673 | 2 | 1922 | .614 | 7 | 1972 | -.132 | 21 | | | |
| | | | 1823 | .635 | 1 | 1873 | .391 | 2 | 1923 | -.699 | 7 | 1973 | 1.668 | 21 | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1824 | 1.617 | 1 | 1874 | -.151 | 2 | 1924 | .212 | 7 | 1974 | .542 | 21 |
| | | | 1825 | .911 | 1 | 1875 | 1.813 | 2 | 1925 | .404 | 7 | 1975 | .627 | 21 |
| | | | 1826 | -1.378 | 1 | 1876 | .544 | 2 | 1926 | -.240 | 8 | 1976 | .843 | 21 |
| | | | 1827 | -.510 | 1 | 1877 | -1.591 | 2 | 1927 | -.197 | 8 | 1977 | .317 | 21 |
| | | | 1828 | -2.312 | 1 | 1878 | .632 | 2 | 1928 | 1.099 | 8 | 1978 | .525 | 21 |
| | | | 1829 | .490 | 1 | 1879 | .717 | 2 | 1929 | .260 | 8 | 1979 | .377 | 21 |
| | | | 1830 | -2.246 | 1 | 1880 | -.299 | 3 | 1930 | -.517 | 9 | 1980 | .222 | 21 |
| | | | 1831 | .111 | 1 | 1881 | -.983 | 3 | 1931 | -.659 | 10 | 1981 | -3.432 | 21 |
| | | | 1832 | -1.227 | 1 | 1882 | -.483 | 3 | 1932 | .898 | 10 | 1982 | .187 | 21 |
| | | | 1833 | -.433 | 1 | 1883 | 1.968 | 3 | 1933 | -1.187 | 11 | 1983 | -.918 | 21 |
| | | | 1834 | -.819 | 1 | 1884 | .086 | 3 | 1934 | .354 | 11 | 1984 | -1.052 | 21 |
| | | | 1835 | -1.678 | 1 | 1885 | .282 | 3 | 1935 | .753 | 11 | 1985 | -.338 | 21 |
| | | | 1836 | .410 | 1 | 1886 | -.380 | 4 | 1936 | -1.777 | 12 | 1986 | .392 | 21 |
| | | | 1837 | .680 | 2 | 1887 | -1.195 | 4 | 1937 | -.175 | 14 | 1987 | -1.005 | 21 |
| | | | 1838 | -.070 | 2 | 1888 | -1.045 | 4 | 1938 | 1.125 | 17 | 1988 | -1.367 | 21 |
| | | | 1839 | -1.093 | 2 | 1889 | .476 | 4 | 1939 | .008 | 18 | 1989 | -.018 | 21 |
| | | | 1840 | -1.345 | 2 | 1890 | .168 | 4 | 1940 | -.274 | 18 | 1990 | 1.391 | 21 |
| | | | 1841 | -.718 | 2 | 1891 | -1.962 | 4 | 1941 | -.383 | 19 | 1991 | -.612 | 21 |
| | | | 1842 | .352 | 2 | 1892 | .921 | 4 | 1942 | 1.124 | 19 | 1992 | 1.116 | 21 |
| | | | 1843 | 1.912 | 2 | 1893 | -.240 | 4 | 1943 | -.011 | 19 | 1993 | .390 | 21 |
| | | | 1844 | 1.847 | 2 | 1894 | .052 | 4 | 1944 | -1.044 | 19 | 1994 | -.527 | 21 |
| | | | 1845 | 1.215 | 2 | 1895 | -1.063 | 4 | 1945 | .582 | 19 | 1995 | .368 | 21 |
| | | | 1846 | .664 | 2 | 1896 | .255 | 4 | 1946 | -.281 | 19 | 1996 | .396 | 21 |
| | | | 1847 | -.114 | 2 | 1897 | 1.159 | 4 | 1947 | -.738 | 19 | 1997 | .013 | 21 |
| 1798 | 2.154 | 1 | 1848 | -.386 | 2 | 1898 | -.705 | 4 | 1948 | -.125 | 19 | 1998 | -.298 | 21 |
| 1799 | -.504 | 1 | 1849 | -.216 | 2 | 1899 | 1.101 | 4 | 1949 | .088 | 19 | 1999 | .747 | 20 |

PART 4: Master Bar Plot:

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1800------A | 1850-e | 1900---------D | 1950-------B | 2000--------C | | |
| | 1801--------B | 1851---b | 1901--b | 1951-------B | 2001-----@ | | |
| | 1802----------F | 1852---b | 1902--------C | 1952---b | 2002-----A | | |
| | 1803-d | 1853--------C | 1903----@ | 1953---b | 2003---a | | |
| | 1804------A | 1854------A | 1904---------B | 1954h | 2004---------D | | |
| | 1805----a | 1855l | 1905----------F | 1955---------D | 2005---a | | |
| | 1806----------I | 1856-d | 1906---b | 1956--------C | 2006------A | | |
| | 1807--------C | 1857---b | 1907------A | 1957-----@ | 2007--c | | |
| | 1808----------F | 1858---b | 1908---b | 1958------A | 2008------A | | |
| | 1809---------D | 1859h | 1909h | 1959------A | 2009-----@ | | |
| | 1810--c | 1860---------E | 1910-----@ | 1960---------D | 2010------A | | |
| | 1811----@ | 1861-------B | 1911--c | 1961-----@ | 2011-------B | | |
| | 1812-e | 1862--------C | 1912----------G | 1962-----A | 2012g | | |
| | 1813----a | 1863-d | 1913-e | 1963----@ | 2013-------B | | |
| | 1814-e | 1864-d | 1914h | 1964-----@ | | | |
| | 1815h | 1865g | 1915----------F | 1965--------C | | | |
| | 1816h | 1866----------G | 1916----------H | 1966-----@ | | | |
| | 1817------A | 1867-d | 1917-------B | 1967--b | | | |
| | 1818----------H | 1868--------B | 1918---b | 1968-------B | | | |
| | 1819--------C | 1869----------I | 1919-----@ | 1969---b | | | |
| | 1820----------G | 1870-------B | 1920----a | 1970f | | | |
| | 1821-------A | 1871---b | 1921--c | 1971--b | | | |
| | 1822---------D | 1872----------G | 1922--------B | 1972----a | | | |
| | 1823--------C | 1873-------B | 1923--c | 1973----------G | | | |
| | 1824----------F | 1874----a | 1924------A | 1974-------B | | | |

```
                1825---------D  1875----------G 1925-------B    1975--------C
                1826-f          1876-------B    1926----a       1976--------C
                1827---b        1877f           1927----a       1977------A
                1828i           1878--------C   1928---------D  1978-------B
                1829-------B    1879--------C   1929------A     1979-------B
                1830i           1880---a        1930---b        1980------A
                1831-----@      1881-d          1931--c         1981n
                1832-e          1882---b        1932---------D  1982------A
                1833---b        1883----------H 1933-e          1983-d
                1834--c         1884-----@      1934-------A    1984-d
                1835g           1885------A     1935--------C   1985---a
                1836-------B    1886---b        1936g           1986-------B
                1837--------C   1887-e          1937----a       1987-d
                1838----@       1888-d          1938---------D  1988-e
                1839-d          1889-------B    1939-----@      1989-----@
                1840-e          1890-----A      1940----a       1990---------F
                1841--c         1891h           1941---b        1991--b
                1842------A     1892---------D  1942---------D  1992---------D
                1843----------H 1893----a       1943-----@      1993-------B
                1844----------G 1894-----@      1944-d          1994---b
                1845---------E  1895-d          1945--------B   1995-------A
                1846--------C   1896------A     1946----a       1996-------B
                1847----@       1897---------E  1947--c         1997-----@
  1798----------I 1848---b      1898--c         1948----@       1998---a
  1799---b      1849----a       1899---------D  1949-----@      1999--------C
```

---

PART 5:  CORRELATION OF SERIES BY SEGMENTS:

---

Correlations of  50-year dated segments, lagged  25 years
Flags:  A = correlation under   .3281 but highest as dated;  B = correlation higher at other than dated position

| Seq | Series | Time_span | 1825 1850 1875 1900 1925 1950 1975<br>1874 1899 1924 1949 1974 1999 2024 |
|---|---|---|---|
| 1 | HWO01A | 1926 2013 | .49 .71 .67 |
| 2 | HWO01B | 1938 2012 | .72 .75 .65 |
| 3 | HWO02A | 1941 2013 | .78 .80 .76 |
| 4 | HWO03A | 1931 2013 | .67 .83 .75 |
| 5 | HWO03B | 1938 2013 | .75 .76 .69 |
| 6 | HWO02B | 1967 2013 | .60 |
| 7 | HWO04A | 1936 2013 | .62 .79 .72 |
| 8 | HWO04B | 1937 2013 | .36 .48 .56 |
| 9 | HWO05A | 1937 2013 | .59 .60 .61 |
| 10 | HWO05B | 1933 2013 | .49 .49 .54 |
| 11 | HWO06A | 1930 2013 | .69 .51 .38 |
| 12 | HWO06B | 1920 2013 | .61 .69 .56 .53 |
| 13 | HWO07A | 1880 2003 | .45 .52 .43 .63 .63 |
| 14 | HWO08A | 1938 2013 | .75 .75 .72 |
| 15 | HWO08B | 1907 2013 | .71 .58 .71 .62 |
| 16 | HWO09A | 1939 2013 | .65 .69 .80 |
| 17 | HWO09B | 1955 2013 | .65 .71 |
| 18 | HWO10A | 1837 1998 | .67 .77 .69 .51 .29B .51 |
| 19 | HWO10B | 1798 2013 | .68 .84 .79 .51 .34 .49 .42 |
| 20 | HWO11A | 1911 2013 | .68 .55 .63 .68 |
| 21 | HWO11B | 1886 2013 | .41 .72 .54 .69 .78 |
| Av segment correlation | | | .68 .81 .58 .61 .58 .65 .64 |

PART 6: POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

HWO01A 1926 to 2013 88 years Series 1

[B] Entire series, effect on correlation ( .549) is:
Lower 2011< -.027 1932< -.019 1930> -.017 1935< -.012 1927> -.011 2005> -.010 Higher 1981 .059 1954 .026

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1930 +3.5 SD; 1954 -6.2 SD

HWO01B 1938 to 2012 75 years Series 2

[B] Entire series, effect on correlation ( .622) is:
Lower 2011< -.046 1999< -.031 2007> -.018 1942< -.013 1947> -.011 1945< -.010 Higher 1981 .078 1954 .032

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1948 +3.2 SD; 2011 -4.8 SD

HWO02A 1941 to 2013 73 years Series 3

[B] Entire series, effect on correlation ( .718) is:
Lower 2003< -.036 1999< -.016 2013< -.013 1941> -.011 1990< -.010 1952< -.009 Higher 1981 .090 1970 .013

HWO03A 1931 to 2013 83 years Series 4

[B] Entire series, effect on correlation ( .719) is:
Lower 2001< -.029 2005< -.015 1945< -.014 1949< -.013 1998> -.012 2008< -.008 Higher 1981 .092 1954 .014

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1982 +3.1 SD

HWO03B 1938 to 2013 76 years Series 5

[B] Entire series, effect on correlation ( .685) is:
Lower 2005< -.020 1998> -.018 1947> -.015 1991> -.013 2007> -.012 2008< -.012 Higher 1981 .030 1954 .028

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year

1998 +3.4 SD

---

HWO02B 1967 to 2013 47 years Series 6

[B] Entire series, effect on correlation ( .604) is:
Lower 1970> -.051 1978< -.040 1976< -.018 1990< -.016 1972> -.015 1989< -.015 Higher 1981 .159 2012 .033

[E] Outliers 3 3.0 SD above or -4.5 SD below mean for year
1970 +3.6 SD; 1972 +3.3 SD; 2010 +3.2 SD

---

HWO04A 1936 to 2013 78 years Series 7

[B] Entire series, effect on correlation ( .562) is:
Lower 1939< -.068 1936> -.024 1944> -.018 1998< -.016 2004< -.013 2012> -.013 Higher 1981 .138 1954 .023

[E] Outliers 3 3.0 SD above or -4.5 SD below mean for year
1939 -6.0 SD; 1950 +3.9 SD; 2001 +3.1 SD

---

HWO04B 1937 to 2013 77 years Series 8

[B] Entire series, effect on correlation ( .364) is:
Lower 1954> -.054 1998< -.050 1938< -.047 1944> -.044 1956< -.025 2011< -.008 Higher 1981 .108 1970 .030

[E] Outliers 8 3.0 SD above or -4.5 SD below mean for year
1938 -4.8 SD; 1944 +4.9 SD; 1954 +4.7 SD; 1956 -4.8 SD; 1982 +3.5 SD; 1998 -7.2 SD; 2001 +3.0 SD;
2008 +3.2 SD

---

HWO05A 1937 to 2013 77 years Series 9

[B] Entire series, effect on correlation ( .612) is:
Lower 1981> -.030 1968< -.016 1993> -.011 1986< -.010 2009< -.009 1969> -.007 Higher 2012 .030 1970 .018

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1993 +3.6 SD

---

HWO05B 1933 to 2013 81 years Series 10

[B] Entire series, effect on correlation ( .522) is:
Lower 1950< -.053 1968< -.024 1947< -.013 1979< -.012 1981> -.010 1943> -.008 Higher 1954 .038 1936 .023

[E] Outliers 3 3.0 SD above or -4.5 SD below mean for year
1947 -4.8 SD; 1950 -5.1 SD; 2008 +3.2 SD

---

HWO06A 1930 to 2013 84 years Series 11

[B] Entire series, effect on correlation ( .500) is:
Lower 1981> -.071 2006< -.051 1992< -.023 1947> -.015 1998> -.013 1931> -.009 Higher 1936 .038 1954 .031

[E] Outliers 6 3.0 SD above or -4.5 SD below mean for year
1955 +3.2 SD; 1981 +4.2 SD; 1982 +3.3 SD; 1998 +3.6 SD; 2006 -4.7 SD; 2011 +3.1 SD

---

```
HWO06B    1920 to  2013      94 years                                                                                    Series  12

[B] Entire series, effect on correlation (  .567) is:
      Lower   1981> -.083   1992< -.016   1927> -.011   1947> -.010   2006< -.009   1998> -.009  Higher   1936  .026   2012  .025

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1981 +4.3 SD;    1982 +3.0 SD
================================================================================================================================

HWO07A    1880 to  2003     124 years                                                                                    Series  13

[B] Entire series, effect on correlation (  .537) is:
      Lower   1927< -.060   1882> -.015   1952> -.009   1890> -.008   1998> -.008   1889> -.008  Higher   1891  .014   1909  .014

[E] Outliers     4   3.0 SD above or -4.5 SD below mean for year
      1882 +3.8 SD;    1904 +3.6 SD;    1927 -6.8 SD;    1960 +4.1 SD
================================================================================================================================

HWO08A    1938 to  2013      76 years                                                                                    Series  14

[B] Entire series, effect on correlation (  .696) is:
      Lower   2009< -.022   1952> -.017   1964< -.014   1977< -.012   1987> -.012   2012> -.010  Higher   1981  .112   1990  .010

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      2006 +3.0 SD
================================================================================================================================

HWO08B    1907 to  2013     107 years                                                                                    Series  15

[B] Entire series, effect on correlation (  .639) is:
      Lower   1963< -.027   2009< -.022   2008< -.019   1982< -.011   1952> -.010   2000< -.008  Higher   1981  .058   1909  .013

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      2008 -4.6 SD;    2009 -4.5 SD
================================================================================================================================

HWO09A    1939 to  2013      75 years                                                                                    Series  16

[B] Entire series, effect on correlation (  .686) is:
      Lower   1941> -.020   1955< -.015   1956< -.014   1993< -.014   1984> -.013   1975< -.011  Higher   1981  .159   2012  .025

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1941 +3.4 SD;    1981 -5.5 SD
================================================================================================================================

HWO09B    1955 to  2013      59 years                                                                                    Series  17

[B] Entire series, effect on correlation (  .643) is:
      Lower   1970> -.032   1975< -.023   1955< -.022   1956< -.016   1967> -.014   1979< -.012  Higher   1981  .288   1990  .016

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1981 -6.1 SD
================================================================================================================================

HWO10A    1837 to  1998     162 years                                                                                    Series  18

[A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
```

```
   1925 1974   -8    .05 -.04  .32* .02 -.15  .18 -.08  .08 -.26  .05  .29|-.16  .04  .03 -.05  .06  .01  .00 -.15  .04  .11

 [B] Entire series, effect on correlation (  .560) is:
       Lower   1941< -.024   1994> -.015   1955< -.013   1843< -.012   1933> -.010   1961< -.010  Higher   1981  .049   1855  .024
     1925 to 1974 segment:
       Lower   1955< -.045   1933> -.039   1970> -.038   1941< -.036   1961< -.017   1954> -.016  Higher   1936  .098   1973  .049

 [E] Outliers     7   3.0 SD above or -4.5 SD below mean for year
       1843 -4.8 SD;    1889 +3.1 SD;    1933 +3.3 SD;    1941 -5.9 SD;    1945 +3.1 SD;    1970 +3.1 SD;    1994 +4.8 SD
================================================================================================================================================

 HWO10B    1798 to  2013     216 years                                                                                          Series  19

 [*] Early part of series cannot be checked from 1798 to 1836 -- not matched by another series

 [B] Entire series, effect on correlation (  .537) is:
       Lower   1961< -.024   2000< -.013   1948< -.012   1844< -.011   2013< -.010   1941< -.009  Higher   1981  .037   1855  .028

 [E] Outliers     8   3.0 SD above or -4.5 SD below mean for year
       1839 +3.1 SD;    1843 +4.8 SD;    1938 +3.0 SD;    1948 -5.2 SD;    1966 +3.1 SD;    1985 +4.0 SD;    1986 +3.1 SD;
       2000 -5.0 SD
================================================================================================================================================

 HWO11A    1911 to  2013     103 years                                                                                          Series  20

 [B] Entire series, effect on correlation (  .664) is:
       Lower   1982< -.063   1958< -.025   2010< -.020   1911> -.007   1962< -.006   1969> -.006  Higher   1981  .082   1914  .010

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1945 +3.1 SD;    1982 -5.9 SD
================================================================================================================================================

 HWO11B    1886 to  2013     128 years                                                                                          Series  21

 [B] Entire series, effect on correlation (  .555) is:
       Lower   1889< -.108   1954> -.025   1937< -.014   1982< -.009   1907< -.009   1895> -.008  Higher   1981  .061   1909  .014

 [E] Outliers     4   3.0 SD above or -4.5 SD below mean for year
       1889 -8.0 SD;    1894 +3.4 SD;    1954 +4.1 SD;    1963 +3.1 SD
================================================================================================================================================

PART 7:  DESCRIPTIVE STATISTICS:
------------------------------------------------------------------------------------------------------------------------------------------------

                                                  Corr   //-------- Unfiltered --------\\  //---- Filtered -----\\
                              No.    No.    No.    with   Mean    Max     Std    Auto   Mean    Max     Std    Auto  AR
 Seq Series   Interval      Years  Segmt  Flags  Master  msmt    msmt     dev    corr   sens   value    dev    corr  ()
 --- -------- ---------    -----  -----  -----  ------ -----   -----   -----   -----  -----  -----   -----  -----  --
   1 HWO01A   1926 2013      88      3      0    .549   2.06    3.99    .818    .501   .287   2.54    .382  -.009   1
   2 HWO01B   1938 2012      75      3      0    .622   1.99    4.01    .657    .464   .259   2.63    .454  -.024   1
   3 HWO02A   1941 2013      73      3      0    .718   2.05    3.39    .694    .538   .277   2.45    .484  -.050   1
   4 HWO03A   1931 2013      83      3      0    .719   2.44    4.13    .674    .240   .270   2.66    .434  -.060   1
   5 HWO03B   1938 2013      76      3      0    .685   2.53    3.93    .734    .423   .249   2.59    .513  -.040   1
   6 HWO02B   1967 2013      47      1      0    .604   1.85    3.30    .599    .166   .355   2.65    .570  -.017   1
   7 HWO04A   1936 2013      78      3      0    .562   2.01    5.76   1.021    .771   .272   2.75    .466   .002   1
   8 HWO04B   1937 2013      77      3      0    .364   2.50    5.48    .991    .299   .360   2.59    .434  -.005   1
   9 HWO05A   1937 2013      77      3      0    .612   2.48    9.66   1.391    .625   .307   2.78    .479  -.021   1
  10 HWO05B   1933 2013      81      3      0    .522   2.15    4.55    .878    .619   .265   2.73    .558  -.125   1
```

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | HWO06A | 1930 2013 | 84 | 3 | 0 | .500 | 2.00 | 4.12 | .750 | .505 | .263 | 2.83 | .575 | -.052 | 1 |
| 12 | HWO06B | 1920 2013 | 94 | 4 | 0 | .567 | 2.44 | 4.49 | .767 | .472 | .253 | 2.67 | .456 | -.005 | 1 |
| 13 | HWO07A | 1880 2003 | 124 | 5 | 0 | .537 | 1.33 | 4.04 | .798 | .633 | .327 | 2.96 | .448 | .017 | 1 |
| 14 | HWO08A | 1938 2013 | 76 | 3 | 0 | .696 | 2.38 | 4.96 | .778 | .543 | .237 | 2.63 | .442 | .025 | 1 |
| 15 | HWO08B | 1907 2013 | 107 | 4 | 0 | .639 | 2.33 | 4.75 | .844 | .419 | .279 | 2.84 | .537 | .056 | 2 |
| 16 | HWO09A | 1939 2013 | 75 | 3 | 0 | .686 | 2.45 | 5.83 | 1.339 | .788 | .290 | 2.46 | .361 | -.053 | 1 |
| 17 | HWO09B | 1955 2013 | 59 | 2 | 0 | .643 | 3.70 | 7.57 | 1.704 | .481 | .357 | 2.48 | .332 | -.052 | 1 |
| 18 | HWO10A | 1837 1998 | 162 | 6 | 1 | .560 | 1.45 | 6.90 | .878 | .647 | .307 | 2.80 | .452 | .011 | 1 |
| 19 | HWO10B | 1798 2013 | 216 | 7 | 0 | .537 | 1.11 | 8.30 | .822 | .606 | .304 | 3.08 | .504 | -.004 | 1 |
| 20 | HWO11A | 1911 2013 | 103 | 4 | 0 | .664 | 1.69 | 3.40 | .742 | .647 | .249 | 2.61 | .434 | .105 | 1 |
| 21 | HWO11B | 1886 2013 | 128 | 5 | 0 | .555 | 1.89 | 3.89 | .785 | .578 | .291 | 2.74 | .500 | .038 | 1 |
| Total or mean: | | | 1983 | 74 | 1 | .590 | 2.00 | 9.66 | .871 | .542 | .289 | 3.08 | .470 | -.006 | |

# APPENDIX I

## COFECHA PROGRAM OUTPUT FOR HOOT WOODS SITE CHRONOLOGY,

## *LIRIODENDRON TULIPIFERA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                    Version 6.06P    29368
------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   hwt_dated.txt

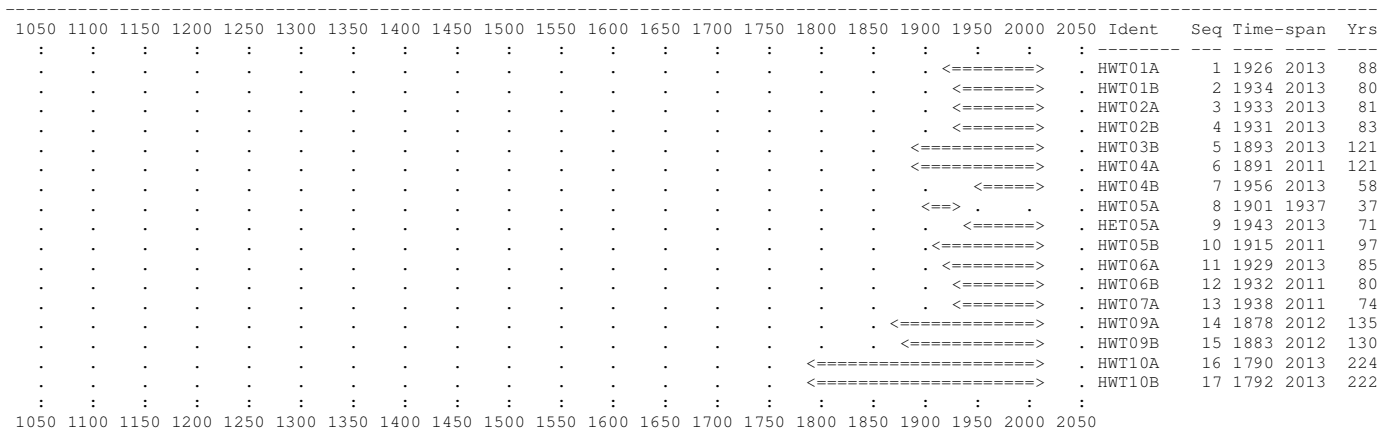
 Time span of Master dating series is  1790 to  2013   224 years
 Continuous time span is               1790 to  2013   224 years
 Portion with two or more series is    1792 to  2013   222 years


                                    ****************************************
                                    *C* Number of dated series        17 *C*
                                    *O* Master series 1790 2013  224 yrs *O*
                                    *F* Total rings in all series   1787 *F*
                                    *E* Total dated rings checked   1785 *E*
                                    *C* Series intercorrelation     .629 *C*
                                    *H* Average mean sensitivity    .366 *H*
                                    *A* Segments, possible problems    3 *A*
                                    *** Mean length of series      105.1 ***
                                    ****************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1800 | .824 | 2 | 1850 | -.607 | 2 | 1900 | 1.360 | 6 | 1950 | 1.178 | 15 | 2000 | -.584 | 16 |
| 1801 | -.013 | 2 | 1851 | 1.015 | 2 | 1901 | -.321 | 7 | 1951 | 1.324 | 15 | 2001 | .950 | 16 |
| 1802 | 1.498 | 2 | 1852 | .978 | 2 | 1902 | -.562 | 7 | 1952 | .418 | 15 | 2002 | .627 | 16 |
| 1803 | -2.598 | 2 | 1853 | -.264 | 2 | 1903 | -.066 | 7 | 1953 | -.870 | 15 | 2003 | -.098 | 16 |
| 1804 | 1.316 | 2 | 1854 | -1.436 | 2 | 1904 | .666 | 7 | 1954 | -1.899 | 15 | 2004 | .448 | 16 |
| 1805 | .738 | 2 | 1855 | -1.786 | 2 | 1905 | 1.096 | 7 | 1955 | -.042 | 15 | 2005 | .385 | 16 |
| 1806 | -.747 | 2 | 1856 | -1.392 | 2 | 1906 | .499 | 7 | 1956 | .132 | 16 | 2006 | .524 | 16 |
| 1807 | .869 | 2 | 1857 | -.198 | 2 | 1907 | .392 | 7 | 1957 | 1.029 | 16 | 2007 | -.137 | 16 |
| 1808 | -1.231 | 2 | 1858 | -.502 | 2 | 1908 | .432 | 7 | 1958 | .860 | 16 | 2008 | -.005 | 16 |
| 1809 | -.226 | 2 | 1859 | .107 | 2 | 1909 | -.018 | 7 | 1959 | .631 | 16 | 2009 | -.265 | 16 |
| 1810 | 1.127 | 2 | 1860 | .761 | 2 | 1910 | -.564 | 7 | 1960 | .066 | 16 | 2010 | 1.074 | 16 |
| 1811 | -.204 | 2 | 1861 | 2.321 | 2 | 1911 | -.464 | 7 | 1961 | -.203 | 16 | 2011 | .108 | 16 |
| 1812 | -.587 | 2 | 1862 | 1.169 | 2 | 1912 | .617 | 7 | 1962 | -.098 | 16 | 2012 | -1.531 | 12 |
| 1813 | -.697 | 2 | 1863 | .344 | 2 | 1913 | -.218 | 7 | 1963 | -.160 | 16 | 2013 | -1.465 | 10 |
| 1814 | -.209 | 2 | 1864 | -.592 | 2 | 1914 | -3.557 | 7 | 1964 | -.839 | 16 | | | |
| 1815 | -3.309 | 2 | 1865 | 1.790 | 2 | 1915 | -.179 | 8 | 1965 | -.423 | 16 | | | |
| 1816 | -1.533 | 2 | 1866 | -.230 | 2 | 1916 | 1.619 | 8 | 1966 | -1.156 | 16 | | | |
| 1817 | .802 | 2 | 1867 | -.351 | 2 | 1917 | -.117 | 8 | 1967 | -2.243 | 16 | | | |
| 1818 | 1.775 | 2 | 1868 | -1.003 | 2 | 1918 | -.341 | 8 | 1968 | .486 | 16 | | | |
| 1819 | -.109 | 2 | 1869 | -.432 | 2 | 1919 | .496 | 8 | 1969 | .536 | 16 | | | |
| 1820 | .462 | 2 | 1870 | -.554 | 2 | 1920 | -.445 | 8 | 1970 | -.827 | 16 | | | |
| 1821 | .153 | 2 | 1871 | -.822 | 2 | 1921 | -.556 | 8 | 1971 | .312 | 16 | | | |
| 1822 | .830 | 2 | 1872 | -.430 | 2 | 1922 | .777 | 8 | 1972 | .249 | 16 | | | |
| 1823 | .359 | 2 | 1873 | -.219 | 2 | 1923 | -.052 | 8 | 1973 | .926 | 16 | | | |
| 1824 | .970 | 2 | 1874 | .410 | 2 | 1924 | 1.214 | 8 | 1974 | .890 | 16 | | | |
| 1825 | .371 | 2 | 1875 | .810 | 2 | 1925 | 1.034 | 8 | 1975 | .718 | 16 | | | |
| 1826 | -.703 | 2 | 1876 | .425 | 2 | 1926 | -.276 | 9 | 1976 | -.116 | 16 | | | |
| 1827 | .270 | 2 | 1877 | .861 | 2 | 1927 | .626 | 9 | 1977 | -.252 | 16 | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1828 | 1.567 | 2 | 1878 | .584 | 3 | 1928 | .327 | 9 | 1978 | .611 | 16 |
| | | | 1829 | -1.121 | 2 | 1879 | 1.225 | 3 | 1929 | .090 | 10 | 1979 | .027 | 16 |
| | | | 1830 | 1.352 | 2 | 1880 | -.362 | 3 | 1930 | -1.033 | 10 | 1980 | 1.251 | 16 |
| | | | 1831 | .712 | 2 | 1881 | .117 | 3 | 1931 | -.922 | 11 | 1981 | .333 | 16 |
| | | | 1832 | -.353 | 2 | 1882 | .822 | 3 | 1932 | .141 | 12 | 1982 | .899 | 16 |
| | | | 1833 | .830 | 2 | 1883 | 1.332 | 4 | 1933 | -.469 | 13 | 1983 | -1.367 | 16 |
| | | | 1834 | -5.532 | 2 | 1884 | .583 | 4 | 1934 | -.201 | 14 | 1984 | -1.766 | 16 |
| | | | 1835 | .357 | 2 | 1885 | -.170 | 4 | 1935 | .778 | 14 | 1985 | -.165 | 16 |
| | | | 1836 | .623 | 2 | 1886 | -1.350 | 4 | 1936 | -1.432 | 14 | 1986 | .293 | 16 |
| | | | 1837 | .937 | 2 | 1887 | -1.774 | 4 | 1937 | 1.024 | 14 | 1987 | .913 | 16 |
| | | | 1838 | -.195 | 2 | 1888 | -1.262 | 4 | 1938 | 1.428 | 14 | 1988 | -1.797 | 16 |
| | | | 1839 | .439 | 2 | 1889 | .294 | 4 | 1939 | .565 | 14 | 1989 | -1.051 | 16 |
| 1790 | -.943 | 1 | 1840 | .050 | 2 | 1890 | -.269 | 4 | 1940 | -.747 | 14 | 1990 | .441 | 16 |
| 1791 | 1.678 | 1 | 1841 | -.919 | 2 | 1891 | .169 | 5 | 1941 | -.683 | 14 | 1991 | -.122 | 16 |
| 1792 | .478 | 2 | 1842 | -.592 | 2 | 1892 | .059 | 5 | 1942 | .126 | 14 | 1992 | .850 | 16 |
| 1793 | .016 | 2 | 1843 | -2.217 | 2 | 1893 | -.361 | 6 | 1943 | -.207 | 15 | 1993 | -.121 | 16 |
| 1794 | 1.101 | 2 | 1844 | 1.335 | 2 | 1894 | -1.286 | 6 | 1944 | -1.307 | 15 | 1994 | -.706 | 16 |
| 1795 | .702 | 2 | 1845 | 1.307 | 2 | 1895 | -1.307 | 6 | 1945 | -.318 | 15 | 1995 | -.862 | 16 |
| 1796 | -.289 | 2 | 1846 | .284 | 2 | 1896 | .980 | 6 | 1946 | -.154 | 15 | 1996 | -.305 | 16 |
| 1797 | -.084 | 2 | 1847 | .067 | 2 | 1897 | .144 | 6 | 1947 | -.078 | 15 | 1997 | -.773 | 16 |
| 1798 | -.584 | 2 | 1848 | .399 | 2 | 1898 | -.108 | 6 | 1948 | .616 | 15 | 1998 | 1.569 | 16 |
| 1799 | -1.366 | 2 | 1849 | -1.098 | 2 | 1899 | .721 | 6 | 1949 | 1.136 | 15 | 1999 | 1.315 | 16 |

PART 4: Master Bar Plot:

```
   Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value
                   1800--------C   1850--b         1900----------E 1950---------E  2000--b
                   1801-----@      1851---------D  1901---a        1951----------E 2001---------D
                   1802----------F 1852---------D  1902--b         1952------B     2002-------C
                   1803j           1853---a        1903----@       1953-c          2003----@
                   1804----------E 1854f           1904--------C   1954h           2004-------B
                   1805--------C   1855g           1905---------D  1955-----@      2005------B
                   1806--c         1856f           1906-------B    1956-----A      2006-------B
                   1807--------C   1857----a       1907------B     1957---------D  2007----a
                   1808-e          1858--b         1908-------B    1958--------C   2008-----@
                   1809---a        1859-----@      1909-----@      1959--------C   2009---a
                   1810---------E  1860--------C   1910--b         1960-----@      2010---------D
                   1811----a       1861----------I 1911--b         1961----a       2011-----@
                   1812--b         1862---------E  1912-------B    1962----@       2012f
                   1813--c         1863------A     1913----a       1963----a       2013f
                   1814----a       1864--b         1914n           1964-c
                   1815m           1865----------G 1915----a       1965---b
                   1816f           1866---a        1916----------F 1966-e
                   1817--------C   1867---a        1917-----@      1967i
                   1818----------G 1868-d          1918---a        1968-------B
                   1819----@       1869---b        1919-------B    1969-------B
                   1820-------B    1870--b         1920--b         1970-c
                   1821-----A      1871-c          1921--b         1971------A
                   1822--------C   1872---b        1922--------C   1972------A
                   1823------A     1873----a       1923----@       1973---------D
                   1824---------D  1874------B     1924----------E 1974--------D
                   1825------A     1875--------C   1925---------D  1975--------C
                   1826--c         1876------B     1926---a        1976----@
                   1827------A     1877--------C   1927-------C    1977---a
                   1828----------F 1878-------B    1928------A     1978-------B
                   1829-d          1879----------E 1929-----@      1979-----@
```

```
                 1830----------E 1880---a        1930-d          1980----------E
                 1831--------C   1881-----@      1931-d          1981------A
                 1832---a        1882--------C   1932-----A      1982---------D
                 1833--------C   1883----------E 1933--b         1983e
                 1834v           1884-------B    1934----a       1984g
                 1835------A     1885----a       1935--------C   1985----a
                 1836-------B    1886-e          1936f           1986------A
                 1837---------D  1887g           1937---------D  1987---------D
                 1838----a       1888-e          1938----------F 1988g
                 1839-------B    1889------A     1939-------B    1989-d
  1790-d         1840-----@      1890---a        1940--c         1990-------B
  1791----------G 1841-d         1891-----A      1941--c         1991----@
  1792-------B   1842--b         1892-----@      1942-----A      1992--------C
  1793-----@     1843i           1893---a        1943----a       1993----@
  1794---------D 1844----------E 1894-e          1944-e          1994--c
  1795--------C  1845----------E 1895-e          1945---a        1995-c
  1796---a       1846------A     1896---------D  1946----a       1996---a
  1797----@      1847-----@      1897-----A      1947----@       1997-c
  1798--b        1848------B     1898----@       1948-------B    1998----------F
  1799e          1849-d          1899--------C   1949---------E  1999----------E
```

PART 5: CORRELATION OF SERIES BY SEGMENTS

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1775 1824 | 1800 1849 | 1825 1874 | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HWT01A | 1926 2013 | | | | | | | .36 | .72 | .71 |
| 2 | HWT01B | 1934 2013 | | | | | | | .78 | .78 | .75 |
| 3 | HWT02A | 1933 2013 | | | | | | | .67 | .70 | .72 |
| 4 | HWT02B | 1931 2013 | | | | | | | .59 | .70 | .73 |
| 5 | HWT03B | 1893 2013 | | | | | .44 | .43 | .78 | .81 | .82 |
| 6 | HWT04A | 1891 2011 | | | | | .74 | .61 | .43 | .66 | .61 |
| 7 | HWT04B | 1956 2013 | | | | | | | | .51 | .42 |
| 8 | HWT05A | 1901 1937 | | | | | | .49 | | | |
| 9 | HET05A | 1943 2013 | | | | | | | .64 | .48 | .47 |
| 10 | HWT05B | 1915 2011 | | | | | | .36B | .32B | .56 | .55 |
| 11 | HWT06A | 1929 2013 | | | | | | | .78 | .75 | .77 |
| 12 | HWT06B | 1932 2011 | | | | | | | .89 | .78 | .72 |
| 13 | HWT07A | 1938 2011 | | | | | | | .67 | .76 | .80 |
| 14 | HWT09A | 1878 2012 | | | | | .30A | .49 | .76 | .84 | .78 |
| 15 | HWT09B | 1883 2012 | | | | | .45 | .61 | .70 | .78 | .77 |
| 16 | HWT10A | 1790 2013 | .71 | .73 | .75 | .55 | .65 | .73 | .52 | .55 | .51 |
| 17 | HWT10B | 1792 2013 | .71 | .73 | .75 | .43 | .49 | .72 | .66 | .74 | .82 |
| Av segment correlation | | | .71 | .73 | .75 | .49 | .51 | .55 | .63 | .69 | .68 |

PART 6: POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series

```
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

 [C] Year-to-year changes very different from the mean change in other series

 [D] Absent rings (zero values)

 [E] Values which are statistical outliers from mean for the year
==========================================================================================================================================

 HWT01A    1926 to  2013      88 years                                                                                    Series   1

 [B] Entire series, effect on correlation (  .518) is:
       Lower   1928< -.075   1936> -.040   1966> -.017   1926> -.017   1933> -.016   1935< -.015  Higher   1967  .041   1988  .035

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1928 -5.9 SD
==========================================================================================================================================

 HWT01B    1934 to  2013      80 years                                                                                    Series   2

 [B] Entire series, effect on correlation (  .748) is:
       Lower   1963< -.014   2001< -.011   1969< -.008   2004< -.007   1981< -.007   2011> -.005  Higher   1967  .023   1988  .013

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

 HWT02A    1933 to  2013      81 years                                                                                    Series   3

 [B] Entire series, effect on correlation (  .717) is:
       Lower   1946< -.022   1987< -.017   1993> -.015   1958< -.013   1969< -.010   1977> -.010  Higher   1988  .031   1967  .025

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

 HWT02B    1931 to  2013      83 years                                                                                    Series   4

 [B] Entire series, effect on correlation (  .662) is:
       Lower   1931> -.023   1966> -.015   1969< -.013   1938< -.012   1973< -.011   1935< -.008  Higher   1967  .027   2012  .013

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1931 +3.1 SD
==========================================================================================================================================

 HWT03B    1893 to  2013     121 years                                                                                    Series   5

 [B] Entire series, effect on correlation (  .635) is:
       Lower   1916< -.023   1914> -.021   1906< -.019   1913< -.015   1959< -.011   1918< -.007  Higher   1988  .021   1983  .013

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1914 +3.2 SD
==========================================================================================================================================

 HWT04A    1891 to  2011     121 years                                                                                    Series   6

 [B] Entire series, effect on correlation (  .616) is:
       Lower   1947< -.043   1970> -.015   1941> -.012   1975< -.012   2010< -.012   1936> -.011  Higher   1914  .048   1983  .020

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1941 +3.1 SD;    1947 -4.9 SD
==========================================================================================================================================
```

HWT04B  1956 to  2013  58 years  Series  7

[B] Entire series, effect on correlation (  .398) is:
Lower  2012> -.052  1966< -.049  2010< -.041  1967> -.040  1957< -.021  1964> -.020  Higher  1988  .054  1983  .034

[C] Year-to-year changes diverging by over 4.0 std deviations:
1966 1967  5.1 SD

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
1966 -6.7 SD;  2012 +3.6 SD

---

HWT05A  1901 to  1937  37 years  Series  8

[B] Entire series, effect on correlation (  .486) is:
Lower  1913> -.040  1901> -.039  1915< -.038  1910< -.035  1928> -.021  1917> -.014  Higher  1914  .137  1937  .022

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1928 +3.1 SD

---

HET05A  1943 to  2013  71 years  Series  9

[B] Entire series, effect on correlation (  .486) is:
Lower  1999< -.078  2000> -.044  1996< -.030  1959< -.025  1982< -.006  1989> -.006  Higher  2012  .029  1988  .028

[C] Year-to-year changes diverging by over 4.0 std deviations:
1999 2000  4.3 SD

---

HWT05B  1915 to  2011  97 years  Series  10

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1915 1964 | 3 | .26 | .09 | .09 | .17 | .03 | .01 | .06 | -.02 | -.30 | -.16 | .36\| | .09 | .04 | .36*- | .32 | -.10 | .12 | -.17 | -.12 | -.14 | .10 |
| 1925 1974 | 3 | .28 | -.08 | .05 | .14 | -.13 | -.05 | .12 | .01 | -.17 | -.17 | .32\| | .32 | .10 | .34*- | .19 | -.10 | .05 | -.18 | -.22 | -.11 | .13 |

[B] Entire series, effect on correlation (  .466) is:
Lower  2008< -.037  1951< -.022  1944> -.012  1935< -.011  1938< -.010  1976> -.010  Higher  1988  .057  1916  .018
1915 to 1964 segment:
Lower  1951< -.055  1935< -.030  1938< -.025  1944> -.023  1928> -.020  1945> -.017  Higher  1916  .055  1930  .026
1925 to 1974 segment:
Lower  1951< -.053  1935< -.029  1938< -.024  1944> -.019  1974< -.017  1928> -.015  Higher  1967  .034  1966  .027

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
1945 +3.1 SD;  2008 -5.4 SD

---

HWT06A  1929 to  2013  85 years  Series  11

[B] Entire series, effect on correlation (  .770) is:
Lower  1987< -.024  1988> -.012  1931> -.011  1936< -.007  1981> -.007  1967> -.007  Higher  1983  .014  1998  .009

---

HWT06B  1932 to  2011  80 years  Series  12

[B] Entire series, effect on correlation ( .783) is:
Lower 2007< -.030 1988> -.029 1986< -.009 1987< -.008 1990< -.008 1984> -.007 Higher 1936 .017 1967 .014

==========

HWT07A 1938 to 2011 74 years Series 13

[B] Entire series, effect on correlation ( .754) is:
Lower 1983> -.042 1959< -.011 1957< -.009 1940> -.009 1942< -.008 1975< -.006 Higher 1988 .038 1967 .026

==========

HWT09A 1878 to 2012 135 years Series 14

[A] Segment High -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1878 1927 | 0 | -.26 | .01 | .06 | .20 | .14 | -.01 | .02 | .01 | -.27 | -.14 | .30* | .26 | -.21 | .12 | .04 | -.03 | -.12 | .14 | .08 | .00 | -.05 |

[B] Entire series, effect on correlation ( .575) is:
Lower 1892< -.028 1895> -.024 1914> -.021 1901> -.015 1900< -.014 1888> -.014 Higher 1988 .027 1983 .020
1878 to 1927 segment:
Lower 1892< -.053 1895> -.049 1901> -.033 1888> -.029 1900< -.024 1915> -.015 Higher 1916 .041 1886 .023

[E] Outliers 4 3.0 SD above or -4.5 SD below mean for year
1888 +3.5 SD; 1895 +3.1 SD; 1914 +4.3 SD; 1915 +3.3 SD

==========

HWT09B 1883 to 2012 130 years Series 15

[B] Entire series, effect on correlation ( .614) is:
Lower 1894> -.027 1901< -.023 1892> -.015 1899< -.010 1923> -.009 1886> -.009 Higher 1914 .030 1988 .014

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1894 +4.1 SD; 1901 -5.8 SD

==========

HWT10A 1790 to 2013 224 years Series 16

[*] Early part of series cannot be checked from 1790 to 1791 -- not matched by another series

[B] Entire series, effect on correlation ( .640) is:
Lower 1875> -.011 1827< -.009 1937< -.008 1876< -.007 2012> -.006 1953> -.006 Higher 1834 .055 1914 .015

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1815 +4.8 SD; 1875 +3.7 SD

==========

HWT10B 1792 to 2013 222 years Series 17

[B] Entire series, effect on correlation ( .669) is:
Lower 1875< -.013 1827> -.008 1831< -.007 1826> -.006 1876> -.006 1879< -.006 Higher 1834 .050 1914 .013

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1815 -4.8 SD; 1827 +3.6 SD

==========

PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HWT01A | 1926 2013 | 88 | 3 | 0 | .518 | 4.08 | 11.56 | 2.642 | .789 | .378 | 2.72 | .537 | -.081 | 2 |
| 2 | HWT01B | 1934 2013 | 80 | 3 | 0 | .748 | 3.83 | 10.89 | 2.926 | .795 | .380 | 2.58 | .436 | -.071 | 2 |
| 3 | HWT02A | 1933 2013 | 81 | 3 | 0 | .717 | 3.98 | 16.40 | 3.627 | .836 | .334 | 2.82 | .567 | .013 | 2 |
| 4 | HWT02B | 1931 2013 | 83 | 3 | 0 | .662 | 3.86 | 17.41 | 3.404 | .748 | .371 | 2.79 | .471 | -.043 | 2 |
| 5 | HWT03B | 1893 2013 | 121 | 5 | 0 | .635 | 3.18 | 7.30 | 1.553 | .620 | .328 | 2.69 | .414 | .005 | 1 |
| 6 | HWT04A | 1891 2011 | 121 | 5 | 0 | .616 | 2.54 | 6.29 | 1.130 | .523 | .355 | 2.64 | .443 | .024 | 2 |
| 7 | HWT04B | 1956 2013 | 58 | 2 | 0 | .398 | 3.52 | 17.14 | 2.924 | .751 | .414 | 2.42 | .393 | .019 | 1 |
| 8 | HWT05A | 1901 1937 | 37 | 1 | 0 | .486 | 1.18 | 2.54 | .524 | .330 | .362 | 2.82 | .663 | .088 | 1 |
| 9 | HET05A | 1943 2013 | 71 | 3 | 0 | .486 | 1.65 | 5.12 | 1.021 | .798 | .295 | 2.79 | .592 | .004 | 1 |
| 10 | HWT05B | 1915 2011 | 97 | 4 | 2 | .466 | 1.65 | 4.25 | .928 | .749 | .306 | 2.68 | .441 | -.076 | 1 |
| 11 | HWT06A | 1929 2013 | 85 | 3 | 0 | .770 | 2.94 | 8.98 | 1.900 | .673 | .404 | 2.54 | .409 | -.054 | 1 |
| 12 | HWT06B | 1932 2011 | 80 | 3 | 0 | .783 | 2.89 | 8.51 | 1.762 | .651 | .378 | 2.59 | .526 | -.071 | 1 |
| 13 | HWT07A | 1938 2011 | 74 | 3 | 0 | .754 | 3.25 | 7.02 | 1.237 | .494 | .322 | 2.75 | .527 | -.029 | 1 |
| 14 | HWT09A | 1878 2012 | 135 | 5 | 1 | .575 | 2.38 | 7.26 | 1.286 | .385 | .451 | 2.92 | .607 | -.024 | 1 |
| 15 | HWT09B | 1883 2012 | 130 | 5 | 0 | .614 | 2.49 | 7.67 | 1.393 | .471 | .471 | 2.76 | .523 | -.044 | 1 |
| 16 | HWT10A | 1790 2013 | 224 | 9 | 0 | .640 | 1.78 | 4.85 | .870 | .504 | .354 | 2.74 | .372 | -.044 | 1 |
| 17 | HWT10B | 1792 2013 | 222 | 9 | 0 | .669 | 1.92 | 5.67 | .848 | .521 | .329 | 2.69 | .364 | .000 | 1 |
| Total or mean: | | | 1787 | 69 | 3 | .629 | 2.64 | 17.41 | 1.595 | .601 | .366 | 2.92 | .466 | -.026 | |

# APPENDIX J

## COFECHA PROGRAM OUTPUT FOR PIONEER MOTHERS SITE CHRONOLOGY, *CARYA OVATA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                    Version 6.06P    29369
------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   PMO.txt


 Time span of Master dating series is  1886 to  2012   127 years
 Continuous time span is               1886 to  2012   127 years
 Portion with two or more series is    1889 to  2012   124 years


                                    ****************************************
                                    *C* Number of dated series        12 *C*
                                    *O* Master series 1886 2012  127 yrs *O*
                                    *F* Total rings in all series   1347 *F*
                                    *E* Total dated rings checked   1344 *E*
                                    *C* Series intercorrelation     .577 *C*
                                    *H* Average mean sensitivity    .308 *H*
                                    *A* Segments, possible problems    2 *A*
                                    *** Mean length of series      112.3 ***
                                    ****************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:

```
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 Ident    Seq Time-span  Yrs
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>.    . PMO1A      1 1900 1998   99
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>.    . PMO1B      2 1900 1998   99
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMO2A      3 1908 2012  105
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==========>   . PMO2B      4 1919 2012   94
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMO3A      5 1906 2012  107
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <===========>   . PMO3B      6 1898 2012  115
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <===========>   . PMO4A      7 1897 2012  116
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <============>   . PMO4B      8 1886 2012  127
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <===========>   . PMO5A      9 1891 2012  122
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <============>   . PMO5B     10 1889 2012  124
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <===========>   . PMO6A     11 1891 2012  122
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <===========>   . PMO6B     12 1896 2012  117
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050
```

PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | .688 | 9 | 1950 | .381 | 12 | 2000 | 1.522 | 10 | | | | | | |
| | | | 1901 | -1.222 | 9 | 1951 | .571 | 12 | 2001 | .550 | 10 | | | | | | |
| | | | 1902 | .843 | 9 | 1952 | -.541 | 12 | 2002 | .612 | 10 | | | | | | |
| | | | 1903 | .862 | 9 | 1953 | -1.446 | 12 | 2003 | -.853 | 10 | | | | | | |
| | | | 1904 | .194 | 9 | 1954 | -.348 | 12 | 2004 | .548 | 10 | | | | | | |
| | | | 1905 | .208 | 9 | 1955 | -.037 | 12 | 2005 | -.481 | 10 | | | | | | |
| | | | 1906 | -.582 | 10 | 1956 | -.503 | 12 | 2006 | .866 | 10 | | | | | | |
| | | | 1907 | .496 | 10 | 1957 | -.666 | 12 | 2007 | -2.213 | 10 | | | | | | |
| | | | 1908 | -1.411 | 11 | 1958 | 1.029 | 12 | 2008 | -.461 | 10 | | | | | | |
| | | | 1909 | -.195 | 11 | 1959 | .581 | 12 | 2009 | 1.240 | 10 | | | | | | |
| | | | 1910 | .908 | 11 | 1960 | 1.864 | 12 | 2010 | 1.055 | 10 | | | | | | |
| | | | 1911 | -1.380 | 11 | 1961 | -1.162 | 12 | 2011 | -.216 | 10 | | | | | | |
| | | | 1912 | .926 | 11 | 1962 | .859 | 12 | 2012 | -1.146 | 10 | | | | | | |
| | | | 1913 | -.388 | 11 | 1963 | -.085 | 12 | | | | | | | | | |
| | | | 1914 | -.840 | 11 | 1964 | -.302 | 12 | | | | | | | | | |
| | | | 1915 | 1.693 | 11 | 1965 | -.118 | 12 | | | | | | | | | |
| | | | 1916 | 1.471 | 11 | 1966 | -.032 | 12 | | | | | | | | | |
| | | | 1917 | 1.247 | 11 | 1967 | -.506 | 12 | | | | | | | | | |
| | | | 1918 | -.363 | 11 | 1968 | -.480 | 12 | | | | | | | | | |
| | | | 1919 | .222 | 12 | 1969 | -.562 | 12 | | | | | | | | | |
| | | | 1920 | -.033 | 12 | 1970 | -.343 | 12 | | | | | | | | | |
| | | | 1921 | -1.908 | 12 | 1971 | .270 | 12 | | | | | | | | | |
| | | | 1922 | -.138 | 12 | 1972 | -.626 | 12 | | | | | | | | | |
| | | | 1923 | -.023 | 12 | 1973 | 2.095 | 12 | | | | | | | | | |
| | | | 1924 | .379 | 12 | 1974 | 1.662 | 12 | | | | | | | | | |
| | | | 1925 | -1.629 | 12 | 1975 | .397 | 12 | | | | | | | | | |
| | | | 1926 | -.038 | 12 | 1976 | 1.079 | 12 | | | | | | | | | |
| | | | 1927 | 1.596 | 12 | 1977 | -.712 | 12 | | | | | | | | | |
| | | | 1928 | 1.472 | 12 | 1978 | -.292 | 12 | | | | | | | | | |
| | | | 1929 | .364 | 12 | 1979 | -.345 | 12 | | | | | | | | | |
| | | | 1930 | -.366 | 12 | 1980 | .671 | 12 | | | | | | | | | |
| | | | 1931 | -1.057 | 12 | 1981 | -1.966 | 12 | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1932 | .786 | 12 | | 1982 | -.625 | 12 | | |
| | | | 1933 | -.501 | 12 | | 1983 | .312 | 12 | | |
| | | | 1934 | -.515 | 12 | | 1984 | -1.110 | 12 | | |
| | | | 1935 | .652 | 12 | | 1985 | -.844 | 12 | | |
| 1886 | -3.700 | 1 | 1936 | -1.720 | 12 | | 1986 | .958 | 12 | | |
| 1887 | .494 | 1 | 1937 | -2.395 | 12 | | 1987 | -1.541 | 12 | | |
| 1888 | -1.167 | 1 | 1938 | 1.527 | 12 | | 1988 | -.401 | 12 | | |
| 1889 | -.438 | 2 | 1939 | 1.068 | 12 | | 1989 | .680 | 12 | | |
| 1890 | .927 | 2 | 1940 | .444 | 12 | | 1990 | .439 | 12 | | |
| 1891 | .554 | 4 | 1941 | -.895 | 12 | | 1991 | -1.634 | 12 | | |
| 1892 | 1.758 | 4 | 1942 | .841 | 12 | | 1992 | .773 | 12 | | |
| 1893 | .079 | 4 | 1943 | -.617 | 12 | | 1993 | .840 | 12 | | |
| 1894 | -.484 | 4 | 1944 | -1.538 | 12 | | 1994 | -.740 | 12 | | |
| 1895 | .230 | 4 | 1945 | 1.312 | 12 | | 1995 | .492 | 12 | | |
| 1896 | .289 | 5 | 1946 | .803 | 12 | | 1996 | .197 | 12 | | |
| 1897 | -.191 | 6 | 1947 | .255 | 12 | | 1997 | -.471 | 12 | | |
| 1898 | -1.314 | 7 | 1948 | 1.125 | 12 | | 1998 | .461 | 12 | | |
| 1899 | -.454 | 7 | 1949 | .372 | 12 | | 1999 | 1.222 | 10 | | |

PART 4: Master Bar Plot:

| Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1900 | -------C | 1950 | ------B | 2000 | ----------F | | | | | | | | |
| | | 1901 | -e | 1951 | -------B | 2001 | -------B | | | | | | | | |
| | | 1902 | --------C | 1952 | ---b | 2002 | -------B | | | | | | | | |
| | | 1903 | --------C | 1953 | f | 2003 | --c | | | | | | | | |
| | | 1904 | ------A | 1954 | ----a | 2004 | -------B | | | | | | | | |
| | | 1905 | ------A | 1955 | -----@ | 2005 | ---b | | | | | | | | |
| | | 1906 | --b | 1956 | ---b | 2006 | --------C | | | | | | | | |
| | | 1907 | -------B | 1957 | --c | 2007 | i | | | | | | | | |
| | | 1908 | f | 1958 | ---------D | 2008 | ---b | | | | | | | | |
| | | 1909 | ----a | 1959 | -------B | 2009 | ---------E | | | | | | | | |
| | | 1910 | --------D | 1960 | ----------G | 2010 | ---------D | | | | | | | | |
| | | 1911 | -f | 1961 | -e | 2011 | ----a | | | | | | | | |
| | | 1912 | --------D | 1962 | --------C | 2012 | -e | | | | | | | | |
| | | 1913 | ---b | 1963 | -----@ | | | | | | | | | | |
| | | 1914 | --c | 1964 | ----a | | | | | | | | | | |
| | | 1915 | ----------G | 1965 | -----@ | | | | | | | | | | |
| | | 1916 | ----------F | 1966 | -----@ | | | | | | | | | | |
| | | 1917 | ---------E | 1967 | ---b | | | | | | | | | | |
| | | 1918 | ----a | 1968 | ---b | | | | | | | | | | |
| | | 1919 | ------A | 1969 | --b | | | | | | | | | | |
| | | 1920 | -----@ | 1970 | ----a | | | | | | | | | | |
| | | 1921 | h | 1971 | ------A | | | | | | | | | | |
| | | 1922 | -----a | 1972 | --c | | | | | | | | | | |
| | | 1923 | -----@ | 1973 | ----------H | | | | | | | | | | |
| | | 1924 | ------B | 1974 | ----------G | | | | | | | | | | |
| | | 1925 | g | 1975 | ------B | | | | | | | | | | |
| | | 1926 | -----@ | 1976 | ---------D | | | | | | | | | | |
| | | 1927 | ----------F | 1977 | --c | | | | | | | | | | |
| | | 1928 | ----------F | 1978 | ----a | | | | | | | | | | |
| | | 1929 | ------A | 1979 | ----a | | | | | | | | | | |
| | | 1930 | ----a | 1980 | -------C | | | | | | | | | | |
| | | 1931 | -d | 1981 | h | | | | | | | | | | |
| | | 1932 | --------C | 1982 | --b | | | | | | | | | | |
| | | 1933 | ---b | 1983 | ------A | | | | | | | | | | |

```
                  1934---b        1984-d
                  1935-------C    1985--c
  1886o           1936g           1986---------D
  1887-------B    1937j           1987f
  1888-e          1938----------F 1988---b
  1889---b        1939---------D  1989-------C
  1890--------D   1940------B     1990------B
  1891-------B    1941-d          1991g
  1892----------G 1942--------C   1992--------C
  1893-----@      1943--b         1993--------C
  1894---b        1944f           1994--c
  1895------A     1945---------E  1995-------B
  1896------A     1946--------C   1996------A
  1897----a       1947------A     1997---b
  1898-e          1948---------D  1998------B
  1899---b        1949------A     1999---------E
```

PART 5: CORRELATION OF SERIES BY SEGMENTS

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1875 1900 1925 1950 1975 1924 1949 1974 1999 2024 |
|---|---|---|---|
| 1 | PMO1A | 1900 1998 | .67 .63 .48 |
| 2 | PMO1B | 1900 1998 | .65 .51 .03B |
| 3 | PMO2A | 1908 2012 | .74 .73 .75 .79 |
| 4 | PMO2B | 1919 2012 | .78 .79 .73 .78 |
| 5 | PMO3A | 1906 2012 | .68 .76 .62 .51 |
| 6 | PMO3B | 1898 2012 | .71 .74 .78 .79 .82 |
| 7 | PMO4A | 1897 2012 | .49 .49 .60 .39 .51 |
| 8 | PMO4B | 1886 2012 | .52 .64 .47 .38 .46 |
| 9 | PMO5A | 1891 2012 | .56 .43 .44 .51 .49 |
| 10 | PMO5B | 1889 2012 | .45 .35 .30A .56 .48 |
| 11 | PMO6A | 1891 2012 | .70 .76 .67 .52 .53 |
| 12 | PMO6B | 1896 2012 | .66 .69 .75 .65 .61 |
| Av segment correlation | | | .58 .63 .62 .53 .60 |

PART 6: POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

PMO1A 1900 to 1998 99 years Series 1

```
 [B] Entire series, effect on correlation (  .585) is:
       Lower   1971< -.022   1903< -.018   1943> -.016   1988< -.016   1938< -.015   1977> -.011  Higher   1937  .036   1981  .021

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

 PMO1B     1900 to  1998      99 years                                                                                          Series   2

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1949 1998    4    .06  .05  .13 -.14  .11  .11 -.11 -.16  .16 -.08  .03| .10  .06 -.22  .31*-.15 -.19  .06  .09 -.18 -.04

 [B] Entire series, effect on correlation (  .356) is:
       Lower   1981> -.074   1995< -.024   1984> -.023   1994> -.019   1938< -.017   1961> -.013  Higher   1937  .064   1936  .029
     1949 to 1998 segment:
       Lower   1981> -.122   1995< -.040   1984> -.035   1994> -.028   1976< -.018   1956> -.015  Higher   1987  .081   1973  .061

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1981 +5.0 SD
================================================================================================================================================

 PMO2A     1908 to  2012     105 years                                                                                          Series   3

 [B] Entire series, effect on correlation (  .763) is:
       Lower   1929< -.011   1962< -.008   1998> -.008   1944> -.007   1954< -.007   1957> -.006  Higher   1981  .014   2007  .011

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

 PMO2B     1919 to  2012      94 years                                                                                          Series   4

 [B] Entire series, effect on correlation (  .794) is:
       Lower   1957> -.016   1962< -.013   2011> -.013   1968> -.010   1990> -.008   1992< -.006  Higher   1937  .016   1981  .012

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

 PMO3A     1906 to  2012     107 years                                                                                          Series   5

 [B] Entire series, effect on correlation (  .607) is:
       Lower   2007> -.024   1910< -.023   2001< -.018   1956> -.017   1911> -.017   1936> -.015  Higher   1937  .030   1981  .022

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

 PMO3B     1898 to  2012     115 years                                                                                          Series   6

 [B] Entire series, effect on correlation (  .754) is:
       Lower   1936> -.017   1956> -.012   1898> -.012   1907< -.011   2008< -.008   1905> -.006  Higher   1937  .017   2007  .011

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

 PMO4A     1897 to  2012     116 years                                                                                          Series   7

 [B] Entire series, effect on correlation (  .478) is:
       Lower   1905< -.085   1981> -.016   1958< -.015   1961> -.010   1959< -.010   2004< -.009  Higher   1936  .024   2007  .021

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1905 -5.5 SD
================================================================================================================================================

 PMO4B     1886 to  2012     127 years                                                                                          Series   8
```

[*] Early part of series cannot be checked from 1886 to 1888 -- not matched by another series

[B] Entire series, effect on correlation ( .473) is:
Lower 1952< -.020 1899< -.018 1976< -.016 2011> -.012 1953> -.012 2005< -.011 Higher 1936 .024 1921 .016

---

PMO5A 1891 to 2012 122 years Series 9

[B] Entire series, effect on correlation ( .485) is:
Lower 1937> -.029 1943< -.027 1996< -.026 1950< -.013 1941> -.013 1931> -.010 Higher 1921 .014 1925 .014

---

PMO5B 1889 to 2012 124 years Series 10

[A] Segment High -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1925 1974 | 0 | .16 | .18 | -.16 | -.05 | .06 | -.04 | -.15 | .07 | .03 | -.34 | .30* | .19 | -.20 | -.11 | -.06 | .05 | -.17 | -.07 | .03 | -.15 | -.03 |

[B] Entire series, effect on correlation ( .434) is:
Lower 1937> -.066 1946< -.043 2003> -.009 1987> -.009 2005> -.009 1999< -.008 Higher 1981 .027 2007 .025
1925 to 1974 segment:
Lower 1937> -.151 1946< -.109 1934> -.014 1962< -.013 1930> -.010 1939< -.009 Higher 1960 .037 1973 .035

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1937 +4.6 SD; 2007 -4.7 SD

---

PMO6A 1891 to 2012 122 years Series 11

[B] Entire series, effect on correlation ( .605) is:
Lower 1956> -.015 1891< -.013 1984> -.013 1952> -.009 1945< -.009 1987> -.008 Higher 1981 .018 1937 .018

---

PMO6B 1896 to 2012 117 years Series 12

[B] Entire series, effect on correlation ( .638) is:
Lower 1911> -.017 1952> -.015 1977> -.014 2005> -.012 2007> -.009 1896> -.008 Higher 1937 .018 1908 .012

---

PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PMO1A | 1900 1998 | 99 | 3 | 0 | .585 | 1.30 | 4.49 | .701 | .580 | .284 | 2.75 | .529 | .035 | 2 |
| 2 | PMO1B | 1900 1998 | 99 | 3 | 1 | .356 | 1.03 | 4.81 | .682 | .671 | .241 | 2.82 | .438 | .059 | 2 |
| 3 | PMO2A | 1908 2012 | 105 | 4 | 0 | .763 | 1.72 | 4.02 | .758 | .440 | .330 | 2.88 | .583 | -.054 | 1 |
| 4 | PMO2B | 1919 2012 | 94 | 4 | 0 | .794 | 2.09 | 4.18 | .818 | .194 | .411 | 2.72 | .552 | -.021 | 1 |
| 5 | PMO3A | 1906 2012 | 107 | 4 | 0 | .607 | 2.25 | 5.29 | .940 | .295 | .352 | 2.90 | .522 | -.037 | 1 |
| 6 | PMO3B | 1898 2012 | 115 | 5 | 0 | .754 | 2.05 | 4.66 | .873 | .437 | .319 | 2.74 | .511 | -.082 | 1 |
| 7 | PMO4A | 1897 2012 | 116 | 5 | 0 | .478 | 1.69 | 4.44 | .838 | .619 | .305 | 2.61 | .417 | -.033 | 2 |
| 8 | PMO4B | 1886 2012 | 127 | 5 | 0 | .473 | 1.58 | 3.89 | .753 | .715 | .300 | 2.70 | .521 | -.006 | 1 |
| 9 | PMO5A | 1891 2012 | 122 | 5 | 0 | .485 | 1.13 | 2.26 | .507 | .640 | .323 | 2.60 | .424 | -.013 | 1 |
| 10 | PMO5B | 1889 2012 | 124 | 5 | 1 | .434 | .82 | 2.15 | .317 | .649 | .266 | 2.59 | .368 | -.063 | 2 |
| 11 | PMO6A | 1891 2012 | 122 | 5 | 0 | .605 | 1.54 | 3.53 | .717 | .604 | .289 | 2.55 | .461 | -.013 | 1 |
| 12 | PMO6B | 1896 2012 | 117 | 5 | 0 | .638 | 1.39 | 3.47 | .594 | .533 | .296 | 2.75 | .490 | -.007 | 1 |
| Total or mean: | | | 1347 | 53 | 2 | .577 | 1.54 | 5.29 | .702 | .540 | .308 | 2.90 | .482 | -.021 | |

# APPENDIX K

## COFECHA PROGRAM OUTPUT FOR PIONEER MOTHERS SITE CHRONOLOGY, *QUERCUS RUBRA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                    Version 6.06P    29369
------------------------------------------------------------------------------------------------------------------------

QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

File of DATED series:   PMR.txt


Time span of Master dating series is  1861 to  2012   152 years
Continuous time span is               1861 to  2012   152 years
Portion with two or more series is    1876 to  2012   137 years


                                    ***************************************
                                    *C* Number of dated series        44 *C*
                                    *O* Master series 1861 2012  152 yrs *O*
                                    *F* Total rings in all series   4438 *F*
                                    *E* Total dated rings checked   4423 *E*
                                    *C* Series intercorrelation     .588 *C*
                                    *H* Average mean sensitivity    .196 *H*
                                    *A* Segments, possible problems    3 *A*
                                    *** Mean length of series      100.9 ***
                                    ***************************************

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

             No ring measurements of zero value
```

```
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 Ident    Seq Time-span  Yrs
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR01A     1 1905 2012  108
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <=======>   . PMR01B     2 1944 2012   69
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR02A     3 1909 2012  104
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==========>   . PMR02B     4 1915 2012   98
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <==============>   . PMR03A     5 1876 2012  137
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==============>   . PMR03B     6 1861 2011  151
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <========>   . PMR04A     7 1936 2012   77
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . PMR06A     8 1894 2012  119
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR06B     9 1905 2012  108
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . PMW07A    10 1890 2012  123
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR09A    11 1907 2012  106
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==========>   . PMR09B    12 1911 2012  102
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . PMR10A    13 1895 2012  118
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR10B    14 1902 2012  111
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR14A    15 1906 2012  107
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR14B    16 1903 2012  110
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==========>   . PMR15A    17 1916 2012   97
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR15B    18 1900 2011  112
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==========>   . PMR16A    19 1910 2012  103
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .     <=====>   . PMR17A    20 1950 2012   63
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>   . PMR16B    21 1940 2012   73
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR17B    22 1905 2012  108
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>   . PMR18A    23 1944 2012   69
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <========>   . PMR18B    24 1920 2012   93
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR19A    25 1904 2012  109
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR19B    26 1905 2012  108
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR20A    27 1907 2012  106
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <========>   . PMR20B    28 1936 2012   77
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <========>   . PMR21B    29 1935 2012   78
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR22B    30 1902 2012  111
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . PMR23A    31 1894 2012  119
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==============>   . PMR23B    32 1881 2011  131
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==========>   . PMR24A    33 1913 2012  100
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <========>   . PMR25A    34 1939 2012   74
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <========>   . PMR25B    35 1937 2012   76
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . PMR26A    36 1897 2012  116
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==========>   . PMR27A    37 1912 2012  101
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>   . PMR27B    38 1949 2012   64
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMR28A    39 1902 2012  111
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . PMR29A2   40 1897 2012  116
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . PMR29B    41 1895 2012  118
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <=======>   . PMR30A    42 1949 2012   64
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <========>   . PMR30B    43 1932 2012   81
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==========>   . PMW02A    44 1901 2012  112
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050
```

PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1900 | .116 | 11 | 1950 | .932 | 44 | 2000 | 1.343 | 44 | | | | | | |
| | | | 1901 | -1.244 | 12 | 1951 | .281 | 44 | 2001 | 1.026 | 44 | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1902 | .845 | 15 | 1952 | -1.548 | 44 | 2002 | .365 | 44 |
| | | | 1903 | .863 | 16 | 1953 | -1.914 | 44 | 2003 | 1.035 | 44 |
| | | | 1904 | -.669 | 17 | 1954 | -2.575 | 44 | 2004 | .618 | 44 |
| | | | 1905 | .256 | 21 | 1955 | .755 | 44 | 2005 | -.116 | 44 |
| | | | 1906 | .646 | 22 | 1956 | .708 | 44 | 2006 | .552 | 44 |
| | | | 1907 | .517 | 24 | 1957 | 1.176 | 44 | 2007 | -2.147 | 44 |
| | | | 1908 | -1.747 | 24 | 1958 | 1.501 | 44 | 2008 | -.964 | 44 |
| | | | 1909 | .010 | 25 | 1959 | .610 | 44 | 2009 | .463 | 44 |
| | | | 1910 | .428 | 26 | 1960 | .674 | 44 | 2010 | .518 | 44 |
| 1861 | -.768 | 1 | 1911 | -1.005 | 27 | 1961 | .823 | 44 | 2011 | .311 | 44 |
| 1862 | 2.186 | 1 | 1912 | .222 | 28 | 1962 | .186 | 44 | 2012 | -1.236 | 41 |
| 1863 | .455 | 1 | 1913 | -1.058 | 29 | 1963 | .726 | 44 | | | |
| 1864 | -.869 | 1 | 1914 | -.989 | 29 | 1964 | .112 | 44 | | | |
| 1865 | 2.764 | 1 | 1915 | 1.121 | 30 | 1965 | -.272 | 44 | | | |
| 1866 | -.398 | 1 | 1916 | 1.592 | 31 | 1966 | -1.547 | 44 | | | |
| 1867 | -2.477 | 1 | 1917 | .382 | 31 | 1967 | -.864 | 44 | | | |
| 1868 | -.597 | 1 | 1918 | -.407 | 31 | 1968 | .445 | 44 | | | |
| 1869 | 1.341 | 1 | 1919 | .267 | 31 | 1969 | -.130 | 44 | | | |
| 1870 | 1.009 | 1 | 1920 | -.007 | 32 | 1970 | .157 | 44 | | | |
| 1871 | -1.860 | 1 | 1921 | -.669 | 32 | 1971 | -1.077 | 44 | | | |
| 1872 | .157 | 1 | 1922 | .196 | 32 | 1972 | -2.309 | 44 | | | |
| 1873 | -.933 | 1 | 1923 | .094 | 32 | 1973 | .520 | 44 | | | |
| 1874 | -1.614 | 1 | 1924 | 1.099 | 32 | 1974 | 1.161 | 44 | | | |
| 1875 | .773 | 1 | 1925 | -1.633 | 32 | 1975 | .744 | 44 | | | |
| 1876 | 1.608 | 2 | 1926 | .029 | 32 | 1976 | .376 | 44 | | | |
| 1877 | .646 | 2 | 1927 | .099 | 32 | 1977 | .514 | 44 | | | |
| 1878 | -.535 | 2 | 1928 | 1.201 | 32 | 1978 | .750 | 44 | | | |
| 1879 | -1.219 | 2 | 1929 | .616 | 32 | 1979 | -.028 | 44 | | | |
| 1880 | -1.055 | 2 | 1930 | -.569 | 32 | 1980 | -.032 | 44 | | | |
| 1881 | -.440 | 3 | 1931 | .097 | 32 | 1981 | .482 | 44 | | | |
| 1882 | -.518 | 3 | 1932 | .692 | 33 | 1982 | 1.051 | 44 | | | |
| 1883 | -.615 | 3 | 1933 | -1.189 | 33 | 1983 | -1.784 | 44 | | | |
| 1884 | -1.482 | 3 | 1934 | -1.078 | 33 | 1984 | -1.971 | 44 | | | |
| 1885 | -.047 | 3 | 1935 | .420 | 34 | 1985 | .179 | 44 | | | |
| 1886 | 1.176 | 3 | 1936 | -2.424 | 36 | 1986 | .255 | 44 | | | |
| 1887 | -.277 | 3 | 1937 | -.264 | 37 | 1987 | .134 | 44 | | | |
| 1888 | -.008 | 3 | 1938 | 1.706 | 37 | 1988 | -1.600 | 44 | | | |
| 1889 | 1.001 | 3 | 1939 | 1.177 | 38 | 1989 | .583 | 44 | | | |
| 1890 | -1.545 | 4 | 1940 | -.168 | 39 | 1990 | -.182 | 44 | | | |
| 1891 | .714 | 4 | 1941 | -.238 | 39 | 1991 | -.610 | 44 | | | |
| 1892 | 1.347 | 4 | 1942 | .802 | 39 | 1992 | .848 | 44 | | | |
| 1893 | -.210 | 4 | 1943 | .048 | 39 | 1993 | .203 | 44 | | | |
| 1894 | .171 | 6 | 1944 | -1.687 | 41 | 1994 | -.467 | 44 | | | |
| 1895 | .120 | 8 | 1945 | .354 | 41 | 1995 | .794 | 44 | | | |
| 1896 | .612 | 8 | 1946 | .334 | 41 | 1996 | -.838 | 44 | | | |
| 1897 | .792 | 10 | 1947 | .961 | 41 | 1997 | -1.518 | 44 | | | |
| 1898 | .247 | 10 | 1948 | .321 | 41 | 1998 | .781 | 44 | | | |
| 1899 | -.430 | 10 | 1949 | .515 | 43 | 1999 | .838 | 44 | | | |

PART 4:  Master Bar Plot:

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1900-----@ | 1950---------D | 2000----------E | | | | |
| | 1901-e | 1951-----A | 2001---------D | | | | |
| | 1902--------C | 1952f | 2002------A | | | | |
| | 1903--------C | 1953h | 2003---------D | | | | |
| | 1904--c | 1954j | 2004-------B | | | | |
| | 1905-----A | 1955--------C | 2005----@ | | | | |
| | 1906-------C | 1956--------C | 2006-------B | | | | |
| | 1907-------B | 1957----------E | 2007i | | | | |
| | 1908g | 1958----------F | 2008-d | | | | |
| | 1909----@ | 1959-------B | 2009------B | | | | |
| | 1910------B | 1960--------C | 2010-------B | | | | |
| 1861--c | 1911-d | 1961--------C | 2011------A | | | | |
| 1862----------I | 1912-----A | 1962-----A | 2012-e | | | | |
| 1863------B | 1913-d | 1963--------C | | | | | |
| 1864--c | 1914-d | 1964-----@ | | | | | |
| 1865----------K | 1915---------D | 1965---a | | | | | |
| 1866---b | 1916----------F | 1966f | | | | | |
| 1867j | 1917------B | 1967--c | | | | | |
| 1868--b | 1918---b | 1968------B | | | | | |
| 1869----------E | 1919-----A | 1969----a | | | | | |
| 1870---------D | 1920----@ | 1970-----A | | | | | |
| 1871g | 1921--c | 1971-d | | | | | |
| 1872-----A | 1922-----A | 1972i | | | | | |
| 1873--d | 1923----@ | 1973-------B | | | | | |
| 1874f | 1924---------D | 1974---------E | | | | | |
| 1875--------C | 1925g | 1975--------C | | | | | |
| 1876----------F | 1926----@ | 1976------B | | | | | |
| 1877-------C | 1927-----@ | 1977-------B | | | | | |
| 1878--b | 1928----------E | 1978--------C | | | | | |
| 1879-e | 1929-------B | 1979----@ | | | | | |
| 1880-d | 1930--b | 1980----@ | | | | | |
| 1881---b | 1931----@ | 1981-------B | | | | | |
| 1882--b | 1932--------C | 1982---------D | | | | | |
| 1883--b | 1933-e | 1983g | | | | | |
| 1884-f | 1934-d | 1984h | | | | | |
| 1885----@ | 1935------B | 1985-----A | | | | | |
| 1886----------E | 1936j | 1986-----A | | | | | |
| 1887---a | 1937---a | 1987-----A | | | | | |
| 1888----@ | 1938----------G | 1988f | | | | | |
| 1889---------D | 1939----------E | 1989-------B | | | | | |
| 1890f | 1940---a | 1990---a | | | | | |
| 1891--------C | 1941---a | 1991--b | | | | | |
| 1892----------E | 1942--------C | 1992--------C | | | | | |
| 1893---a | 1943----@ | 1993-----A | | | | | |
| 1894-----A | 1944g | 1994---b | | | | | |
| 1895-----@ | 1945------A | 1995--------C | | | | | |
| 1896-------B | 1946------A | 1996--c | | | | | |
| 1897--------C | 1947---------D | 1997-f | | | | | |
| 1898-----A | 1948------A | 1998--------C | | | | | |
| 1899---b | 1949-------B | 1999--------C | | | | | |

PART 5:  CORRELATION OF SERIES BY SEGMENTS:

Correlations of  50-year dated segments, lagged  25 years
Flags:  A = correlation under   .3281 but highest as dated;  B = correlation higher at other than dated position

| Seq | Series | Time_span | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|
| 1 | PMR01A | 1905 2012 | | .38 | .53 | .71 | .71 |
| 2 | PMR01B | 1944 2012 | | | .77 | .75 | .75 |
| 3 | PMR02A | 1909 2012 | | .67 | .68 | .69 | .68 |
| 4 | PMR02B | 1915 2012 | | .67 | .68 | .58 | .59 |
| 5 | PMR03A | 1876 2012 | .44 | .67 | .62 | .57 | .53 |
| 6 | PMR03B | 1861 2011 | .41 | .52 | .60 | .52 | .38 |
| 7 | PMR04A | 1936 2012 | | | .51 | .49 | .56 |
| 8 | PMR06A | 1894 2012 | .60 | .59 | .56 | .54 | .52 |
| 9 | PMR06B | 1905 2012 | | .40 | .64 | .62 | .43 |
| 10 | PMW07A | 1890 2012 | .63 | .73 | .52 | .47 | .50 |
| 11 | PMR09A | 1907 2012 | | .63 | .74 | .80 | .73 |
| 12 | PMR09B | 1911 2012 | | .63 | .68 | .77 | .65 |
| 13 | PMR10A | 1895 2012 | .64 | .71 | .74 | .69 | .64 |
| 14 | PMR10B | 1902 2012 | | .45 | .70 | .67 | .50 |
| 15 | PMR14A | 1906 2012 | | .88 | .82 | .69 | .52 |
| 16 | PMR14B | 1903 2012 | | .75 | .78 | .77 | .77 |
| 17 | PMR15A | 1916 2012 | | .34 | .46 | .62 | .63 |
| 18 | PMR15B | 1900 2011 | | .73 | .76 | .68 | .61 |
| 19 | PMR16A | 1910 2012 | | .66 | .76 | .72 | .68 |
| 20 | PMR17A | 1950 2012 | | | | .66 | .60 |
| 21 | PMR16B | 1940 2012 | | | .74 | .66 | .60 |
| 22 | PMR17B | 1905 2012 | | .76 | .76 | .55 | .55 |
| 23 | PMR18A | 1944 2012 | | | .72 | .71 | .66 |
| 24 | PMR18B | 1920 2012 | | .72 | .72 | .48 | .37 |
| 25 | PMR19A | 1904 2012 | | .76 | .70 | .53 | .54 |
| 26 | PMR19B | 1905 2012 | | .61 | .61 | .45 | .45 |
| 27 | PMR20A | 1907 2012 | | .59 | .51 | .48 | .56 |
| 28 | PMR20B | 1936 2012 | | | .59 | .64 | .67 |
| 29 | PMR21B | 1935 2012 | | | .64 | .60 | .48 |
| 30 | PMR22B | 1902 2012 | | .30A | .65 | .75 | .66 |
| 31 | PMR23A | 1894 2012 | .53 | .55 | .53 | .48 | .45 |
| 32 | PMR23B | 1881 2011 | .35 | .52 | .52 | .54 | .35 |
| 33 | PMR24A | 1913 2012 | | .46 | .56 | .50 | .46 |
| 34 | PMR25A | 1939 2012 | | | .69 | .67 | .70 |
| 35 | PMR25B | 1937 2012 | | | .69 | .68 | .67 |
| 36 | PMR26A | 1897 2012 | .75 | .74 | .79 | .69 | .67 |
| 37 | PMR27A | 1912 2012 | | .68 | .72 | .59 | .61 |
| 38 | PMR27B | 1949 2012 | | | .63 | .62 | .65 |
| 39 | PMR28A | 1902 2012 | | .59 | .52 | .29A | .42 |
| 40 | PMR29A2 | 1897 2012 | .48 | .51 | .58 | .52 | .54 |
| 41 | PMR29B | 1895 2012 | .68 | .65 | .70 | .72 | .64 |
| 42 | PMR30A | 1949 2012 | | | .55 | .54 | .57 |
| 43 | PMR30B | 1932 2012 | | | .55 | .71 | .75 |
| 44 | PMW02A | 1901 2012 | | .31A | .77 | .73 | .70 |
| Av segment correlation | | | .55 | .60 | .65 | .62 | .58 |

PART 6: POTENTIAL PROBLEMS:

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

```
 [B] Effect of those data values which most lower or raise correlation with master series
     Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

 [C] Year-to-year changes very different from the mean change in other series

 [D] Absent rings (zero values)

 [E] Values which are statistical outliers from mean for the year
=============================================================================================================================================

 PMR01A    1905 to  2012     108 years                                                                                      Series   1

 [B] Entire series, effect on correlation (  .556) is:
       Lower   1908> -.037   1938< -.027   1935< -.022   1929< -.016   1944> -.014   1988> -.012  Higher   1983  .036   2007  .031

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

 PMR01B    1944 to  2012      69 years                                                                                      Series   2

 [B] Entire series, effect on correlation (  .765) is:
       Lower   2002< -.014   1962< -.013   1967> -.010   1971< -.008   1979> -.007   1978< -.007  Higher   2007  .017   1988  .011

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

 PMR02A    1909 to  2012     104 years                                                                                      Series   3

 [B] Entire series, effect on correlation (  .668) is:
       Lower   1944> -.027   1996> -.014   1937< -.013   1988< -.009   2008> -.009   1983> -.009  Higher   1925  .021   1954  .019

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

 PMR02B    1915 to  2012      98 years                                                                                      Series   4

 [B] Entire series, effect on correlation (  .626) is:
       Lower   1978< -.019   1983> -.015   1944> -.013   1955< -.013   2002< -.011   2000< -.009  Higher   2007  .027   1925  .025

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

 PMR03A    1876 to  2012     137 years                                                                                      Series   5

 [B] Entire series, effect on correlation (  .481) is:
       Lower   1890> -.063   1958< -.013   1945< -.010   1988> -.010   2007> -.008   1926< -.007  Higher   1908  .032   1925  .018

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1890 +4.6 SD
=============================================================================================================================================

 PMR03B    1861 to  2011     151 years                                                                                      Series   6

 [*] Early part of series cannot be checked from 1861 to 1875 -- not matched by another series

 [B] Entire series, effect on correlation (  .424) is:
       Lower   1890> -.052   1995< -.025   1903< -.017   2007> -.016   2011< -.016   1984> -.014  Higher   1972  .032   1983  .030

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1890 +4.3 SD;    1978 +3.6 SD;    1984 +3.1 SD
=============================================================================================================================================
```

```
PMR04A    1936 to  2012      77 years                                                                                    Series   7

[B] Entire series, effect on correlation (  .513) is:
      Lower   1954> -.033   1999< -.030   1973< -.026   1960< -.020   1996> -.012   1950< -.011  Higher   1983  .054   1988  .018

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

PMR06A    1894 to  2012     119 years                                                                                    Series   8

[B] Entire series, effect on correlation (  .562) is:
      Lower   1987< -.031   1988> -.023   1935< -.015   2012> -.014   1927< -.009   2011< -.007  Higher   2007  .040   1908  .033

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

PMR06B    1905 to  2012     108 years                                                                                    Series   9

[B] Entire series, effect on correlation (  .440) is:
      Lower   1908> -.033   1907< -.027   2012> -.021   1914> -.019   1944> -.016   1911> -.015  Higher   1925  .040   1954  .024

[C] Year-to-year changes diverging by over 4.0 std deviations:
      1907 1908   4.1 SD

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1914 +3.3 SD;    1976 +3.3 SD
================================================================================================================================

PMW07A    1890 to  2012     123 years                                                                                    Series  10

[B] Entire series, effect on correlation (  .531) is:
      Lower   1954> -.033   1899> -.018   1890< -.017   1947< -.014   1968< -.012   1967> -.010  Higher   1936  .026   1925  .021

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1899 +3.1 SD;    1954 +3.3 SD;    1979 +3.2 SD
================================================================================================================================

PMR09A    1907 to  2012     106 years                                                                                    Series  11

[B] Entire series, effect on correlation (  .677) is:
      Lower   1925> -.019   1908> -.014   2007> -.010   2009< -.009   1975< -.009   2005> -.008  Higher   1972  .017   1954  .013

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

PMR09B    1911 to  2012     102 years                                                                                    Series  12

[B] Entire series, effect on correlation (  .643) is:
      Lower   1925> -.028   1911> -.025   1999< -.020   1971> -.017   1937< -.011   2002< -.011  Higher   1954  .028   1983  .027

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1911 +3.1 SD
================================================================================================================================

PMR10A    1895 to  2012     118 years                                                                                    Series  13

[B] Entire series, effect on correlation (  .658) is:
      Lower   1897< -.015   1975< -.013   2005< -.012   1983> -.011   1925> -.011   1895> -.010  Higher   1936  .031   2007  .028

================================================================================================================================
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```
PMR10B    1902 to  2012     111 years                                                                                    Series  14

[B] Entire series, effect on correlation (  .488) is:
      Lower   2010< -.067   1908> -.024   1925> -.023   1915< -.016   1970< -.014   1909< -.014  Higher   1936  .071   1966  .012

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

PMR14A    1906 to  2012     107 years                                                                                    Series  15

[B] Entire series, effect on correlation (  .717) is:
      Lower   2007> -.027   1977< -.023   1989< -.022   2009< -.014   1995< -.009   1963< -.006  Higher   1936  .020   1908  .017

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

PMR14B    1903 to  2012     110 years                                                                                    Series  16

[B] Entire series, effect on correlation (  .764) is:
      Lower   1917< -.013   1968< -.011   1984< -.007   1979> -.007   1951< -.006   1944> -.006  Higher   1936  .011   1983  .010

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

PMR15A    1916 to  2012      97 years                                                                                    Series  17

[B] Entire series, effect on correlation (  .487) is:
      Lower   1923< -.026   1934> -.021   1935< -.017   1998< -.013   1927< -.011   2012> -.011  Higher   2007  .037   1988  .029

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1934 +3.3 SD
=============================================================================================================================

PMR15B    1900 to  2011     112 years                                                                                    Series  18

[B] Entire series, effect on correlation (  .706) is:
      Lower   1984> -.047   1939< -.011   1944> -.010   1968< -.009   2004< -.008   1997> -.008  Higher   1983  .021   1954  .019

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1984 +4.8 SD
=============================================================================================================================

PMR16A    1910 to  2012     103 years                                                                                    Series  19

[B] Entire series, effect on correlation (  .664) is:
      Lower   1963< -.015   1911> -.013   1915< -.011   1913> -.010   1923< -.009   1916< -.008  Higher   1936  .051   1954  .014

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

PMR17A    1950 to  2012      63 years                                                                                    Series  20

[B] Entire series, effect on correlation (  .639) is:
      Lower   1999< -.025   1983> -.022   1996> -.022   2001< -.019   2000< -.014   1975< -.013  Higher   1954  .047   1972  .038

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

PMR16B    1940 to  2012      73 years                                                                                    Series  21

[B] Entire series, effect on correlation (  .659) is:
      Lower   2010< -.027   1993< -.027   1998< -.017   1984> -.012   1988> -.009   1980< -.007  Higher   1983  .042   1953  .011
```

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

 PMR17B    1905 to  2012     108 years                                                                              Series  22

 [B] Entire series, effect on correlation (  .644) is:
       Lower   1990< -.014   1920< -.010   1996> -.009   1957< -.008   1988> -.008   2001< -.008  Higher   1936  .049   1972  .020

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1989 +3.3 SD
================================================================================================================================

 PMR18A    1944 to  2012      69 years                                                                              Series  23

 [B] Entire series, effect on correlation (  .698) is:
       Lower   2007> -.025   1979< -.024   2002< -.012   1992< -.011   1958< -.011   1993< -.010  Higher   1954  .028   1988  .021

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

 PMR18B    1920 to  2012      93 years                                                                              Series  24

 [B] Entire series, effect on correlation (  .580) is:
       Lower   2007> -.036   1988> -.026   1954> -.013   1977< -.011   1933> -.010   1998< -.009  Higher   1936  .066   1925  .019

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1988 +3.1 SD
================================================================================================================================

 PMR19A    1904 to  2012     109 years                                                                              Series  25

 [B] Entire series, effect on correlation (  .606) is:
       Lower   1983> -.026   1954> -.024   2005< -.020   1932< -.011   1987< -.010   1965< -.009  Higher   1936  .024   1972  .023

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 PMR19B    1905 to  2012     108 years                                                                              Series  26

 [B] Entire series, effect on correlation (  .554) is:
       Lower   1908> -.022   1966> -.019   1911< -.016   1974< -.015   1928< -.015   1927> -.013  Higher   1936  .065   1944  .015

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1927 +3.6 SD
================================================================================================================================

 PMR20A    1907 to  2012     106 years                                                                              Series  27

 [B] Entire series, effect on correlation (  .530) is:
       Lower   1959< -.030   1996< -.028   1934> -.018   1952> -.011   2007> -.011   1957< -.008  Higher   1988  .015   1936  .014

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1934 +3.1 SD
================================================================================================================================

 PMR20B    1936 to  2012      77 years                                                                              Series  28

 [B] Entire series, effect on correlation (  .613) is:
       Lower   1943< -.053   1995< -.029   1960< -.015   1978< -.010   2011< -.009   1941> -.009  Higher   1936  .028   1983  .023

================================================================================================================================
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PMR21B    1935 to  2012      78 years                                                                                                  Series  29

[B] Entire series, effect on correlation (  .569) is:
      Lower   2003< -.037   1938< -.018   1971> -.015   1997> -.014   1986< -.013   1972> -.013  Higher   1983  .046   1954  .031

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PMR22B    1902 to  2012     111 years                                                                                                  Series  30

[A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
   ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1902 1951    0   -.12 -.07  .07 -.24  .01  .02  .10 -.03  .24 -.07  .30*-.21 -.18  .16 -.09 -.18  .11 -.05  .07  .07  .05

[B] Entire series, effect on correlation (  .551) is:
      Lower   1908> -.032   1927< -.021   1938< -.017   1915< -.015   1910< -.013   1909< -.012  Higher   1936  .038   1954  .032
    1902 to 1951 segment:
      Lower   1908> -.059   1927< -.034   1938< -.033   1915< -.029   1909< -.024   1921> -.023  Higher   1936  .172   1925  .033

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1932 +3.7 SD
================================================================================================================================================

PMR23A    1894 to  2012     119 years                                                                                                  Series  31

[B] Entire series, effect on correlation (  .517) is:
      Lower   1982< -.053   1988> -.032   1936> -.020   1894< -.013   1942< -.011   1956< -.009  Higher   1972  .031   1908  .030

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1988 +3.2 SD
================================================================================================================================================

PMR23B    1881 to  2011     131 years                                                                                                  Series  32

[B] Entire series, effect on correlation (  .359) is:
      Lower   1882> -.029   1936> -.028   1896< -.027   1884> -.025   2006< -.017   1889< -.015  Higher   1908  .049   1972  .020

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1882 +3.9 SD;    1890 -5.4 SD;    1995 +3.2 SD
================================================================================================================================================

PMR24A    1913 to  2012     100 years                                                                                                  Series  33

[B] Entire series, effect on correlation (  .459) is:
      Lower   1925> -.055   1983> -.028   1913> -.022   2012> -.018   1938< -.015   1981< -.010  Higher   1936  .082   1972  .036

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1925 +3.8 SD;    1972 -4.7 SD;    1983 +3.1 SD
================================================================================================================================================

PMR25A    1939 to  2012      74 years                                                                                                  Series  34

[B] Entire series, effect on correlation (  .708) is:
      Lower   1972> -.034   1954> -.013   1963< -.010   1978< -.009   1964< -.009   1994< -.008  Higher   1983  .025   2007  .014

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PMR25B    1937 to  2012      76 years                                                                                                  Series  35
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 [B] Entire series, effect on correlation (  .729) is:
       Lower   1971< -.051   1972> -.029   1984> -.013   1981< -.012   1994< -.009   1988> -.007  Higher   2007  .022   1954  .019

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 PMR26A    1897 to  2012     116 years                                                                                    Series  36

 [B] Entire series, effect on correlation (  .701) is:
       Lower   1995< -.014   1953> -.013   1988> -.011   1921> -.010   1923> -.008   1950< -.007  Higher   1983  .018   1925  .015

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 PMR27A    1912 to  2012     101 years                                                                                    Series  37

 [B] Entire series, effect on correlation (  .644) is:
       Lower   1981< -.030   1972> -.024   1914> -.021   1988> -.020   1944> -.012   1933> -.011  Higher   1936  .040   2007  .034

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1914 +3.5 SD
==========================================================================================================================================

 PMR27B    1949 to  2012      64 years                                                                                    Series  38

 [B] Entire series, effect on correlation (  .661) is:
       Lower   1972> -.044   1991< -.018   1984> -.016   1961< -.015   2005< -.014   1988> -.011  Higher   1983  .039   2007  .033

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 PMR28A    1902 to  2012     111 years                                                                                    Series  39

 [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    0    .01 -.16 -.24 -.02 -.02 -.06 -.18  .08  .00  .18  .29* .27  .11 -.02  .17 -.12 -.08 -.15 -.20 -.10 -.19

 [B] Entire series, effect on correlation (  .471) is:
       Lower   1982< -.024   1955< -.020   1919< -.015   1996> -.015   1991> -.012   1966> -.011  Higher   2007  .057   1936  .047
     1950 to 1999 segment:
       Lower   1982< -.066   1955< -.054   1996> -.035   1991> -.027   1966> -.022   1993< -.018  Higher   1972  .037   1984  .025

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 PMR29A2   1897 to  2012     116 years                                                                                    Series  40

 [B] Entire series, effect on correlation (  .528) is:
       Lower   1923< -.019   1962< -.018   1971> -.016   1966> -.015   1913> -.013   1910< -.013  Higher   1972  .030   2007  .016

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 PMR29B    1895 to  2012     118 years                                                                                    Series  41

 [B] Entire series, effect on correlation (  .664) is:
       Lower   1937< -.014   1963< -.012   1946< -.011   1902< -.011   1919< -.009   2007> -.008  Higher   1936  .044   1983  .015

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

 PMR30A    1949 to  2012      64 years                                                                                    Series  42

 [B] Entire series, effect on correlation (  .604) is:
```

Lower 1972> -.039 1976< -.026 1971> -.018 1974< -.018 1992< -.013 1956< -.011 Higher 2007 .065 1954 .055

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PMR30B 1932 to 2012 81 years Series 43

[B] Entire series, effect on correlation ( .676) is:
Lower 1936> -.048 1940< -.043 1972> -.033 1963< -.009 1953> -.009 1991> -.007 Higher 2007 .037 1954 .029

---

PMW02A 1901 to 2012 112 years Series 44

[A] Segment High -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 +0 +1 +2 +3 +4 +5 +6 +7 +8 +9 +10

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1901 1950 | 0 | .03 | .03 | .13 | .01 | -.17 | -.13 | -.06 | .02 | -.12 | -.05 | .31* | .15 | .11 | -.04 | .09 | -.15 | .01 | .04 | -.10 | -.18 | .07 |

[B] Entire series, effect on correlation ( .525) is:
Lower 1907< -.132 1983> -.016 1908> -.012 1904> -.012 1990> -.008 1914> -.007 Higher 2007 .037 1954 .021
1901 to 1950 segment:
Lower 1907< -.245 1904> -.020 1914> -.012 1908> -.012 1909< -.009 1901> -.008 Higher 1936 .038 1944 .023

[C] Year-to-year changes diverging by over 4.0 std deviations:
1907 1908 5.4 SD

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1907 -7.4 SD

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PART 7: DESCRIPTIVE STATISTICS

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PMR01A | 1905 2012 | 108 | 4 | 0 | .556 | 3.14 | 9.41 | 1.588 | .871 | .188 | 2.81 | .442 | .019 | 2 |
| 2 | PMR01B | 1944 2012 | 69 | 3 | 0 | .765 | 5.02 | 7.84 | 1.357 | .671 | .170 | 2.64 | .609 | .018 | 1 |
| 3 | PMR02A | 1909 2012 | 104 | 4 | 0 | .668 | 3.78 | 10.71 | 1.447 | .675 | .185 | 2.47 | .380 | .040 | 2 |
| 4 | PMR02B | 1915 2012 | 98 | 4 | 0 | .626 | 3.96 | 7.54 | 1.504 | .707 | .221 | 2.58 | .444 | -.015 | 2 |
| 5 | PMR03A | 1876 2012 | 137 | 5 | 0 | .481 | 3.09 | 8.39 | 1.272 | .797 | .173 | 2.62 | .431 | -.053 | 4 |
| 6 | PMR03B | 1861 2011 | 151 | 5 | 0 | .424 | 3.38 | 9.53 | 1.144 | .605 | .214 | 3.00 | .510 | .018 | 3 |
| 7 | PMR04A | 1936 2012 | 77 | 3 | 0 | .513 | 3.00 | 5.42 | .964 | .644 | .202 | 2.43 | .382 | -.036 | 1 |
| 8 | PMR06A | 1894 2012 | 119 | 5 | 0 | .562 | 3.57 | 6.41 | 1.205 | .816 | .162 | 2.57 | .451 | -.033 | 2 |
| 9 | PMR06B | 1905 2012 | 108 | 4 | 0 | .440 | 4.59 | 9.94 | 1.653 | .620 | .201 | 2.74 | .383 | -.034 | 1 |
| 10 | PMW07A | 1890 2012 | 123 | 5 | 0 | .531 | 3.75 | 7.54 | 1.355 | .693 | .220 | 2.81 | .442 | -.066 | 1 |
| 11 | PMR09A | 1907 2012 | 106 | 4 | 0 | .677 | 2.92 | 12.09 | 1.428 | .679 | .201 | 2.68 | .543 | .027 | 2 |
| 12 | PMR09B | 1911 2012 | 102 | 4 | 0 | .643 | 2.90 | 13.42 | 1.537 | .771 | .215 | 2.65 | .549 | .066 | 1 |
| 13 | PMR10A | 1895 2012 | 118 | 5 | 0 | .658 | 3.00 | 5.74 | .998 | .710 | .201 | 2.47 | .417 | -.013 | 2 |
| 14 | PMR10B | 1902 2012 | 111 | 4 | 0 | .488 | 2.89 | 5.07 | .894 | .608 | .189 | 2.70 | .446 | -.029 | 2 |
| 15 | PMR14A | 1906 2012 | 107 | 4 | 0 | .717 | 3.58 | 5.78 | .888 | .448 | .194 | 2.60 | .528 | .026 | 1 |
| 16 | PMR14B | 1903 2012 | 110 | 4 | 0 | .764 | 3.23 | 11.69 | 1.383 | .637 | .214 | 2.61 | .523 | .079 | 1 |
| 17 | PMR15A | 1916 2012 | 97 | 4 | 0 | .487 | 3.91 | 10.25 | 1.418 | .733 | .191 | 2.77 | .470 | -.049 | 1 |
| 18 | PMR15B | 1900 2011 | 112 | 4 | 0 | .706 | 3.28 | 8.04 | 1.014 | .464 | .240 | 3.16 | .551 | -.024 | 1 |
| 19 | PMR16A | 1910 2012 | 103 | 4 | 0 | .664 | 3.25 | 14.69 | 1.891 | .826 | .213 | 2.65 | .377 | -.041 | 2 |
| 20 | PMR17A | 1950 2012 | 63 | 2 | 0 | .639 | 2.71 | 4.08 | .536 | .243 | .183 | 2.73 | .562 | .024 | 2 |
| 21 | PMR16B | 1940 2012 | 73 | 3 | 0 | .659 | 4.97 | 8.69 | 1.862 | .778 | .195 | 2.64 | .541 | -.027 | 2 |
| 22 | PMR17B | 1905 2012 | 108 | 4 | 0 | .644 | 2.01 | 3.51 | .661 | .732 | .197 | 2.77 | .443 | -.042 | 1 |
| 23 | PMR18A | 1944 2012 | 69 | 3 | 0 | .698 | 5.08 | 8.47 | 1.221 | .592 | .168 | 2.51 | .528 | -.083 | 2 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | PMR18B | 1920 | 2012 | 93 | 4 | 0 | .580 | 4.20 | 9.56 | 1.701 | .631 | .250 | 2.56 | .378 | -.050 | 1 |
| 25 | PMR19A | 1904 | 2012 | 109 | 4 | 0 | .606 | 2.43 | 6.48 | 1.036 | .828 | .195 | 2.56 | .476 | -.002 | 1 |
| 26 | PMR19B | 1905 | 2012 | 108 | 4 | 0 | .554 | 3.33 | 6.99 | 1.299 | .858 | .164 | 2.77 | .426 | .002 | 1 |
| 27 | PMR20A | 1907 | 2012 | 106 | 4 | 0 | .530 | 3.16 | 17.04 | 1.536 | .202 | .183 | 2.48 | .386 | -.025 | 2 |
| 28 | PMR20B | 1936 | 2012 | 77 | 3 | 0 | .613 | 4.63 | 7.43 | 1.341 | .692 | .176 | 2.65 | .545 | .017 | 2 |
| 29 | PMR21B | 1935 | 2012 | 78 | 3 | 0 | .569 | 2.41 | 3.90 | .721 | .687 | .193 | 2.47 | .423 | .021 | 1 |
| 30 | PMR22B | 1902 | 2012 | 111 | 4 | 1 | .551 | 3.03 | 7.30 | 1.271 | .656 | .241 | 3.19 | .565 | .037 | 1 |
| 31 | PMR23A | 1894 | 2012 | 119 | 5 | 0 | .517 | 1.97 | 4.09 | .665 | .800 | .153 | 2.62 | .459 | -.019 | 2 |
| 32 | PMR23B | 1881 | 2011 | 131 | 5 | 0 | .359 | 2.13 | 3.97 | .684 | .701 | .183 | 2.81 | .358 | .008 | 1 |
| 33 | PMR24A | 1913 | 2012 | 100 | 4 | 0 | .459 | 1.91 | 4.66 | .690 | .765 | .193 | 2.48 | .334 | .004 | 1 |
| 34 | PMR25A | 1939 | 2012 | 74 | 3 | 0 | .708 | 5.18 | 9.86 | 1.682 | .736 | .172 | 2.42 | .347 | -.046 | 1 |
| 35 | PMR25B | 1937 | 2012 | 76 | 3 | 0 | .729 | 4.84 | 11.36 | 1.354 | .506 | .211 | 2.49 | .416 | -.026 | 1 |
| 36 | PMR26A | 1897 | 2012 | 116 | 5 | 0 | .701 | 3.04 | 6.05 | .843 | .634 | .183 | 2.63 | .384 | -.017 | 1 |
| 37 | PMR27A | 1912 | 2012 | 101 | 4 | 0 | .644 | 3.72 | 5.78 | .790 | .485 | .167 | 2.58 | .501 | .044 | 1 |
| 38 | PMR27B | 1949 | 2012 | 64 | 3 | 0 | .661 | 5.50 | 8.59 | 1.189 | .601 | .150 | 2.39 | .422 | -.034 | 1 |
| 39 | PMR28A | 1902 | 2012 | 111 | 4 | 1 | .471 | 2.90 | 5.93 | .799 | .533 | .203 | 2.48 | .375 | -.028 | 2 |
| 40 | PMR29A2 | 1897 | 2012 | 116 | 5 | 0 | .528 | 1.92 | 4.75 | .951 | .901 | .162 | 2.60 | .511 | -.027 | 1 |
| 41 | PMR29B | 1895 | 2012 | 118 | 5 | 0 | .664 | 2.72 | 5.03 | .840 | .778 | .164 | 2.52 | .358 | .053 | 1 |
| 42 | PMR30A | 1949 | 2012 | 64 | 3 | 0 | .604 | 4.67 | 8.93 | 1.763 | .743 | .204 | 2.73 | .521 | .029 | 1 |
| 43 | PMR30B | 1932 | 2012 | 81 | 3 | 0 | .676 | 3.76 | 6.33 | 1.026 | .579 | .205 | 2.47 | .516 | -.029 | 1 |
| 44 | PMW02A | 1901 | 2012 | 112 | 4 | 1 | .525 | 3.13 | 5.80 | 1.281 | .690 | .293 | 2.41 | .349 | -.005 | 1 |
| Total or mean: | | | | 4438 | 173 | 3 | .588 | 3.33 | 17.04 | 1.182 | .673 | .196 | 3.19 | .451 | -.007 | |

# APPENDIX L

# COFECHA PROGRAM OUTPUT FOR PIONEER MOTHERS SITE CHRONOLOGY, *QUERCUS ALBA*, INDIANA, U.S.A.

```
`
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29369
-------------------------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   PMA.txt

 Time span of Master dating series is  1817 to  2011   195 years
 Continuous time span is               1817 to  2011   195 years
 Portion with two or more series is    1826 to  2011   186 years

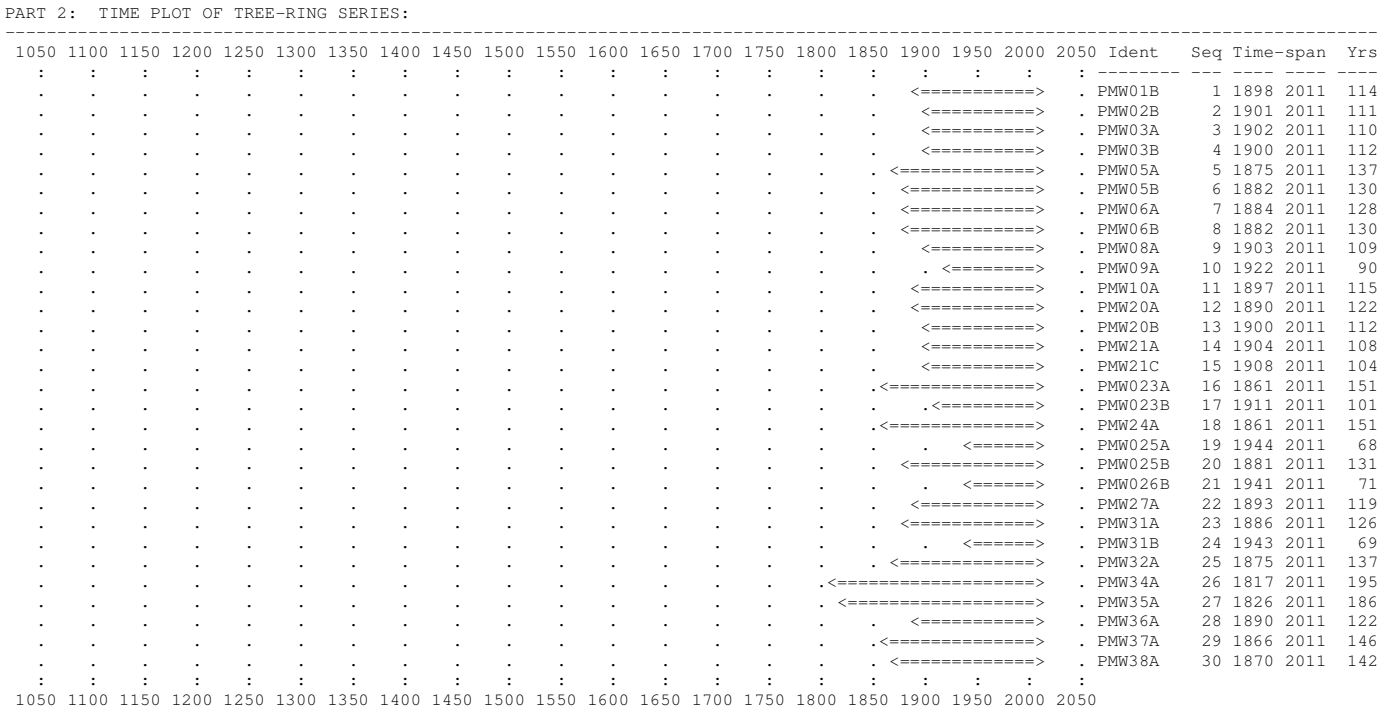

                                    ****************************************
                                    *C* Number of dated series        30 *C*
                                    *O* Master series 1817 2011  195 yrs *O*
                                    *F* Total rings in all series   3647 *F*
                                    *E* Total dated rings checked   3638 *E*
                                    *C* Series intercorrelation     .577 *C*
                                    *H* Average mean sensitivity    .238 *H*
                                    *A* Segments, possible problems   11 *A*
                                    *** Mean length of series      121.6 ***
                                    ****************************************

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

 PMW023A     1 absent rings:   1925
 PMW32A      1 absent rings:   1913

             2 absent rings    .055%
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1850 | -1.005 | 2 | 1900 | .885 | 20 | 1950 | 1.254 | 30 | 2000 | .177 | 30 | | | |
| | | | 1851 | -.739 | 2 | 1901 | -1.524 | 21 | 1951 | 1.303 | 30 | 2001 | 1.145 | 30 | | | |
| | | | 1852 | -.829 | 2 | 1902 | .603 | 22 | 1952 | -.259 | 30 | 2002 | .630 | 30 | | | |
| | | | 1853 | -1.892 | 2 | 1903 | 1.007 | 23 | 1953 | -.908 | 30 | 2003 | -1.330 | 30 | | | |
| | | | 1854 | -1.582 | 2 | 1904 | -.200 | 24 | 1954 | -2.880 | 30 | 2004 | -.845 | 30 | | | |
| | | | 1855 | .307 | 2 | 1905 | .373 | 24 | 1955 | 1.036 | 30 | 2005 | -1.132 | 30 | | | |
| | | | 1856 | -4.140 | 2 | 1906 | -.325 | 24 | 1956 | -.238 | 30 | 2006 | -.111 | 30 | | | |
| | | | 1857 | -.622 | 2 | 1907 | 1.275 | 24 | 1957 | .574 | 30 | 2007 | -1.419 | 30 | | | |
| | | | 1858 | -.643 | 2 | 1908 | -1.177 | 25 | 1958 | 1.085 | 30 | 2008 | .042 | 30 | | | |
| | | | 1859 | .878 | 2 | 1909 | .192 | 25 | 1959 | .115 | 30 | 2009 | 1.021 | 30 | | | |
| | | | 1860 | -.347 | 2 | 1910 | 1.376 | 25 | 1960 | -.316 | 30 | 2010 | .555 | 30 | | | |
| | | | 1861 | .804 | 4 | 1911 | -1.027 | 26 | 1961 | .730 | 30 | 2011 | .188 | 30 | | | |
| | | | 1862 | 1.312 | 4 | 1912 | .597 | 26 | 1962 | -.041 | 30 | | | | | | |
| | | | 1863 | 1.935 | 4 | 1913 | -.637 | 26 | 1 | 1963 | .298 | 30 | | | | | |
| | | | 1864 | .159 | 4 | 1914 | -1.275 | 26 | | 1964 | .055 | 30 | | | | | |
| | | | 1865 | .401 | 4 | 1915 | 1.178 | 26 | | 1965 | .400 | 30 | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1866 | -.279 | 5 | | 1916 | 1.290 | 26 | | 1966 | -.920 | 30 | |
| 1817 | 1.170 | 1 | 1867 | -.596 | 5 | | 1917 | .825 | 26 | | 1967 | -1.130 | 30 | |
| 1818 | .131 | 1 | 1868 | -.466 | 5 | | 1918 | -.733 | 26 | | 1968 | .059 | 30 | |
| 1819 | -.684 | 1 | 1869 | .528 | 5 | | 1919 | .062 | 26 | | 1969 | -.330 | 30 | |
| 1820 | -.962 | 1 | 1870 | .340 | 6 | | 1920 | -.192 | 26 | | 1970 | -.107 | 30 | |
| 1821 | -1.262 | 1 | 1871 | -.840 | 6 | | 1921 | -1.134 | 26 | | 1971 | -.532 | 30 | |
| 1822 | -2.502 | 1 | 1872 | -.086 | 6 | | 1922 | .580 | 27 | | 1972 | -1.350 | 30 | |
| 1823 | -1.135 | 1 | 1873 | -.692 | 6 | | 1923 | -.041 | 27 | | 1973 | 1.363 | 30 | |
| 1824 | 1.352 | 1 | 1874 | -1.514 | 6 | | 1924 | .378 | 27 | | 1974 | 1.333 | 30 | |
| 1825 | 1.006 | 1 | 1875 | .241 | 8 | | 1925 | -2.357 | 27 | 1 | 1975 | .249 | 30 | |
| 1826 | 1.283 | 2 | 1876 | .977 | 8 | | 1926 | .316 | 27 | | 1976 | .888 | 30 | |
| 1827 | .595 | 2 | 1877 | .149 | 8 | | 1927 | .584 | 27 | | 1977 | -.285 | 30 | |
| 1828 | 1.714 | 2 | 1878 | .718 | 8 | | 1928 | 1.171 | 27 | | 1978 | .408 | 30 | |
| 1829 | .608 | 2 | 1879 | -.565 | 8 | | 1929 | -.282 | 27 | | 1979 | -.232 | 30 | |
| 1830 | 1.609 | 2 | 1880 | -.314 | 8 | | 1930 | -.768 | 27 | | 1980 | .006 | 30 | |
| 1831 | -1.463 | 2 | 1881 | .311 | 9 | | 1931 | -.030 | 27 | | 1981 | -.421 | 30 | |
| 1832 | -1.060 | 2 | 1882 | .566 | 11 | | 1932 | 1.132 | 27 | | 1982 | 1.449 | 30 | |
| 1833 | -1.873 | 2 | 1883 | .728 | 11 | | 1933 | -.088 | 27 | | 1983 | -.530 | 30 | |
| 1834 | -1.479 | 2 | 1884 | .402 | 12 | | 1934 | -1.480 | 27 | | 1984 | -1.537 | 30 | |
| 1835 | -.552 | 2 | 1885 | -.195 | 12 | | 1935 | .658 | 27 | | 1985 | .312 | 30 | |
| 1836 | .258 | 2 | 1886 | -.250 | 13 | | 1936 | -1.796 | 27 | | 1986 | -.153 | 30 | |
| 1837 | .194 | 2 | 1887 | -1.247 | 13 | | 1937 | -.111 | 27 | | 1987 | -.539 | 30 | |
| 1838 | .707 | 2 | 1888 | -.146 | 13 | | 1938 | 1.580 | 27 | | 1988 | -2.587 | 30 | |
| 1839 | -1.604 | 2 | 1889 | 1.396 | 13 | | 1939 | 1.356 | 27 | | 1989 | 1.042 | 30 | |
| 1840 | .037 | 2 | 1890 | .115 | 15 | | 1940 | .034 | 27 | | 1990 | .542 | 30 | |
| 1841 | -.516 | 2 | 1891 | .422 | 15 | | 1941 | -.205 | 28 | | 1991 | -.359 | 30 | |
| 1842 | 2.297 | 2 | 1892 | -.195 | 15 | | 1942 | .083 | 28 | | 1992 | .691 | 30 | |
| 1843 | 1.399 | 2 | 1893 | -1.240 | 16 | | 1943 | -.235 | 29 | | 1993 | .955 | 30 | |
| 1844 | .463 | 2 | 1894 | -.836 | 16 | | 1944 | -1.945 | 30 | | 1994 | .027 | 30 | |
| 1845 | -.430 | 2 | 1895 | -1.152 | 16 | | 1945 | .488 | 30 | | 1995 | 1.421 | 30 | |
| 1846 | 1.161 | 2 | 1896 | 1.442 | 16 | | 1946 | -.044 | 30 | | 1996 | -.084 | 30 | |
| 1847 | .564 | 2 | 1897 | .415 | 17 | | 1947 | .301 | 30 | | 1997 | -.278 | 30 | |
| 1848 | 1.422 | 2 | 1898 | -.104 | 18 | | 1948 | .332 | 30 | | 1998 | .701 | 30 | |
| 1849 | .981 | 2 | 1899 | .488 | 18 | | 1949 | .984 | 30 | | 1999 | .815 | 30 | |

PART 4: Master Bar Plot:

---

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1850-d | 1900--------D | 1950---------E | 2000-----A | | | |
| | 1851--c | 1901f | 1951----------E | 2001---------E | | | |
| | 1852--c | 1902-------B | 1952---a | 2002-------C | | | |
| | 1853h | 1903---------D | 1953--d | 2003-e | | | |
| | 1854f | 1904----a | 19541 | 2004--c | | | |
| | 1855------A | 1905------A | 1955---------D | 2005-e | | | |
| | 1856q | 1906---a | 1956---a | 2006----@ | | | |
| | 1857--b | 1907---------E | 1957-------B | 2007f | | | |
| | 1858--c | 1908-e | 1958---------D | 2008-----@ | | | |
| | 1859--------D | 1909------A | 1959-----@ | 2009---------D | | | |
| | 1860---a | 1910----------F | 1960---a | 2010-------B | | | |
| | 1861--------C | 1911-d | 1961---------C | 2011------A | | | |
| | 1862----------E | 1912-------B | 1962----@ | | | | |
| | 1863----------H | 1913--c | 1963------A | | | | |
| | 1864-----A | 1914-e | 1964-----@ | | | | |
| | 1865------B | 1915---------E | 1965------B | | | | |
| | 1866---a | 1916----------E | 1966-d | | | | |

```
  1817---------E  1867--b          1917--------C   1967-e
  1818-----A       1868---b        1918--c         1968-----@
  1819--c          1869-------B    1919-----@      1969---a
  1820-d           1870------A     1920----a       1970----@
  1821-e           1871--c         1921-e          1971--b
  1822j            1872----@       1922-------B    1972-e
  1823-e           1873--c         1923----@       1973----------E
  1824----------E 1874f            1924------B     1974----------E
  1825---------D  1875------A     1925i           1975------A
  1826---------E  1876---------D  1926------A     1976--------D
  1827-------B     1877-----A      1927-------B    1977---a
  1828----------G 1878--------C   1928---------E  1978------B
  1829-------B     1879--b         1929---a        1979---a
  1830----------F 1880---a        1930--c         1980-----@
  1831f            1881------A     1931----@       1981---b
  1832-d           1882-------B    1932---------E  1982----------F
  1833g            1883--------C   1933----@       1983--b
  1834f            1884------B     1934f           1984f
  1835--b          1885----a       1935-------C    1985------A
  1836------A      1886---a        1936g           1986----a
  1837------A      1887-e          1937----@       1987--b
  1838--------C    1888----a       1938----------F 1988j
  1839f            1889----------F 1939----------E 1989---------D
  1840-----@       1890-----@      1940-----@      1990-------B
  1841--b          1891------B     1941----a       1991---a
  1842----------I 1892----a       1942-----@      1992--------C
  1843----------F 1893-e          1943---a        1993--------D
  1844-------B     1894--c         1944h           1994-----@
  1845---b         1895-e          1945-------B    1995----------F
  1846---------E  1896----------F 1946----@       1996----@
  1847-------B     1897------B     1947------A     1997---a
  1848----------F 1898----@       1948------A     1998--------C
  1849---------D  1899-------B    1949---------D  1999--------C
```

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PART 5:  CORRELATION OF SERIES BY SEGMENTS:

---

Correlations of  50-year dated segments, lagged  25 years
Flags:  A = correlation under   .3281 but highest as dated;  B = correlation higher at other than dated position

| Seq | Series | Time_span | 1825 1850 1875 1900 1925 1950 1975<br>1874 1899 1924 1949 1974 1999 2024 |
|---|---|---|---|
| 1 | PMW01B | 1898 2011 | .59 .62 .46 .31A .36 |
| 2 | PMW02B | 1901 2011 | .79 .74 .62 .49 |
| 3 | PMW03A | 1902 2011 | .72 .62 .63 .61 |
| 4 | PMW03B | 1900 2011 | .80 .79 .77 .80 |
| 5 | PMW05A | 1875 2011 | .59 .74 .67 .70 .61 |
| 6 | PMW05B | 1882 2011 | .64 .78 .76 .76 .77 |
| 7 | PMW06A | 1884 2011 | .52 .59 .61 .55 .49 |
| 8 | PMW06B | 1882 2011 | .53 .74 .73 .71 .62 |
| 9 | PMW08A | 1903 2011 | .66 .72 .57 .52 |
| 10 | PMW09A | 1922 2011 | .60 .60 .50 .56 |
| 11 | PMW10A | 1897 2011 | .71 .71 .66 .55 .63 |
| 12 | PMW20A | 1890 2011 | .58 .67 .71 .53 .42 |
| 13 | PMW20B | 1900 2011 | .74 .64 .53 .50 |
| 14 | PMW21A | 1904 2011 | .57 .60 .54 .50 |
| 15 | PMW21C | 1908 2011 | .75 .68 .68 .58 |
| 16 | PMW023A | 1861 2011 | .42 .11B .32A .46 .34 .45 |

```
  17 PMW023B  1911 2011                  .55  .64  .62  .57
  18 PMW24A   1861 2011        .35  .43  .18B .09B .37  .50
  19 PMW025A  1944 2011                  .64  .61  .57
  20 PMW025B  1881 2011             .41B .45  .59  .63  .59
  21 PMW026B  1941 2011                  .40  .52  .39
  22 PMW27A   1893 2011             .53  .56  .55  .33A .22A
  23 PMW31A   1886 2011             .80  .83  .83  .76  .56
  24 PMW31B   1943 2011                  .73  .72  .49
  25 PMW32A   1875 2011             .52  .72  .75  .76  .59
  26 PMW34A   1817 2011   .32A .37  .57  .68  .54  .51  .40
  27 PMW35A   1826 2011   .28A .22A .50  .64  .59  .61  .54
  28 PMW36A   1890 2011             .76  .75  .77  .73  .58
  29 PMW37A   1866 2011        .62  .65  .80  .72  .56  .45
  30 PMW38A   1870 2011        .73  .73  .84  .84  .79  .62
Av segment correlation   .30  .45  .56  .66  .64  .59  .53

PART 6:  POTENTIAL PROBLEMS:
--------------------------------------------------------------------------------------------------------------------------------

 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

 [B] Effect of those data values which most lower or raise correlation with master series
     Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

 [C] Year-to-year changes very different from the mean change in other series

 [D] Absent rings (zero values)

 [E] Values which are statistical outliers from mean for the year
================================================================================================================================

 PMW01B    1898 to  2011     114 years                                                                          Series   1

 [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    0    .05 -.23 -.25 -.30  .10  .10  .19 -.07  .00 -.11  .31*-.10  .18 -.16  .07  .16  .00  .19  .09 -.13 -.22

 [B] Entire series, effect on correlation (  .472) is:
       Lower   1954> -.018   1982< -.017   1899< -.016   1988> -.010   1958< -.010   1967> -.009  Higher   1925  .031   1936  .026
     1950 to 1999 segment:
       Lower   1982< -.045   1958< -.028   1967> -.018   1962> -.017   1976< -.016   1987> -.016  Higher   1995  .038   1974  .025

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

 PMW02B    1901 to  2011     111 years                                                                          Series   2

 [B] Entire series, effect on correlation (  .665) is:
       Lower   2003> -.023   1994< -.020   1932< -.014   1989< -.010   2004> -.010   1992< -.010  Higher   1954  .025   1925  .018

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

 PMW03A    1902 to  2011     110 years                                                                          Series   3

 [B] Entire series, effect on correlation (  .639) is:
       Lower   1972< -.027   1979> -.010   1997> -.010   1987> -.009   1947< -.008   1952> -.006  Higher   1988  .025   1944  .013
```

```
================================================================================================================================

 PMW03B    1900 to  2011     112 years                                                                          Series   4

 [B] Entire series, effect on correlation (  .784) is:
       Lower   1982< -.014   1960> -.008   1906< -.007   1956> -.007   1980< -.007   1952< -.004  Higher   1988  .022   1936  .011

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

 PMW05A    1875 to  2011     137 years                                                                          Series   5

 [B] Entire series, effect on correlation (  .632) is:
       Lower   1876< -.017   1972< -.014   2003> -.014   1879< -.010   1927< -.009   1888> -.007  Higher   1988  .033   1944  .012

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

 PMW05B    1882 to  2011     130 years                                                                          Series   6

 [B] Entire series, effect on correlation (  .731) is:
       Lower   1883< -.017   2002< -.011   1895> -.008   1903< -.008   1919< -.007   1923> -.006  Higher   1988  .026   1936  .011

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

 PMW06A    1884 to  2011     128 years                                                                          Series   7

 [B] Entire series, effect on correlation (  .536) is:
       Lower   1902< -.059   1884< -.016   1996< -.015   1895> -.010   1964< -.010   1888> -.008  Higher   1925  .029   1936  .023

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1888 +3.0 SD;    1902 -4.7 SD
================================================================================================================================

 PMW06B    1882 to  2011     130 years                                                                          Series   8

 [B] Entire series, effect on correlation (  .636) is:
       Lower   1882< -.031   2004< -.019   1975< -.017   1925> -.014   1902< -.010   1906> -.008  Higher   1988  .035   1936  .014

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

 PMW08A    1903 to  2011     109 years                                                                          Series   9

 [B] Entire series, effect on correlation (  .600) is:
       Lower   1908> -.044   1998< -.024   2007> -.017   1988> -.016   1934> -.012   1948< -.009  Higher   1925  .035   1944  .018

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1908 +3.5 SD
================================================================================================================================

 PMW09A    1922 to  2011      90 years                                                                          Series  10

 [B] Entire series, effect on correlation (  .585) is:
       Lower   1960< -.082   1999< -.020   1929> -.011   1942< -.009   1985< -.008   1966> -.008  Higher   1925  .038   1944  .015

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1960 -5.4 SD
================================================================================================================================

 PMW10A    1897 to  2011     115 years                                                                          Series  11
```

```
 [B] Entire series, effect on correlation (  .632) is:
       Lower   1954> -.022   1997< -.014   1921< -.012   1908> -.012   2004> -.009   1961< -.006  Higher   1944  .016   1901  .012

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

 PMW20A    1890 to  2011     122 years                                                                                          Series  12

 [B] Entire series, effect on correlation (  .566) is:
       Lower   1988> -.027   1980< -.023   1915< -.018   1927< -.012   1950< -.012   1965< -.011  Higher   1954  .058   1936  .014

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

 PMW20B    1900 to  2011     112 years                                                                                          Series  13

 [B] Entire series, effect on correlation (  .620) is:
       Lower   1988> -.033   1967< -.018   2007> -.016   1904> -.009   1992< -.008   1964> -.008  Higher   1925  .019   1954  .015

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

 PMW21A    1904 to  2011     108 years                                                                                          Series  14

 [B] Entire series, effect on correlation (  .515) is:
       Lower   1914> -.028   2003> -.020   1972> -.013   1958< -.013   1908> -.008   1936> -.008  Higher   1925  .017   1938  .011

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1914 +3.5 SD
================================================================================================================================================

 PMW21C    1908 to  2011     104 years                                                                                          Series  15

 [B] Entire series, effect on correlation (  .682) is:
       Lower   1967> -.018   1962< -.018   1914> -.011   1975> -.011   1936> -.011   1956> -.010  Higher   1954  .044   1988  .013

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1954 -4.7 SD
================================================================================================================================================

 PMW023A   1861 to  2011     151 years                                                                                          Series  16

 [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    3   -.23 -.09  .07  .13 -.03  .05  .10 -.10  .02 -.23  .11| .04 -.15  .26*-.11 -.04 -.05  .04  .05 -.10  .07
    1900 1949    0    .02  .00 -.11 -.10 -.10 -.13  .25 -.15  .32 -.23  .32* .07 -.22 -.04 -.32 -.12  .03  .09  .30  .03  .07

 [B] Entire series, effect on correlation (  .430) is:
       Lower   1911> -.023   1916< -.017   1879> -.016   1921> -.015   1910< -.013   1972> -.010  Higher   1925  .067   1936  .024
     1875 to 1924 segment:
       Lower   1911> -.073   1916< -.061   1879> -.052   1921> -.047   1910< -.046   1882< -.024  Higher   1908  .077   1896  .069
     1900 to 1949 segment:
       Lower   1911> -.060   1916< -.040   1921> -.037   1910< -.031   1914> -.016   1946< -.012  Higher   1925  .169   1936  .049

 [D]    1 Absent rings:  Year   Master  N series Absent
                         1925   -2.357      27       1

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1879 +3.1 SD;    1925 -6.3 SD
================================================================================================================================================
```

PMW023B  1911 to  2011    101 years                                                                                                    Series  17

[B] Entire series, effect on correlation (  .545) is:
      Lower   2001< -.062   1911> -.034   1976< -.012   1950< -.012   1923< -.011   1975< -.009  Higher   1988  .061   1936  .020

==========

PMW24A   1861 to  2011    151 years                                                                                                    Series  18

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1900 1949 | 7 | .12 | .02 | -.24 | -.18 | .11 | .00 | .04 | .27 | .03 | -.08 | .18\|-.08 | -.15 | -.07 | -.24 | .15 | -.01 | .34*-.09 | -.01 | -.01 | | |
| 1925 1974 | 7 | .10 | .14 | -.08 | -.05 | -.01 | -.02 | .12 | .14 | .00 | .05 | .09\|-.06 | -.19 | -.04 | -.16 | .03 | .00 | .27* | .13 | .13 | -.21 | |

[B] Entire series, effect on correlation (  .295) is:
      Lower   1939< -.032   1975< -.026   1944> -.016   1867> -.016   1921> -.015   1869< -.013  Higher   1988  .025   1908  .018
    1900 to 1949 segment:
      Lower   1939< -.086   1944> -.041   1921> -.039   1911> -.030   1937< -.025   1945< -.018  Higher   1908  .060   1914  .037
    1925 to 1974 segment:
      Lower   1939< -.089   1944> -.037   1937< -.024   1961< -.019   1945< -.019   1963< -.015  Higher   1932  .037   1955  .037

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1867 +3.0 SD;    1921 +3.1 SD;    1939 -4.6 SD

==========

PMW025A  1944 to  2011     68 years                                                                                                    Series  19

[B] Entire series, effect on correlation (  .633) is:
      Lower   1976< -.026   2003> -.023   1960< -.022   1972> -.021   1961< -.019   1967> -.019  Higher   1954  .084   2007  .016

==========

PMW025B  1881 to  2011    131 years                                                                                                    Series  20

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1881 1930 | 3 | -.17 | -.17 | -.07 | .15 | -.07 | -.07 | .20 | -.05 | -.12 | -.05 | .41\|-.07 | -.24 | .43*-.20 | -.08 | .08 | -.04 | .02 | -.08 | -.04 | | |

[B] Entire series, effect on correlation (  .506) is:
      Lower   1922< -.061   1928< -.018   1936> -.013   1967> -.011   1921> -.008   1977< -.008  Higher   1925  .043   1954  .022
    1881 to 1930 segment:
      Lower   1922< -.130   1928< -.038   1921> -.021   1901> -.017   1904> -.014   1906> -.012  Higher   1925  .139   1908  .064

[C] Year-to-year changes diverging by over 4.0 std deviations:
      1921 1922  -4.1 SD

==========

PMW026B  1941 to  2011     71 years                                                                                                    Series  21

[B] Entire series, effect on correlation (  .442) is:
      Lower   1973< -.049   1976< -.038   1967> -.035   1944> -.022   1943> -.022   1966> -.021  Higher   1954  .120   1988  .080

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1943 +3.4 SD;    1967 +3.8 SD

==========

PMW27A   1893 to  2011    119 years                                                                                                    Series  22

```
[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    0   -.04  .15  .19 -.20  .00  .19 -.01 -.13 -.05 -.08  .33*-.20  .03 -.32  .07 -.07 -.08  .16  .12 -.06 -.03
   1962 2011    0   -.12  .20  .10 -.22 -.02  .10  .08 -.08 -.06 -.11  .22*   -    -    -    -    -    -    -    -    -    -

[B] Entire series, effect on correlation (  .466) is:
      Lower   1988> -.054   1928< -.030   1911> -.024   1966> -.016   1987> -.015   1929< -.014  Higher   1925  .055   1954  .044
    1950 to 1999 segment:
      Lower   1988> -.129   1966> -.039   1987> -.036   1992< -.026   1961< -.014   1967> -.013  Higher   1954  .172   1972  .028
    1962 to 2011 segment:
      Lower   1988> -.133   1966> -.040   1987> -.035   1992< -.033   2002< -.023   1993< -.013  Higher   2007  .056   1972  .041

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1966 +3.1 SD;    1987 +3.4 SD;    1988 +4.9 SD
================================================================================================================================

PMW31A    1886 to  2011     126 years                                                                              Series  23

[B] Entire series, effect on correlation (  .735) is:
      Lower   2006< -.016   2003> -.016   1911< -.013   1949< -.007   2000> -.007   2004> -.007  Higher   1954  .017   1925  .010

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

PMW31B    1943 to  2011      69 years                                                                              Series  24

[B] Entire series, effect on correlation (  .630) is:
      Lower   2006< -.070   1992< -.030   1974< -.013   2007> -.011   1946> -.009   1959< -.008  Higher   1954  .080   1944  .018

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

PMW32A    1875 to  2011     137 years                                                                              Series  25

[B] Entire series, effect on correlation (  .623) is:
      Lower   1913< -.022   1927< -.013   2003> -.013   2009< -.012   1888< -.012   1885> -.008  Higher   1954  .031   1944  .013

[D]    1 Absent rings:  Year   Master  N series Absent
                        1913    -.637      26       1

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

PMW34A    1817 to  2011     195 years                                                                              Series  26

[*] Early part of series cannot be checked from 1817 to 1825 -- not matched by another series

[A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
   --------- ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1826 1875    0      - -.17 -.10 -.28  .03 -.12 -.01  .00  .22  .05  .32* .04  .08 -.20  .06 -.16  .00 -.12 -.15 -.34 -.12

[B] Entire series, effect on correlation (  .444) is:
      Lower   1831> -.039   2007> -.019   1853< -.016   1856< -.011   1995< -.011   1958< -.008  Higher   1988  .035   1954  .014
    1826 to 1875 segment:
      Lower   1831> -.077   1853< -.040   1856< -.023   1872> -.011   1835> -.011   1841< -.011  Higher   1842  .025   1863  .021

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1856 -5.4 SD;    2007 +3.7 SD
================================================================================================================================

PMW35A    1826 to  2011     186 years                                                                              Series  27
```

```
 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    --------- ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1826 1875    0      - -.02  .03 -.21 -.07 -.15  .08 -.21  .11  .08  .28* .03  .18 -.04 -.04 -.09  .12 -.24 -.06 -.15 -.04
    1850 1899    0   -.12 -.05  .15 -.13 -.05 -.16  .03 -.05  .00  .12  .22*-.04  .06  .00 -.03  .05  .22  .09  .11 -.20  .05

 [B] Entire series, effect on correlation (  .418) is:
       Lower   1856> -.047   1853> -.019   1831< -.015   1877< -.012   1865< -.009   2011< -.007  Higher   1988  .021   1925  .012
     1826 to 1875 segment:
       Lower   1831< -.058   1853> -.032   1865< -.025   1856> -.013   1835< -.013   1871> -.011  Higher   1842  .029   1863  .020
     1850 to 1899 segment:
       Lower   1877< -.043   1853> -.035   1865< -.028   1896< -.015   1885< -.013   1851< -.013  Higher   1863  .029   1889  .017

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1855 1856   4.4 SD    1856 1857  -4.6 SD

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1853 +3.6 SD;    1856 +5.4 SD
==========================================================================================================================================

 PMW36A    1890 to  2011     122 years                                                                                  Series  28

 [B] Entire series, effect on correlation (  .712) is:
       Lower   1942< -.016   1984> -.013   1995< -.011   2003> -.010   1965< -.007   1937< -.006  Higher   1954  .032   1925  .017

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

 PMW37A    1866 to  2011     146 years                                                                                  Series  29

 [B] Entire series, effect on correlation (  .608) is:
       Lower   1978< -.022   2001< -.019   1998< -.016   1972> -.009   1979> -.007   1888< -.007  Higher   1988  .033   1954  .030

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1961 +3.5 SD
==========================================================================================================================================

 PMW38A    1870 to  2011     142 years                                                                                  Series  30

 [B] Entire series, effect on correlation (  .742) is:
       Lower   2009< -.028   1989< -.010   1996> -.008   1987> -.007   2007> -.007   1879> -.006  Higher   1954  .025   1988  .023

==========================================================================================================================================
PART 7:  DESCRIPTIVE STATISTICS:
------------------------------------------------------------------------------------------------------------------------------------------

                                                 Corr   //-------- Unfiltered --------\\  //---- Filtered -----\\
                          No.    No.    No.      with   Mean    Max     Std    Auto   Mean    Max     Std    Auto  AR
 Seq Series   Interval   Years  Segmt  Flags    Master  msmt    msmt     dev    corr   sens   value    dev    corr  ()
 --- -------- ---------  -----  -----  -----    ------ -----   -----   -----  -----  -----  -----  -----  -----  --
   1 PMW01B   1898 2011    114      5      1      .472   2.89    6.70   1.194   .507   .294   2.61   .413  -.075   6
   2 PMW02B   1901 2011    111      4      0      .665   2.63    5.95   1.121   .705   .268   2.75   .575   .006   3
   3 PMW03A   1902 2011    110      4      0      .639   1.91    7.22    .844   .658   .251   2.45   .390  -.052   2
   4 PMW03B   1900 2011    112      4      0      .784   2.41    4.37    .701   .461   .238   2.57   .488  -.064   1
   5 PMW05A   1875 2011    137      5      0      .632   2.62    8.02   1.334   .759   .245   2.57   .405  -.005   1
   6 PMW05B   1882 2011    130      5      0      .731   2.70    7.80   1.305   .761   .240   2.69   .451   .050   1
   7 PMW06A   1884 2011    128      5      0      .536   2.27    5.08    .993   .821   .195   2.73   .523   .006   1
   8 PMW06B   1882 2011    130      5      0      .636   2.28    4.69    .828   .763   .197   2.56   .490  -.003   1
   9 PMW08A   1903 2011    109      4      0      .600   2.91    8.49   1.370   .675   .262   2.71   .472  -.042   1
  10 PMW09A   1922 2011     90      4      0      .585   4.25    7.89   1.306   .519   .230   2.49   .397   .003   2
```

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | PMW10A | 1897 2011 | 115 | 5 | 0 | .632 | 3.39 | 6.88 | 1.063 | .514 | .257 | 2.54 | .498 | -.031 | 1 |
| 12 | PMW20A | 1890 2011 | 122 | 5 | 0 | .566 | 2.47 | 6.05 | .823 | .507 | .213 | 2.73 | .378 | -.005 | 1 |
| 13 | PMW20B | 1900 2011 | 112 | 4 | 0 | .620 | 2.67 | 4.73 | .804 | .460 | .250 | 2.70 | .465 | -.013 | 2 |
| 14 | PMW21A | 1904 2011 | 108 | 4 | 0 | .515 | 2.74 | 6.84 | 1.502 | .798 | .254 | 2.67 | .372 | .009 | 1 |
| 15 | PMW21C | 1908 2011 | 104 | 4 | 0 | .682 | 2.83 | 8.58 | 1.261 | .645 | .271 | 2.72 | .389 | -.012 | 1 |
| 16 | PMW023A | 1861 2011 | 151 | 6 | 2 | .430 | 1.61 | 3.59 | .607 | .594 | .280 | 2.51 | .318 | -.021 | 1 |
| 17 | PMW023B | 1911 2011 | 101 | 4 | 0 | .545 | 2.21 | 4.06 | .824 | .694 | .246 | 2.62 | .430 | -.008 | 1 |
| 18 | PMW24A | 1861 2011 | 151 | 6 | 2 | .295 | 1.44 | 3.44 | .732 | .844 | .230 | 2.63 | .435 | -.022 | 1 |
| 19 | PMW025A | 1944 2011 | 68 | 3 | 0 | .633 | 4.03 | 9.66 | 1.553 | .606 | .234 | 2.67 | .495 | .022 | 1 |
| 20 | PMW025B | 1881 2011 | 131 | 5 | 1 | .506 | 2.00 | 4.75 | 1.170 | .873 | .227 | 2.60 | .484 | -.103 | 1 |
| 21 | PMW026B | 1941 2011 | 71 | 3 | 0 | .442 | 2.92 | 5.60 | .864 | .708 | .159 | 2.74 | .505 | -.032 | 1 |
| 22 | PMW27A | 1893 2011 | 119 | 5 | 2 | .466 | 2.07 | 3.95 | .632 | .756 | .173 | 2.59 | .451 | .025 | 1 |
| 23 | PMW31A | 1886 2011 | 126 | 5 | 0 | .735 | 2.59 | 4.63 | .592 | .323 | .215 | 2.56 | .427 | -.026 | 2 |
| 24 | PMW31B | 1943 2011 | 69 | 3 | 0 | .630 | 2.07 | 2.93 | .393 | .353 | .166 | 2.70 | .513 | .090 | 1 |
| 25 | PMW32A | 1875 2011 | 137 | 5 | 0 | .623 | 1.97 | 4.25 | .696 | .290 | .336 | 2.68 | .443 | .031 | 1 |
| 26 | PMW34A | 1817 2011 | 195 | 7 | 1 | .444 | 1.63 | 4.26 | .741 | .807 | .202 | 2.76 | .319 | -.025 | 1 |
| 27 | PMW35A | 1826 2011 | 186 | 7 | 2 | .418 | 1.70 | 4.62 | .731 | .774 | .209 | 2.87 | .466 | -.045 | 1 |
| 28 | PMW36A | 1890 2011 | 122 | 5 | 0 | .712 | 2.27 | 4.67 | .826 | .446 | .267 | 2.67 | .498 | .000 | 1 |
| 29 | PMW37A | 1866 2011 | 146 | 6 | 0 | .608 | 1.86 | 3.69 | .513 | .296 | .248 | 2.99 | .519 | -.030 | 1 |
| 30 | PMW38A | 1870 2011 | 142 | 6 | 0 | .742 | 2.24 | 6.90 | 1.248 | .783 | .251 | 2.57 | .512 | -.035 | 1 |
| Total or mean: | | | 3647 | 143 | 11 | .577 | 2.36 | 9.66 | .933 | .634 | .238 | 2.99 | .447 | -.016 | |

# APPENDIX M

## COFECHA PROGRAM OUTPUT FOR PIONEER MOTHERS SITE CHRONOLOGY, *JUGLANS NIGRA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29369
------------------------------------------------------------------------------------------------------------------------------------------

QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

File of DATED series:   PMN.txt

Time span of Master dating series is  1781 to  2013   233 years
Continuous time span is               1781 to  2013   233 years
Portion with two or more series is    1781 to  2013   233 years


                                     ****************************************
                                     *C* Number of dated series        22 *C*
                                     *O* Master series 1781 2013  233 yrs *O*
                                     *F* Total rings in all series   3913 *F*
                                     *E* Total dated rings checked   3913 *E*
                                     *C* Series intercorrelation     .604 *C*
                                     *H* Average mean sensitivity    .304 *H*
                                     *A* Segments, possible problems    6 *A*
                                     *** Mean length of series      177.9 ***
                                     ****************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:

```
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 Ident    Seq Time-span  Yrs
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <====================>   . WAL02A     1 1803 2013  211
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <====================>    . WAL02B     2 1784 2000  217
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <======================>   . WAL03A     3 1781 2013  233
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <======================>   . WAL03B     4 1781 2012  232
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<====================>   . WAL04A     5 1818 2013  196
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==================>    . WAL04B     6 1816 2001  186
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==================>.   . WAL05A     7 1815 1991  177
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<====================>   . WAL05b     8 1815 2011  197
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <============>   . WAL06A     9 1880 2013  134
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <==============>   . WAL06B    10 1876 2013  138
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <================>   . WAL07A    11 1852 2013  162
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==================>   . WAL07B    12 1831 2013  183
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <================>   . WAL08A    13 1849 2013  165
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <==================>   . WAL08B    14 1828 2013  186
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==================>.    . WAL09A    15 1809 1999  191
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <====================>   . WAL09B    16 1799 2013  215
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <============>   . WAL10A    17 1888 2012  125
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <============>   . WAL10B    18 1890 2013  124
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==================>   . WAL11A    19 1835 2013  179
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<================>   . WAL11B    20 1867 2013  147
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <================>   . WAL12A    21 1842 2013  172
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <==============>   . WAL12B    22 1871 2013  143
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050
```

PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1800 | .716 | 4 | 1850 | -.169 | 15 | 1900 | .291 | 22 | 1950 | -.343 | 22 | 2000 | .029 | 20 |
| 1801 | .295 | 4 | 1851 | -.531 | 15 | 1901 | -1.985 | 22 | 1951 | .284 | 22 | 2001 | 1.064 | 19 |
| 1802 | -.427 | 4 | 1852 | -.397 | 16 | 1902 | 1.299 | 22 | 1952 | -1.291 | 22 | 2002 | .165 | 18 |
| 1803 | -.474 | 5 | 1853 | -.524 | 16 | 1903 | 1.038 | 22 | 1953 | -.758 | 22 | 2003 | -.526 | 18 |
| 1804 | -1.649 | 5 | 1854 | -.810 | 16 | 1904 | -.582 | 22 | 1954 | -2.471 | 22 | 2004 | .513 | 18 |
| 1805 | -1.658 | 5 | 1855 | .838 | 16 | 1905 | .845 | 22 | 1955 | .432 | 22 | 2005 | -.278 | 18 |
| 1806 | -1.560 | 5 | 1856 | -2.701 | 16 | 1906 | -.597 | 22 | 1956 | -.280 | 22 | 2006 | -.588 | 18 |
| 1807 | -.281 | 5 | 1857 | .762 | 16 | 1907 | .720 | 22 | 1957 | .237 | 22 | 2007 | -.457 | 18 |
| 1808 | -.520 | 5 | 1858 | -.208 | 16 | 1908 | -1.625 | 22 | 1958 | .964 | 22 | 2008 | -.866 | 18 |
| 1809 | .922 | 6 | 1859 | .875 | 16 | 1909 | -.577 | 22 | 1959 | .159 | 22 | 2009 | .503 | 18 |
| 1810 | .454 | 6 | 1860 | 1.178 | 16 | 1910 | .882 | 22 | 1960 | 1.215 | 22 | 2010 | .855 | 18 |
| 1811 | .626 | 6 | 1861 | .273 | 16 | 1911 | -.565 | 22 | 1961 | 1.085 | 22 | 2011 | -.433 | 18 |
| 1812 | -.098 | 6 | 1862 | 1.633 | 16 | 1912 | 1.091 | 22 | 1962 | .182 | 22 | 2012 | -1.695 | 17 |
| 1813 | -.129 | 6 | 1863 | -.146 | 16 | 1913 | -1.584 | 22 | 1963 | .152 | 22 | 2013 | .367 | 15 |
| 1814 | 2.343 | 6 | 1864 | -1.046 | 16 | 1914 | -2.873 | 22 | 1964 | -.463 | 22 | | | |
| 1815 | .644 | 8 | 1865 | .426 | 16 | 1915 | 1.569 | 22 | 1965 | .064 | 22 | | | |
| 1816 | .043 | 9 | 1866 | .248 | 16 | 1916 | 1.704 | 22 | 1966 | -1.236 | 22 | | | |
| 1817 | .137 | 9 | 1867 | -.859 | 17 | 1917 | .825 | 22 | 1967 | -.840 | 22 | | | |
| 1818 | 1.175 | 10 | 1868 | -.642 | 17 | 1918 | .724 | 22 | 1968 | -.692 | 22 | | | |
| 1819 | -1.172 | 10 | 1869 | -.155 | 17 | 1919 | -.203 | 22 | 1969 | .597 | 22 | | | |
| 1820 | -1.659 | 10 | 1870 | .788 | 17 | 1920 | .141 | 22 | 1970 | .294 | 22 | | | |
| 1821 | -1.753 | 10 | 1871 | -.631 | 18 | 1921 | -1.359 | 22 | 1971 | .019 | 22 | | | |
| 1822 | .297 | 10 | 1872 | -.229 | 18 | 1922 | .753 | 22 | 1972 | -1.195 | 22 | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1823 | .383 | 10 | 1873 | .425 | 18 | 1923 | .914 | 22 | 1973 | 1.230 | 22 |
| | | | 1824 | 1.035 | 10 | 1874 | -1.066 | 18 | 1924 | .605 | 22 | 1974 | .354 | 22 |
| | | | 1825 | .236 | 10 | 1875 | -.229 | 18 | 1925 | -.724 | 22 | 1975 | -.397 | 22 |
| | | | 1826 | 1.022 | 10 | 1876 | 1.272 | 19 | 1926 | .844 | 22 | 1976 | -.245 | 22 |
| | | | 1827 | .499 | 10 | 1877 | -.482 | 19 | 1927 | .221 | 22 | 1977 | 1.366 | 22 |
| | | | 1828 | 1.922 | 11 | 1878 | .747 | 19 | 1928 | 1.637 | 22 | 1978 | .464 | 22 |
| | | | 1829 | -1.154 | 11 | 1879 | .494 | 19 | 1929 | -.044 | 22 | 1979 | .798 | 22 |
| | | | 1830 | -.519 | 11 | 1880 | 1.634 | 20 | 1930 | -1.154 | 22 | 1980 | .683 | 22 |
| 1781 | 1.489 | 2 | 1831 | .987 | 12 | 1881 | .018 | 20 | 1931 | -.040 | 22 | 1981 | .614 | 22 |
| 1782 | 1.037 | 2 | 1832 | -2.341 | 12 | 1882 | .437 | 20 | 1932 | -.269 | 22 | 1982 | 1.456 | 22 |
| 1783 | .830 | 2 | 1833 | 1.080 | 12 | 1883 | .397 | 20 | 1933 | -1.083 | 22 | 1983 | -1.808 | 22 |
| 1784 | -.410 | 3 | 1834 | .000 | 12 | 1884 | .316 | 20 | 1934 | -1.151 | 22 | 1984 | -2.658 | 22 |
| 1785 | -1.786 | 3 | 1835 | -.108 | 13 | 1885 | -.312 | 20 | 1935 | -.491 | 22 | 1985 | .182 | 22 |
| 1786 | -1.177 | 3 | 1836 | .471 | 13 | 1886 | .207 | 20 | 1936 | -2.308 | 22 | 1986 | -.243 | 22 |
| 1787 | -1.921 | 3 | 1837 | .248 | 13 | 1887 | -2.564 | 20 | 1937 | -1.341 | 22 | 1987 | -.346 | 22 |
| 1788 | .552 | 3 | 1838 | -.239 | 13 | 1888 | -2.547 | 21 | 1938 | 1.363 | 22 | 1988 | -1.791 | 22 |
| 1789 | -.016 | 3 | 1839 | -1.122 | 13 | 1889 | .176 | 21 | 1939 | .923 | 22 | 1989 | .207 | 22 |
| 1790 | -.052 | 3 | 1840 | .199 | 13 | 1890 | .309 | 22 | 1940 | -.538 | 22 | 1990 | .248 | 22 |
| 1791 | 1.231 | 3 | 1841 | -1.127 | 13 | 1891 | -.650 | 22 | 1941 | .509 | 22 | 1991 | -1.590 | 22 |
| 1792 | 1.785 | 3 | 1842 | .508 | 14 | 1892 | 1.008 | 22 | 1942 | 1.384 | 22 | 1992 | -.556 | 21 |
| 1793 | .774 | 3 | 1843 | 1.043 | 14 | 1893 | -.084 | 22 | 1943 | .649 | 22 | 1993 | .555 | 21 |
| 1794 | 2.144 | 3 | 1844 | 1.439 | 14 | 1894 | -.493 | 22 | 1944 | -1.240 | 22 | 1994 | .973 | 21 |
| 1795 | -1.138 | 3 | 1845 | -.293 | 14 | 1895 | .286 | 22 | 1945 | 1.118 | 22 | 1995 | 1.015 | 21 |
| 1796 | -.513 | 3 | 1846 | .465 | 14 | 1896 | 1.534 | 22 | 1946 | .246 | 22 | 1996 | .730 | 21 |
| 1797 | -1.175 | 3 | 1847 | -.676 | 14 | 1897 | .408 | 22 | 1947 | .963 | 22 | 1997 | .104 | 21 |
| 1798 | 1.493 | 3 | 1848 | -.399 | 14 | 1898 | -.386 | 22 | 1948 | .542 | 22 | 1998 | 1.283 | 21 |
| 1799 | -.499 | 4 | 1849 | -.405 | 15 | 1899 | .076 | 22 | 1949 | -.156 | 22 | 1999 | .319 | 21 |

PART 4: Master Bar Plot:

```
   Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value  Year Rel value
                   1800--------C   1850----a       1900------A     1950---a        2000-----@
                   1801------A     1851--b         1901h           1951------A     2001---------D
                   1802---b        1852---b        1902----------E 1952-e          2002-----A
                   1803---b        1853--b         1903---------D  1953--c         2003--b
                   1804g           1854--c         1904--b         1954j           2004-------B
                   1805g           1855--------C   1905--------C   1955-------B    2005----a
                   1806f           1856k           1906--b         1956----a       2006--b
                   1807---a        1857--------C   1907--------C   1957------A     2007---b
                   1808--b         1858----a       1908f           1958---------D  2008--c
                   1809---------D  1859--------C   1909--b         1959-----A      2009-------B
                   1810-------B    1860---------E  1910--------D   1960---------E  2010--------C
                   1811-------C    1861------A     1911--b         1961---------D  2011---b
                   1812----@       1862----------G 1912---------D  1962-----A      2012g
                   1813----a       1863----a       1913f           1963-----A      2013------A
                   1814----------I 1864-d          1914k           1964---b
                   1815-------C    1865-------B    1915----------F 1965-----@
                   1816-----@      1866------A     1916----------G 1966-e
                   1817-----A      1867--c         1917--------C   1967--c
                   1818---------E  1868--c         1918--------C   1968--c
                   1819-e          1869----a       1919----a       1969-------B
                   1820g           1870--------C   1920-----A      1970------A
                   1821g           1871--c         1921-e          1971-----@
                   1822------A     1872----a       1922--------C   1972-e
                   1823------B     1873-------B    1923--------D   1973---------E
                   1824---------D  1874-d          1924-------B    1974------A
```

```
                1825------A     1875----a       1925--c         1975---b
                1826---------D  1876----------E 1926--------C   1976----a
                1827-------B    1877---b        1927-----A      1977----------E
                1828----------H 1878--------C   1928----------G 1978-------B
                1829-e          1879-------B    1929----@       1979--------C
                1830--b         1880----------G 1930-e          1980--------C
  1781----------F 1831---------D  1881-----@      1931----@       1981-------B
  1782---------D  1832i           1882-------B    1932----a       1982----------F
  1783--------C   1833---------D  1883------B     1933-d          1983g
  1784---b        1834-----@      1884------A     1934-e          1984k
  1785g           1835----@       1885---a        1935---b        1985-----A
  1786-e          1836-------B    1886-----A      1936i           1986----a
  1787h           1837------A     1887j           1937-e          1987---a
  1788-------B    1838----a       1888j           1938----------E 1988g
  1789----@       1839-d          1889-----A      1939---------D  1989-----A
  1790----@       1840-----A      1890------A     1940--b         1990------A
  1791---------E  1841-e          1891--c         1941-------B    1991f
  1792----------G 1842-------B    1892---------D  1942----------F 1992--b
  1793--------C   1843---------D  1893----@       1943-------C    1993-------B
  1794----------I 1844----------F 1894---b        1944-e          1994---------D
  1795-e          1845---a        1895------A     1945---------D  1995---------D
  1796--b         1846-------B    1896----------F 1946------A     1996--------C
  1797-e          1847--c         1897-------B    1947---------D  1997-----@
  1798----------F 1848---b        1898---b        1948-------B    1998----------E
  1799--b         1849---b        1899-----@      1949----a       1999------A
```

PART 5:  CORRELATION OF SERIES BY SEGMENTS:

Correlations of  50-year dated segments, lagged  25 years
Flags:  A = correlation under   .3281 but highest as dated;  B = correlation higher at other than dated position

| Seq | Series | Time_span | 1775 1824 | 1800 1849 | 1825 1874 | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WAL02A | 1803 2013 | | .69 | .51 | .42 | .73 | .69 | .61 | .59 | .47 |
| 2 | WAL02B | 1784 2000 | .33A | .42 | .35 | .39 | .63 | .56 | .32A | .35 | .35 |
| 3 | WAL03A | 1781 2013 | .57 | .31A | .33B | .54 | .70 | .70 | .44 | .57 | .50 |
| 4 | WAL03B | 1781 2012 | .54 | .64 | .62 | .37 | .52 | .55 | .37 | .56 | .61 |
| 5 | WAL04A | 1818 2013 | | .62 | .58 | .67 | .79 | .76 | .56 | .48 | .45 |
| 6 | WAL04B | 1816 2001 | | .60 | .56 | .65 | .79 | .77 | .69 | .66 | .63 |
| 7 | WAL05A | 1815 1991 | | .58 | .60 | .69 | .76 | .68 | .50 | .49 | |
| 8 | WAL05b | 1815 2011 | | .61 | .61 | .68 | .60 | .65 | .75 | .64 | .47 |
| 9 | WAL06A | 1880 2013 | | | | | .71 | .71 | .59 | .59 | .62 |
| 10 | WAL06B | 1876 2013 | | | | | .71 | .61 | .33 | .34 | .33 |
| 11 | WAL07A | 1852 2013 | | | | .72 | .74 | .74 | .65 | .65 | .62 |
| 12 | WAL07B | 1831 2013 | | | .74 | .75 | .79 | .81 | .70 | .63 | .48 |
| 13 | WAL08A | 1849 2013 | | | .71 | .71 | .75 | .74 | .46 | .44 | .60 |
| 14 | WAL08B | 1828 2013 | | | .62 | .74 | .80 | .75 | .61 | .67 | .70 |
| 15 | WAL09A | 1809 1999 | | .69 | .47 | .28A | .64 | .77 | .60 | .75 | |
| 16 | WAL09B | 1799 2013 | .46 | .45 | .65 | .59 | .74 | .81 | .74 | .74 | .73 |
| 17 | WAL10A | 1888 2012 | | | | | .81 | .82 | .66 | .63 | .60 |
| 18 | WAL10B | 1890 2013 | | | | | .78 | .79 | .64 | .67 | .65 |
| 19 | WAL11A | 1835 2013 | | | .46 | .38 | .67 | .74 | .57 | .64 | .63 |
| 20 | WAL11B | 1867 2013 | | | | .60 | .67 | .64 | .63 | .67 | .55 |
| 21 | WAL12A | 1842 2013 | | | .33A | .40 | .74 | .77 | .70 | .78 | .81 |
| 22 | WAL12B | 1871 2013 | | | | .62 | .71 | .77 | .75 | .81 | .76 |
| Av segment correlation | | | .47 | .56 | .54 | .57 | .72 | .72 | .58 | .61 | .58 |

PART 6:  POTENTIAL PROBLEMS:

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

[B] Effect of those data values which most lower or raise correlation with master series
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

WAL02A  1803 to  2013  211 years  Series 1

[B] Entire series, effect on correlation (  .587) is:
Lower 1866< -.016 1999< -.016 1864> -.009 1856> -.009 2001< -.008 2011< -.008 Higher 1983 .009 1954 .008

WAL02B  1784 to  2000  217 years  Series 2

[A]

| Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1784 1833 | 0 | - | - | - | - | - | - | - | -.11 | .28 | .01 | .33*-.04 | .11 | .08 | -.09 | -.03 | -.04 | -.04 | -.10 | .23 | -.01 | |
| 1925 1974 | 0 | -.19 | -.03 | -.06 | -.05 | -.13 | -.15 | .17 | .19 | .26 | -.20 | .32* | .23 | -.03 | -.01 | .06 | -.16 | -.20 | -.06 | -.15 | -.07 | -.01 |

[B] Entire series, effect on correlation (  .394) is:
Lower 1998< -.019 1786> -.018 1799< -.016 1797> -.011 1803< -.010 1874> -.009 Higher 1984 .017 1887 .016
1784 to 1833 segment:
Lower 1786> -.057 1799< -.049 1797> -.035 1803< -.030 1805> -.025 1785> -.021 Higher 1787 .032 1814 .031
1925 to 1974 segment:
Lower 1974< -.036 1967> -.033 1956< -.026 1939< -.025 1944> -.022 1961< -.021 Higher 1942 .030 1973 .029

[E] Outliers  4  3.0 SD above or -4.5 SD below mean for year
1786 +3.8 SD;  1856 +3.3 SD;  1874 +3.1 SD;  1967 +3.1 SD

WAL03A  1781 to  2013  233 years  Series 3

[A]

| Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1800 1849 | 0 | .07 | .05 | -.01 | -.03 | -.10 | .08 | -.10 | -.14 | -.24 | .14 | .31*-.06 | .23 | .20 | -.03 | -.03 | -.09 | -.05 | .02 | -.05 | .09 | |
| 1825 1874 | 10 | .00 | -.08 | .15 | .12 | -.05 | .15 | -.13 | -.03 | -.27 | .01 | .33\|-.23 | .10 | .15 | -.21 | .09 | -.16 | .00 | .09 | .01 | .43* | |

[B] Entire series, effect on correlation (  .515) is:
Lower 1846< -.053 1797< -.012 1889< -.007 1802> -.007 1957< -.006 1943< -.005 Higher 1856 .012 1914 .010
1800 to 1849 segment:
Lower 1846< -.209 1802> -.027 1841> -.023 1832> -.013 1836< -.012 1812> -.012 Higher 1814 .048 1828 .043
1825 to 1874 segment:
Lower 1846< -.211 1841> -.023 1867> -.016 1851> -.016 1832> -.015 1836< -.013 Higher 1856 .075 1828 .042

```
 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1846 -6.7 SD
=============================================================================================================================================

 WAL03B    1781 to  2012     232 years                                                                                        Series   4

 [B] Entire series, effect on correlation (  .517) is:
       Lower   1951< -.021   1799> -.012   1961< -.011   1894> -.009   1805< -.008   1889< -.007  Higher   1832  .019   1814  .008

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1855 +3.0 SD;    1894 +3.2 SD;    1931 +3.0 SD
=============================================================================================================================================

 WAL04A    1818 to  2013     196 years                                                                                        Series   5

 [B] Entire series, effect on correlation (  .635) is:
       Lower   1856> -.012   2011< -.008   1978< -.007   1956> -.006   1833< -.006   1902< -.006  Higher   1914  .017   1832  .012

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

 WAL04B    1816 to  2001     186 years                                                                                        Series   6

 [B] Entire series, effect on correlation (  .661) is:
       Lower   1834< -.017   1862< -.012   1937> -.009   1988< -.009   1956> -.008   1829> -.006  Higher   1914  .013   1887  .012

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

 WAL05A    1815 to  1991     177 years                                                                                        Series   7

 [B] Entire series, effect on correlation (  .592) is:
       Lower   1956< -.031   1981< -.012   1983> -.011   1861< -.008   1839> -.008   1829> -.007  Higher   1832  .020   1954  .013

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

 WAL05b    1815 to  2011     197 years                                                                                        Series   8

 [B] Entire series, effect on correlation (  .614) is:
       Lower   2010< -.021   1983> -.015   1850< -.012   1879< -.007   1913> -.006   1962> -.006  Higher   1856  .021   1936  .012

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

 WAL06A    1880 to  2013     134 years                                                                                        Series   9

 [B] Entire series, effect on correlation (  .642) is:
       Lower   1893> -.016   1936> -.013   1898< -.011   1958< -.011   1999< -.011   1947< -.008  Higher   1887  .022   1983  .017

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1893 +3.4 SD
=============================================================================================================================================

 WAL06B    1876 to  2013     138 years                                                                                        Series  10

 [B] Entire series, effect on correlation (  .457) is:
       Lower   1947< -.018   1936> -.015   1952> -.015   2010< -.014   1963< -.013   1988> -.013  Higher   1914  .023   1887  .020

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

 WAL07A    1852 to  2013     162 years                                                                                        Series  11
```

```
 [B] Entire series, effect on correlation (  .696) is:
       Lower   1890< -.014   1998< -.010   1880< -.010   1972> -.009   1996< -.009   1937> -.008  Higher   1856  .021   1887  .015

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

 WAL07B    1831 to  2013     183 years                                                                                    Series  12

 [B] Entire series, effect on correlation (  .686) is:
       Lower   2013< -.011   1998< -.010   2012> -.010   1847< -.009   1877> -.008   1957< -.007  Higher   1856  .020   1914  .012

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

 WAL08A    1849 to  2013     165 years                                                                                    Series  13

 [B] Entire series, effect on correlation (  .622) is:
       Lower   1954> -.024   1958< -.014   1957< -.014   1866> -.009   2013< -.007   1987< -.006  Higher   1856  .024   1936  .012

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1856 -4.6 SD
==========================================================================================================================================

 WAL08B    1828 to  2013     186 years                                                                                    Series  14

 [B] Entire series, effect on correlation (  .686) is:
       Lower   1902< -.019   1965< -.007   2011> -.006   1845> -.006   1837< -.005   1903< -.005  Higher   1856  .014   1914  .012

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1856 -5.0 SD
==========================================================================================================================================

 WAL09A    1809 to  1999     191 years                                                                                    Series  15

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1850 1899    0    .10 -.08 -.03 -.01 -.02 -.01 -.04  .04  .03 -.21  .28* .02  .06 -.02 -.16  .19  .01  .09  .09 -.22 -.01

 [B] Entire series, effect on correlation (  .604) is:
       Lower   1866< -.026   1882< -.015   1864> -.014   1871> -.010   1870< -.009   1881< -.009  Higher   1856  .021   1832  .017
     1850 to 1899 segment:
       Lower   1866< -.061   1864> -.042   1882< -.040   1871> -.029   1870< -.027   1874> -.027  Higher   1856  .161   1880  .029

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1864 +3.0 SD
==========================================================================================================================================

 WAL09B    1799 to  2013     215 years                                                                                    Series  16

 [B] Entire series, effect on correlation (  .657) is:
       Lower   1802< -.024   1876< -.009   1803> -.007   1808> -.007   1840< -.006   1882< -.006  Higher   1914  .014   1856  .010

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

 WAL10A    1888 to  2012     125 years                                                                                    Series  17

 [B] Entire series, effect on correlation (  .709) is:
       Lower   1966> -.010   1995< -.010   1962< -.010   2003> -.008   1912< -.008   1914> -.007  Higher   1901  .011   1915  .008

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
```

```
      1954 -4.6 SD
================================================================================================================================================

 WAL10B    1890 to  2013     124 years                                                                                          Series  18

 [B] Entire series, effect on correlation (  .684) is:
      Lower   2000< -.014   1901> -.011   2002< -.010   1959> -.009   1946< -.009   1947< -.009  Higher   1914  .021   1954  .016

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 WAL11A    1835 to  2013     179 years                                                                                          Series  19

 [B] Entire series, effect on correlation (  .572) is:
      Lower   2003< -.024   1979< -.015   1955< -.011   1960< -.008   1858> -.007   1927< -.007  Higher   1983  .016   1914  .010

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

 WAL11B    1867 to  2013     147 years                                                                                          Series  20

 [B] Entire series, effect on correlation (  .580) is:
      Lower   1870< -.015   2012> -.013   1983> -.011   1913> -.011   1938< -.011   1988> -.010  Higher   1984  .023   1914  .014

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

 WAL12A    1842 to  2013     172 years                                                                                          Series  21

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1842 1891    0    .00 -.16 -.11  .16 -.01  .02  .06  .04  .05 -.15  .33* .02 -.04 -.09  .07 -.26 -.06 -.02 -.13 -.11  .08

 [B] Entire series, effect on correlation (  .636) is:
      Lower   1856> -.047   1844< -.010   1942< -.010   1847> -.009   1843< -.008   2007< -.007  Higher   1983  .015   1936  .012
    1842 to 1891 segment:
      Lower   1856> -.136   1844< -.034   1843< -.027   1847> -.024   1891> -.015   1853> -.013  Higher   1887  .093   1888  .029

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1856 +4.1 SD
================================================================================================================================================

 WAL12B    1871 to  2013     143 years                                                                                          Series  22

 [B] Entire series, effect on correlation (  .689) is:
      Lower   1874< -.038   1914> -.015   1924< -.011   2011> -.011   1967< -.008   1891> -.007  Higher   1887  .017   1983  .014

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1874 -5.4 SD
================================================================================================================================================
```

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | WAL02A | 1803 2013 | 211 | 8 | 0 | .587 | 1.62 | 5.28 | .747 | .757 | .257 | 2.67 | .371 | -.038 | 1 |
| 2 | WAL02B | 1784 2000 | 217 | 9 | 2 | .394 | 1.57 | 4.23 | .850 | .823 | .260 | 2.76 | .544 | -.037 | 1 |
| 3 | WAL03A | 1781 2013 | 233 | 9 | 2 | .515 | 1.79 | 6.32 | .950 | .785 | .290 | 2.70 | .385 | .051 | 1 |
| 4 | WAL03B | 1781 2012 | 232 | 9 | 0 | .517 | 1.95 | 7.90 | .983 | .776 | .258 | 2.92 | .487 | .050 | 1 |
| 5 | WAL04A | 1818 2013 | 196 | 8 | 0 | .635 | 1.95 | 3.88 | .690 | .539 | .270 | 2.73 | .440 | .046 | 1 |
| 6 | WAL04B | 1816 2001 | 186 | 8 | 0 | .661 | 2.31 | 4.76 | .808 | .312 | .316 | 2.57 | .388 | .013 | 1 |
| 7 | WAL05A | 1815 1991 | 177 | 7 | 0 | .592 | 1.22 | 3.37 | .658 | .795 | .252 | 2.83 | .441 | -.029 | 1 |
| 8 | WAL05b | 1815 2011 | 197 | 8 | 0 | .614 | 1.57 | 3.32 | .731 | .766 | .264 | 2.70 | .476 | .019 | 1 |
| 9 | WAL06A | 1880 2013 | 134 | 5 | 0 | .642 | 1.18 | 3.18 | .571 | .712 | .264 | 2.81 | .447 | .029 | 1 |
| 10 | WAL06B | 1876 2013 | 138 | 5 | 0 | .457 | 1.21 | 3.33 | .614 | .780 | .235 | 2.79 | .474 | -.045 | 1 |
| 11 | WAL07A | 1852 2013 | 162 | 6 | 0 | .696 | 1.29 | 3.13 | .549 | .522 | .309 | 2.69 | .470 | .037 | 1 |
| 12 | WAL07B | 1831 2013 | 183 | 7 | 0 | .686 | 1.67 | 5.29 | .900 | .704 | .315 | 2.69 | .430 | -.002 | 1 |
| 13 | WAL08A | 1849 2013 | 165 | 7 | 0 | .622 | 1.10 | 3.42 | .553 | .618 | .328 | 2.59 | .344 | .022 | 1 |
| 14 | WAL08B | 1828 2013 | 186 | 7 | 0 | .686 | 1.43 | 3.63 | .633 | .545 | .332 | 2.71 | .356 | .027 | 1 |
| 15 | WAL09A | 1809 1999 | 191 | 7 | 1 | .604 | 1.76 | 4.20 | .757 | .629 | .288 | 2.74 | .547 | .028 | 1 |
| 16 | WAL09B | 1799 2013 | 215 | 9 | 0 | .657 | 1.80 | 5.43 | .799 | .578 | .305 | 2.79 | .416 | .019 | 1 |
| 17 | WAL10A | 1888 2012 | 125 | 5 | 0 | .709 | 2.20 | 5.56 | .940 | .443 | .333 | 2.77 | .425 | .040 | 1 |
| 18 | WAL10B | 1890 2013 | 124 | 5 | 0 | .684 | 1.85 | 4.68 | .817 | .518 | .347 | 2.84 | .568 | -.037 | 1 |
| 19 | WAL11A | 1835 2013 | 179 | 7 | 0 | .572 | .97 | 4.09 | .729 | .591 | .384 | 2.83 | .434 | -.001 | 3 |
| 20 | WAL11B | 1867 2013 | 147 | 6 | 0 | .580 | 1.08 | 4.23 | .754 | .522 | .406 | 3.05 | .490 | .027 | 2 |
| 21 | WAL12A | 1842 2013 | 172 | 7 | 1 | .636 | 1.83 | 4.71 | .891 | .470 | .396 | 2.84 | .454 | -.006 | 1 |
| 22 | WAL12B | 1871 2013 | 143 | 6 | 0 | .689 | 1.74 | 5.65 | 1.026 | .620 | .359 | 2.59 | .394 | -.032 | 1 |
| Total or mean: | | | 3913 | 155 | 6 | .604 | 1.61 | 7.90 | .776 | .637 | .304 | 3.05 | .443 | .010 | |

# APPENDIX N

## COFECHA PROGRAM OUTPUT FOR PIONEER MOTHERS SITE CHRONOLOGY,

## *LIRIODENDRON TULIPIFERA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29369
-------------------------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   PMT.txt

 Time span of Master dating series is  1717 to  2012   296 years
 Continuous time span is               1717 to  2012   296 years
 Portion with two or more series is    1782 to  2012   231 years

 >> PMT23       1927 absent in   1 of   18 series, but is not usually narrow: master index is   .201

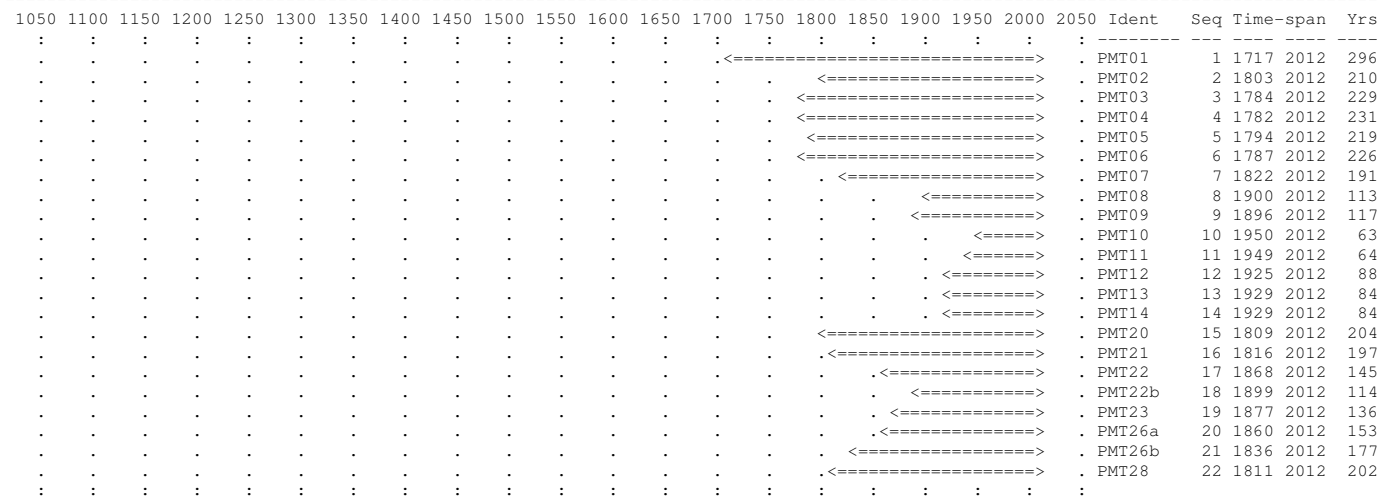
                                     ****************************************
                                     *C* Number of dated series        22 *C*
                                     *O* Master series 1717 2012  296 yrs *O*
                                     *F* Total rings in all series   3543 *F*
                                     *E* Total dated rings checked   3478 *E*
                                     *C* Series intercorrelation     .595 *C*
                                     *H* Average mean sensitivity    .323 *H*
                                     *A* Segments, possible problems    9 *A*
                                     *** Mean length of series      161.0 ***
                                     ****************************************

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

 PMT01       1 absent rings:   1954
 PMT03       4 absent rings:   1834  1888  1895  1914
 PMT23       2 absent rings:   1926  1927

             7 absent rings    .198%
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1750 | .722 | 1 | 1800 | -.653 | 5 | 1850 | .913 | 11 | 1900 | .867 | 17 | 1950 | .752 | 22 | |
| | | | 1751 | 1.147 | 1 | 1801 | -.947 | 5 | 1851 | .000 | 11 | 1901 | -.437 | 17 | 1951 | 1.251 | 22 | |
| | | | 1752 | 2.175 | 1 | 1802 | 1.005 | 5 | 1852 | -.136 | 11 | 1902 | -.115 | 17 | 1952 | -.110 | 22 | |
| | | | 1753 | .564 | 1 | 1803 | -1.517 | 6 | 1853 | .273 | 11 | 1903 | .654 | 17 | 1953 | -1.787 | 22 | |
| | | | 1754 | 1.508 | 1 | 1804 | .347 | 6 | 1854 | -.058 | 11 | 1904 | .632 | 17 | 1954 | -2.436 | 22 | 1 |
| | | | 1755 | -.441 | 1 | 1805 | .840 | 6 | 1855 | -.797 | 11 | 1905 | .732 | 17 | 1955 | -.650 | 22 | |
| | | | 1756 | -.649 | 1 | 1806 | .295 | 6 | 1856 | -2.125 | 11 | 1906 | .566 | 17 | 1956 | .221 | 22 | |
| | | | 1757 | -1.885 | 1 | 1807 | -.008 | 6 | 1857 | -.135 | 11 | 1907 | 1.183 | 17 | 1957 | .624 | 22 | |
| | | | 1758 | -1.484 | 1 | 1808 | .286 | 6 | 1858 | -.412 | 11 | 1908 | -.896 | 17 | 1958 | .577 | 22 | |
| | | | 1759 | -.714 | 1 | 1809 | 1.409 | 7 | 1859 | -.444 | 11 | 1909 | -1.096 | 17 | 1959 | .240 | 22 | |
| | | | 1760 | -.090 | 1 | 1810 | 1.118 | 7 | 1860 | -.396 | 12 | 1910 | .287 | 17 | 1960 | 1.426 | 22 | |
| | | | 1761 | 1.622 | 1 | 1811 | .410 | 8 | 1861 | -.007 | 12 | 1911 | -.755 | 17 | 1961 | .680 | 22 | |
| | | | 1762 | 2.358 | 1 | 1812 | .280 | 8 | 1862 | 1.098 | 12 | 1912 | .265 | 17 | 1962 | .811 | 22 | |
| | | | 1763 | -1.058 | 1 | 1813 | -1.047 | 8 | 1863 | -.020 | 12 | 1913 | -1.200 | 17 | 1963 | -.387 | 22 | |
| | | | 1764 | -.766 | 1 | 1814 | -.334 | 8 | 1864 | -1.608 | 12 | 1914 | -1.996 | 17 | 1 | 1964 | -.396 | 22 | |
| | | | 1765 | -.905 | 1 | 1815 | -.177 | 8 | 1865 | .308 | 12 | 1915 | .600 | 17 | | 1965 | -1.020 | 22 | |
| | | | 1766 | .149 | 1 | 1816 | -1.303 | 9 | 1866 | 1.250 | 12 | 1916 | 1.735 | 17 | | 1966 | -2.114 | 22 | |
| 1717 | 1.795 | 1 | 1767 | 1.148 | 1 | 1817 | -1.275 | 9 | 1867 | .491 | 12 | 1917 | 1.188 | 17 | | 1967 | -1.365 | 22 | |
| 1718 | 1.163 | 1 | 1768 | -1.143 | 1 | 1818 | -.578 | 9 | 1868 | .021 | 13 | 1918 | -.169 | 17 | | 1968 | -.165 | 22 | |
| 1719 | 1.173 | 1 | 1769 | .226 | 1 | 1819 | -.168 | 9 | 1869 | .398 | 13 | 1919 | .281 | 17 | | 1969 | .529 | 22 | |
| 1720 | .631 | 1 | 1770 | -1.149 | 1 | 1820 | .427 | 9 | 1870 | -.169 | 13 | 1920 | .439 | 17 | | 1970 | -.658 | 22 | |
| 1721 | .227 | 1 | 1771 | -1.075 | 1 | 1821 | -.381 | 9 | 1871 | -.555 | 13 | 1921 | -.490 | 17 | | 1971 | .068 | 22 | |
| 1722 | -3.377 | 1 | 1772 | .255 | 1 | 1822 | .236 | 10 | 1872 | .473 | 13 | 1922 | .425 | 17 | | 1972 | -.935 | 22 | |

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1723 | .114 | 1 | 1773 | -2.074 | 1 | 1823 | 1.435 | 10 | 1873 | .660 | 13 | 1923 | .363 | 17 | 1973 | 1.290 | 22 |
| 1724 | -.915 | 1 | 1774 | .188 | 1 | 1824 | .545 | 10 | 1874 | -.886 | 13 | 1924 | .536 | 17 | 1974 | .417 | 22 |
| 1725 | -1.183 | 1 | 1775 | -1.729 | 1 | 1825 | 1.226 | 10 | 1875 | -.172 | 13 | 1925 | -1.316 | 18 | 1975 | .603 | 22 |
| 1726 | 1.021 | 1 | 1776 | 1.062 | 1 | 1826 | .225 | 10 | 1876 | .818 | 13 | 1926 | -1.034 | 18 | 1 | 1976 | .185 | 22 |
| 1727 | .648 | 1 | 1777 | -.147 | 1 | 1827 | .025 | 10 | 1877 | .472 | 14 | 1927 | .201 | 18 | 1<< | 1977 | .128 | 22 |
| 1728 | -1.426 | 1 | 1778 | 2.289 | 1 | 1828 | .636 | 10 | 1878 | .858 | 14 | 1928 | 1.592 | 18 | | 1978 | -.087 | 22 |
| 1729 | 1.309 | 1 | 1779 | .476 | 1 | 1829 | -.246 | 10 | 1879 | -1.005 | 14 | 1929 | .618 | 20 | | 1979 | .147 | 22 |
| 1730 | -.266 | 1 | 1780 | 1.653 | 1 | 1830 | -.481 | 10 | 1880 | .458 | 14 | 1930 | -.553 | 20 | | 1980 | 1.163 | 22 |
| 1731 | -.982 | 1 | 1781 | 1.993 | 1 | 1831 | -.970 | 10 | 1881 | -1.107 | 14 | 1931 | -.031 | 20 | | 1981 | .530 | 22 |
| 1732 | -.912 | 1 | 1782 | 1.343 | 2 | 1832 | -.829 | 10 | 1882 | .201 | 14 | 1932 | .401 | 20 | | 1982 | 1.734 | 22 |
| 1733 | .067 | 1 | 1783 | 1.184 | 2 | 1833 | -.086 | 10 | 1883 | 1.333 | 14 | 1933 | -.432 | 20 | | 1983 | -.366 | 22 |
| 1734 | 1.282 | 1 | 1784 | .118 | 3 | 1834 | -1.921 | 10 | 1 | 1884 | .643 | 14 | 1934 | -1.094 | 20 | | 1984 | -1.786 | 22 |
| 1735 | 2.857 | 1 | 1785 | -.774 | 3 | 1835 | .153 | 10 | | 1885 | -.193 | 14 | 1935 | -.198 | 20 | | 1985 | .624 | 22 |
| 1736 | 1.383 | 1 | 1786 | .744 | 3 | 1836 | .708 | 11 | | 1886 | -.087 | 14 | 1936 | -2.356 | 20 | | 1986 | .978 | 22 |
| 1737 | -.966 | 1 | 1787 | .571 | 4 | 1837 | 1.551 | 11 | | 1887 | -1.014 | 14 | 1937 | -1.391 | 20 | | 1987 | .905 | 22 |
| 1738 | -.477 | 1 | 1788 | -.254 | 4 | 1838 | .619 | 11 | | 1888 | -2.723 | 14 | 1 | 1938 | .648 | 20 | | 1988 | -1.985 | 22 |
| 1739 | .468 | 1 | 1789 | -.304 | 4 | 1839 | -1.170 | 11 | | 1889 | -.070 | 14 | | 1939 | 1.328 | 20 | | 1989 | -1.386 | 22 |
| 1740 | 1.149 | 1 | 1790 | -1.271 | 4 | 1840 | .254 | 11 | | 1890 | 1.395 | 14 | | 1940 | -.301 | 20 | | 1990 | -.744 | 22 |
| 1741 | -.582 | 1 | 1791 | .601 | 4 | 1841 | -1.082 | 11 | | 1891 | .722 | 14 | | 1941 | -.619 | 20 | | 1991 | -.505 | 22 |
| 1742 | -1.609 | 1 | 1792 | .357 | 4 | 1842 | -.695 | 11 | | 1892 | 1.156 | 14 | | 1942 | .926 | 20 | | 1992 | -.988 | 22 |
| 1743 | -1.723 | 1 | 1793 | .897 | 4 | 1843 | -.561 | 11 | | 1893 | .346 | 14 | | 1943 | .346 | 20 | | 1993 | -.949 | 22 |
| 1744 | -1.655 | 1 | 1794 | -1.257 | 5 | 1844 | .639 | 11 | | 1894 | -.641 | 14 | | 1944 | -1.265 | 20 | | 1994 | -.599 | 22 |
| 1745 | -1.245 | 1 | 1795 | -1.312 | 5 | 1845 | .455 | 11 | | 1895 | -2.399 | 14 | 1 | 1945 | .027 | 20 | | 1995 | .838 | 22 |
| 1746 | -.296 | 1 | 1796 | -.161 | 5 | 1846 | .433 | 11 | | 1896 | -.220 | 15 | | 1946 | .910 | 20 | | 1996 | .392 | 22 |
| 1747 | -.004 | 1 | 1797 | .209 | 5 | 1847 | -.090 | 11 | | 1897 | 1.193 | 15 | | 1947 | .981 | 20 | | 1997 | .062 | 22 |
| 1748 | .470 | 1 | 1798 | -.326 | 5 | 1848 | .307 | 11 | | 1898 | -.890 | 15 | | 1948 | .353 | 20 | | 1998 | 1.487 | 22 |
| 1749 | .721 | 1 | 1799 | -.282 | 5 | 1849 | .855 | 11 | | 1899 | -.614 | 16 | | 1949 | .863 | 21 | | 1999 | 1.205 | 22 |
| 2000 | -.533 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2001 | .418 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2002 | .468 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2003 | -.854 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2004 | 1.210 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2005 | .652 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2006 | .893 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2007 | -1.598 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2008 | -.759 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2009 | .217 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2010 | .817 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2011 | .616 | 22 | | | | | | | | | | | | | | | | | | | | | |
| 2012 | -2.165 | 22 | | | | | | | | | | | | | | | | | | | | | |

PART 4: Master Bar Plot:

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1750--------C | 1800--c | 1850--------D | 1900--------C | 1950--------C | 2000---b | |
| | 1751---------E | 1801-d | 1851-----@ | 1901---b | 1951---------E | 2001------B | |
| | 1752----------I | 1802---------D | 1852----a | 1902----@ | 1952----@ | 2002-------B | |
| | 1753-------B | 1803f | 1853------A | 1903--------C | 1953g | 2003--c | |
| | 1754----------F | 1804------A | 1854----@ | 1904-------C | 1954j | 2004---------E | |
| | 1755---b | 1805--------C | 1855--c | 1905--------C | 1955--c | 2005--------C | |
| | 1756--c | 1806------A | 1856h | 1906-------B | 1956-----A | 2006--------D | |
| | 1757h | 1807----@ | 1857----a | 1907---------E | 1957-------B | 2007f | |
| | 1758f | 1808------A | 1858---b | 1908--d | 1958-------B | 2008--c | |
| | 1759--c | 1809----------F | 1859---b | 1909-d | 1959-----A | 2009-----A | |
| | 1760----@ | 1810---------D | 1860---b | 1910------A | 1960----------F | 2010--------C | |

```
                 1761----------F 1811------B     1861----@       1911--c         1961--------C   2011-------B
                 1762----------I 1812------A     1862---------D  1912------A     1962--------C   2012i
                 1763-d          1813-d          1863----@       1913-e          1963---b
                 1764--c         1814---a        1864f           1914h           1964---b
                 1765--d         1815----a       1865------A     1915-------B    1965-d
                 1766-----A      1816-e          1866---------E  1916----------G 1966h
  1717----------G 1767---------E  1817-e          1867-------B    1917---------E  1967-e
  1718---------E  1768-e          1818---b        1868-----@      1918----a       1968----a
  1719---------E  1769-----A      1819----a       1869------B     1919------A     1969-------B
  1720-------C    1770-e          1820------B     1870----a       1920------B     1970--c
  1721-----A      1771-d          1821---b        1871---b        1921---b        1971-----@
  1722n           1772------A     1822-----A      1872-------B    1922------B     1972--d
  1723-----@      1773h           1823----------F 1873--------C   1923------A     1973---------E
  1724--d         1774-----A      1824-------B    1874--d         1924-------B    1974------B
  1725-e          1775g           1825---------E  1875----a       1925-e          1975-------B
  1726---------D  1776---------D  1826-----A      1876--------C   1926-d          1976-----A
  1727--------C   1777----a       1827-----@      1877-------B    1927-----A      1977-----A
  1728-f          1778----------I 1828--------C   1878--------C   1928----------F 1978----@
  1729---------E  1779-------B    1829----a       1879-d          1929-------B    1979-----A
  1730----a       1780----------G 1830---b        1880-------B    1930---b        1980---------E
  1731-d          1781----------H 1831-d          1881-d          1931----@       1981-------B
  1732--d         1782----------E 1832--c         1882-----A      1932------B     1982---------G
  1733-----@      1783---------E  1833----@       1883----------E 1933---b        1983---a
  1734---------E  1784-----@      1834h           1884--------C   1934-d          1984g
  1735----------K 1785--c         1835-----A      1885----a       1935----a       1985-------B
  1736----------F 1786--------C   1836--------C   1886----@       1936i           1986---------D
  1737-d          1787-------B    1837----------F 1887-d          1937-f          1987--------D
  1738---b        1788----a       1838-------B    1888k           1938--------C   1988h
  1739-------B    1789---a        1839-e          1889----@       1939---------E  1989-f
  1740---------E  1790-e          1840------A     1890----------F 1940---a        1990--c
  1741---b        1791-------B    1841-d          1891--------C   1941--b         1991---b
  1742f           1792------A     1842--c         1892---------E  1942--------D   1992-d
  1743g           1793--------D   1843---b        1893------A     1943------A     1993-d
  1744g           1794-e          1844--------C   1894--c         1944-e          1994---b
  1745-e          1795-e          1845-------B    1895j           1945-----@      1995--------C
  1746---a        1796----a       1846------B     1896----a       1946--------D   1996------B
  1747----@       1797-----A      1847----@       1897---------E  1947---------D  1997-----@
  1748-------B    1798---a        1848------A     1898--d         1948------A     1998----------F
  1749--------C   1799----a       1849--------C   1899--b         1949--------C   1999---------E
```

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1775 1824 | 1800 1849 | 1825 1874 | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PMT01 | 1717 2012 | .32A | .51 | .64 | .75 | .52 | .35B | .41B | .60 | .66 |
| 2 | PMT02 | 1803 2012 | | .37 | .52 | .62 | .66 | .51 | .48 | .58 | .70 |
| 3 | PMT03 | 1784 2012 | .33 | .31A | .34 | .43 | .23B | .46 | .67 | .66 | .58 |
| 4 | PMT04 | 1782 2012 | .36 | .40B | .41 | .66 | .75 | .75 | .72 | .77 | .64 |
| 5 | PMT05 | 1794 2012 | .27B | .33 | .42 | .51 | .69 | .63 | .57 | .65 | .75 |
| 6 | PMT06 | 1787 2012 | .58 | .63 | .56 | .56 | .69 | .77 | .75 | .71 | .70 |
| 7 | PMT07 | 1822 2012 | | .45 | .43 | .45 | .48 | .46 | .55 | .74 | .79 |
| 8 | PMT08 | 1900 2012 | | | | | | .40B | .58 | .63 | .66 |
| 9 | PMT09 | 1896 2012 | | | | | .50 | .52 | .55 | .51 | .50 |
| 10 | PMT10 | 1950 2012 | | | | | | | | .65 | .65 |

```
  11 PMT11    1949 2012                                  .52  .51  .53
  12 PMT12    1925 2012                                  .66  .76  .73
  13 PMT13    1929 2012                                  .54  .77  .70
  14 PMT14    1929 2012                                  .70  .70  .63
  15 PMT20    1809 2012        .58  .43  .57  .73  .63  .64  .69  .76
  16 PMT21    1816 2012        .48  .49  .64  .69  .73  .79  .72  .77
  17 PMT22    1868 2012             .34  .41  .75  .76  .80  .81
  18 PMT22b   1899 2012                  .74  .73  .73  .77  .76
  19 PMT23    1877 2012                  .67  .66  .58  .56  .54
  20 PMT26a   1860 2012             .58  .61  .62  .56  .63  .65
  21 PMT26b   1836 2012        .31A .44  .68  .74  .71  .72  .75
  22 PMT28    1811 2012   .45  .38  .59  .75  .64  .65  .72  .67
Av segment correlation   .38  .45  .45  .55  .61  .61  .63  .68  .68
```

PART 6: POTENTIAL PROBLEMS:

---

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

[B] Effect of those data values which most lower or raise correlation with master series
Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

==========

PMT01 1717 to 2012 296 years Series 1

[*] Early part of series cannot be checked from 1717 to 1781 -- not matched by another series

```
[A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
   ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1782 1831    0   -.14  .14 -.02 -.10 -.15  .21 -.05  .10  .06 -.15  .32*-.06 -.24 -.12  .05 -.12 -.15 -.26 -.07  .04  .31
   1900 1949    1    .02 -.16 -.14  .02 -.06  .11 -.01  .13  .04 -.23  .35| .41*-.24 -.43 -.04  .11 -.07 -.17  .16  .10  .21
   1925 1974    1    .10 -.12 -.12 -.01 -.21 -.16 -.06 -.02 -.02  .09  .41| .47* .01 -.36  .02  .02 -.11 -.23  .03  .08  .00
```

[B] Entire series, effect on correlation ( .512) is:

```
      Lower   1795> -.010   1935< -.010   1917< -.008   1803< -.008   1937> -.007   1916< -.007  Higher   2007  .012   1888  .010
    1782 to 1831 segment:
      Lower   1795> -.051   1784< -.026   1786< -.014   1826> -.011   1796> -.011   1814> -.011  Higher   1803  .035   1816  .025
    1900 to 1949 segment:
      Lower   1935< -.030   1917< -.029   1937> -.027   1916< -.024   1914> -.023   1921> -.016  Higher   1913  .054   1925  .041
    1925 to 1974 segment:
      Lower   1935< -.037   1937> -.026   1953> -.024   1973< -.021   1928< -.016   1932< -.016  Higher   1954  .061   1925  .029
```

[C] Year-to-year changes diverging by over 4.0 std deviations:

```
      1953 1954  -4.2 SD
```

[D] 1 Absent rings:

| Year | Master | N series | Absent |
|---|---|---|---|
| 1954 | -2.436 | 22 | 1 |

[E] Outliers 5 3.0 SD above or -4.5 SD below mean for year
1795 +4.0 SD; 1803 -5.4 SD; 1912 +3.9 SD; 1937 +3.3 SD; 1954 -7.2 SD

---

PMT02 1803 to 2012 210 years Series 2

[B] Entire series, effect on correlation ( .553) is:
Lower 1803> -.014 1829> -.012 1928< -.012 1812< -.010 1921> -.008 1887> -.008 Higher 1888 .018 2012 .016

[E] Outliers 3 3.0 SD above or -4.5 SD below mean for year
1805 +3.4 SD; 1829 +3.6 SD; 1870 +3.4 SD

---

PMT03 1784 to 2012 229 years Series 3

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1800 1849 | 0 | -.11 | .06 | .10 | .14 | -.01 | .23 | .26 | .07 | .16 | -.24 | .31*-.01 | -.01 | .04 | -.31 | .08 | -.36 | -.32 | -.12 | .06 | .17 |
| 1875 1924 | -2 | .01 | -.05 | -.07 | .16 | .07 | .26 | -.23 | -.38 | .33*-.16 | .23\| | .30 | .01 | -.37 | -.09 | -.10 | .01 | .15 | .18 | -.15 | -.09 |

[B] Entire series, effect on correlation ( .530) is:
Lower 1909> -.011 1805< -.010 1900< -.008 1897< -.008 1898> -.007 1916< -.007 Higher 1834 .019 1895 .017
1800 to 1849 segment:
Lower 1805< -.044 1841> -.032 1838< -.026 1836< -.018 1831> -.012 1822< -.012 Higher 1834 .168 1803 .048
1875 to 1924 segment:
Lower 1909> -.047 1900< -.032 1897< -.030 1898> -.030 1916< -.027 1899> -.022 Higher 1895 .079 1888 .073

[D] 4 Absent rings:

| Year | Master | N series | Absent |
|---|---|---|---|
| 1834 | -1.921 | 10 | 1 |
| 1888 | -2.723 | 14 | 1 |
| 1895 | -2.399 | 14 | 1 |
| 1914 | -1.996 | 17 | 1 |

[E] Outliers 4 3.0 SD above or -4.5 SD below mean for year
1828 +3.4 SD; 1834 -7.6 SD; 1899 +3.2 SD; 1909 +4.0 SD

---

PMT04 1782 to 2012 231 years Series 4

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1800 1849 | -5 | .22 | -.16 | -.01 | -.13 | -.22 | .43*-.19 | .17 | -.06 | .06 | .40\|-.21 | | .13 | -.06 | -.07 | -.03 | -.26 | -.06 | -.12 | -.24 | -.18 |

[B] Entire series, effect on correlation ( .592) is:
Lower 1844< -.024 1827< -.017 2007> -.015 2006< -.012 1846< -.010 1790> -.009 Higher 1888 .015 1856 .010
1800 to 1849 segment:
Lower 1844< -.096 1827< -.062 1846< -.040 1830> -.017 1831> -.015 1833> -.015 Higher 1834 .071 1839 .037

[E] Outliers 5 3.0 SD above or -4.5 SD below mean for year
1810 +3.3 SD; 1827 -5.0 SD; 1833 +3.4 SD; 1844 -5.7 SD; 1855 +3.1 SD

---

PMT05 1794 to 2012 219 years Series 5

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1794 1843 | 5 | .17 | -.08 | -.26 | -.17 | -.25 | -.08 | -.26 | -.10 | -.04 | .16 | .27\| | .00 | .16 | .28 | -.01 | .37*-.23 | | .00 | -.03 | -.23 | -.24 |

```
 [B] Entire series, effect on correlation (  .520) is:
       Lower   1803> -.036   1851< -.024   1794> -.021   1855> -.017   1958< -.015   1867< -.008  Higher   2012  .020   1888  .016
     1794 to 1843 segment:
       Lower   1803> -.150   1794> -.077   1812< -.021   1798< -.017   1821> -.014   1814< -.011  Higher   1834  .089   1837  .045

 [E] Outliers     6   3.0 SD above or -4.5 SD below mean for year
       1794 +3.8 SD;    1803 +5.9 SD;    1851 -6.4 SD;    1855 +4.8 SD;    1958 -4.9 SD;    2012 -6.0 SD
================================================================================================================================================

 PMT06     1787 to  2012     226 years                                                                                          Series   6

 [B] Entire series, effect on correlation (  .635) is:
       Lower   1788> -.008   2007> -.007   1794< -.007   1848< -.007   1862< -.007   1878< -.006  Higher   1988  .008   1954  .008

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1794 -4.5 SD;    1865 +3.1 SD;    1991 +3.5 SD
================================================================================================================================================

 PMT07     1822 to  2012     191 years                                                                                          Series   7

 [B] Entire series, effect on correlation (  .569) is:
       Lower   1918< -.028   1936> -.024   1854< -.016   1946< -.013   1888> -.011   1897< -.005  Higher   2007  .011   2012  .011

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1844 +3.6 SD;    1854 -5.7 SD;    1936 +3.4 SD
================================================================================================================================================

 PMT08     1900 to  2012     113 years                                                                                          Series   8

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1900 1949   -1    .05 -.06 -.05  .05 -.04 -.20  .07 -.06 -.20  .42* .40|-.02 -.05 -.03  .33 -.07 -.10 -.16 -.11  .01 -.16

 [B] Entire series, effect on correlation (  .513) is:
       Lower   1953> -.033   1925> -.026   1908> -.024   1912< -.013   1901> -.013   2006< -.012  Higher   1936  .053   1988  .022
     1900 to 1949 segment:
       Lower   1925> -.057   1908> -.053   1901> -.028   1913> -.025   1912< -.023   1907< -.021  Higher   1936  .182   1916  .034

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1925 +3.6 SD;    1953 +4.1 SD
================================================================================================================================================

 PMT09     1896 to  2012     117 years                                                                                          Series   9

 [B] Entire series, effect on correlation (  .488) is:
       Lower   1908> -.038   1907< -.022   1971< -.020   1902< -.017   1898> -.016   1972> -.014  Higher   1936  .045   1988  .022

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1971 1972   4.0 SD

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1908 +3.7 SD;    1971 -5.2 SD
================================================================================================================================================

 PMT10     1950 to  2012      63 years                                                                                          Series  10

 [B] Entire series, effect on correlation (  .690) is:
```

```
      Lower   1980< -.022   1993> -.018   1998< -.017   1972> -.016   1992> -.011   1971< -.009  Higher   1988  .039   2007  .022
================================================================================================================================================

 PMT11     1949 to  2012      64 years                                                                                          Series  11

 [B] Entire series, effect on correlation (  .528) is:
      Lower   1989> -.027   1986< -.026   1955> -.023   1999< -.021   2003> -.019   1980< -.014  Higher   1988  .043   1954  .027

 [E] Outliers     4   3.0 SD above or -4.5 SD below mean for year
      1955 +3.8 SD;    1966 -5.5 SD;    1989 +3.6 SD;    1990 +3.1 SD
================================================================================================================================================

 PMT12     1925 to  2012      88 years                                                                                          Series  12

 [B] Entire series, effect on correlation (  .687) is:
      Lower   1926> -.015   1925> -.014   1927< -.011   1950< -.009   2003> -.008   2009< -.008  Higher   1936  .033   2012  .017

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1926 +3.5 SD
================================================================================================================================================

 PMT13     1929 to  2012      84 years                                                                                          Series  13

 [B] Entire series, effect on correlation (  .592) is:
      Lower   1943< -.072   1946< -.020   2005< -.016   1934> -.012   1955> -.012   2000> -.010  Higher   1936  .044   1988  .026

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1955 +3.2 SD
================================================================================================================================================

 PMT14     1929 to  2012      84 years                                                                                          Series  14

 [B] Entire series, effect on correlation (  .651) is:
      Lower   2012> -.041   1986< -.015   1954> -.013   1983> -.013   1978< -.012   2011< -.012  Higher   1936  .046   2007  .021

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1935 +3.4 SD
================================================================================================================================================

 PMT20     1809 to  2012     204 years                                                                                          Series  15

 [B] Entire series, effect on correlation (  .641) is:
      Lower   1864> -.021   1852< -.007   1908> -.007   1866< -.007   1986< -.006   1904< -.006  Higher   1988  .013   2012  .007

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1864 +4.3 SD
================================================================================================================================================

 PMT21     1816 to  2012     197 years                                                                                          Series  16

 [B] Entire series, effect on correlation (  .670) is:
      Lower   1834> -.018   1921< -.014   1982< -.009   1951< -.008   1818> -.007   1868< -.007  Higher   1936  .017   1988  .012

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1818 +3.2 SD
================================================================================================================================================
```

```
PMT22     1868 to  2012     145 years                                                                                    Series  17

[B] Entire series, effect on correlation (  .616) is:
      Lower   1878< -.038   1881> -.025   1879> -.022   1869< -.017   1889< -.009   1868> -.009  Higher   1936  .026   2012  .020

[C] Year-to-year changes diverging by over 4.0 std deviations:
      1878 1879   4.3 SD

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1868 +3.2 SD;    1878 -5.0 SD;    1881 +3.8 SD
================================================================================================================================

PMT22b    1899 to  2012     114 years                                                                                    Series  18

[B] Entire series, effect on correlation (  .768) is:
      Lower   1988> -.017   1936> -.011   1901< -.008   1930> -.008   1981< -.007   2000> -.006  Higher   2012  .014   1954  .009

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

PMT23     1877 to  2012     136 years                                                                                    Series  19

[B] Entire series, effect on correlation (  .599) is:
      Lower   1926< -.015   1988> -.014   1925> -.014   1927< -.011   1917< -.010   2008< -.008  Higher   1895  .016   1936  .012

[D]    2 Absent rings:  Year   Master  N series Absent
                        1926   -1.034      18       1
                        1927     .201      18       1  >> WARNING:  Ring is not usually narrow

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

PMT26a    1860 to  2012     153 years                                                                                    Series  20

[B] Entire series, effect on correlation (  .627) is:
      Lower   1882< -.015   1944> -.013   1973< -.012   1908< -.012   1917< -.010   1945< -.008  Higher   2007  .013   1936  .012

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

PMT26b    1836 to  2012     177 years                                                                                    Series  21

[A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
   ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1836 1885    0    .21  .13  .05 -.05 -.34  .08 -.06 -.07 -.23  .25  .31*-.14 -.27  .04  .09 -.16 -.02 -.06 -.07  .05 -.16

[B] Entire series, effect on correlation (  .638) is:
      Lower   1856> -.023   1887< -.016   1879> -.013   1844< -.010   1872< -.008   1865< -.008  Higher   1888  .010   2007  .009
    1836 to 1885 segment:
      Lower   1856> -.075   1879> -.042   1844< -.037   1872< -.030   1865< -.030   1863> -.017  Higher   1839  .036   1874  .035

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1879 +3.3 SD;    1887 -4.7 SD
================================================================================================================================

PMT28     1811 to  2012     202 years                                                                                    Series  22

[B] Entire series, effect on correlation (  .621) is:
      Lower   1851> -.013   1873< -.012   1847< -.012   2007> -.010   1867< -.009   1925> -.009  Higher   2012  .017   1988  .010

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
```

1851 +4.0 SD;  1925 +3.0 SD;  2012 -4.7 SD

PART 7:  DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | PMT01 | 1717 2012 | 296 | 9 | 3 | .512 | 1.98 | 7.46 | 1.395 | .827 | .334 | 2.66 | .329 | -.026 | 1 |
| 2 | PMT02 | 1803 2012 | 210 | 8 | 0 | .553 | 2.12 | 10.32 | 1.491 | .766 | .295 | 2.72 | .404 | .004 | 1 |
| 3 | PMT03 | 1784 2012 | 229 | 9 | 2 | .530 | 2.14 | 6.62 | 1.027 | .654 | .349 | 2.67 | .347 | .023 | 1 |
| 4 | PMT04 | 1782 2012 | 231 | 9 | 1 | .592 | 1.63 | 6.37 | .888 | .816 | .262 | 2.74 | .467 | -.051 | 1 |
| 5 | PMT05 | 1794 2012 | 219 | 9 | 1 | .520 | 1.60 | 4.15 | .747 | .547 | .316 | 2.70 | .408 | -.037 | 1 |
| 6 | PMT06 | 1787 2012 | 226 | 9 | 0 | .635 | 1.99 | 4.64 | .796 | .531 | .314 | 2.62 | .404 | .013 | 3 |
| 7 | PMT07 | 1822 2012 | 191 | 8 | 0 | .569 | 1.34 | 4.00 | .780 | .679 | .345 | 2.90 | .437 | -.031 | 1 |
| 8 | PMT08 | 1900 2012 | 113 | 4 | 1 | .513 | 3.62 | 19.24 | 2.973 | .758 | .308 | 2.64 | .415 | -.022 | 2 |
| 9 | PMT09 | 1896 2012 | 117 | 5 | 0 | .488 | 3.21 | 6.33 | 1.273 | .459 | .347 | 2.67 | .542 | .027 | 2 |
| 10 | PMT10 | 1950 2012 | 63 | 2 | 0 | .690 | 5.99 | 15.37 | 3.438 | .778 | .361 | 2.57 | .467 | .065 | 1 |
| 11 | PMT11 | 1949 2012 | 64 | 3 | 0 | .528 | 4.95 | 14.89 | 3.011 | .723 | .415 | 2.66 | .435 | -.001 | 2 |
| 12 | PMT12 | 1925 2012 | 88 | 3 | 0 | .687 | 3.66 | 13.21 | 2.575 | .821 | .281 | 2.50 | .411 | -.043 | 1 |
| 13 | PMT13 | 1929 2012 | 84 | 3 | 0 | .592 | 3.72 | 8.64 | 1.651 | .671 | .304 | 2.69 | .496 | .027 | 1 |
| 14 | PMT14 | 1929 2012 | 84 | 3 | 0 | .651 | 4.32 | 9.12 | 1.789 | .543 | .309 | 2.60 | .462 | -.041 | 1 |
| 15 | PMT20 | 1809 2012 | 204 | 8 | 0 | .641 | 1.75 | 3.91 | .703 | .588 | .277 | 2.88 | .482 | .001 | 1 |
| 16 | PMT21 | 1816 2012 | 197 | 8 | 0 | .670 | 1.99 | 6.14 | 1.161 | .781 | .308 | 2.67 | .421 | .026 | 1 |
| 17 | PMT22 | 1868 2012 | 145 | 6 | 0 | .616 | 1.50 | 4.34 | .754 | .501 | .352 | 2.81 | .543 | -.025 | 1 |
| 18 | PMT22b | 1899 2012 | 114 | 5 | 0 | .768 | 1.93 | 5.95 | .804 | .283 | .361 | 2.92 | .529 | .056 | 1 |
| 19 | PMT23 | 1877 2012 | 136 | 5 | 0 | .599 | 1.86 | 4.95 | .823 | .558 | .323 | 2.76 | .545 | .049 | 1 |
| 20 | PMT26a | 1860 2012 | 153 | 6 | 0 | .627 | 1.08 | 4.72 | .825 | .787 | .307 | 2.57 | .404 | -.049 | 2 |
| 21 | PMT26b | 1836 2012 | 177 | 7 | 1 | .638 | 1.40 | 3.67 | .713 | .637 | .321 | 2.83 | .467 | .013 | 2 |
| 22 | PMT28 | 1811 2012 | 202 | 8 | 0 | .621 | 2.02 | 5.88 | 1.034 | .533 | .387 | 2.75 | .443 | -.036 | 2 |
| Total or mean: | | | 3543 | 137 | 9 | .595 | 2.17 | 19.24 | 1.190 | .654 | .323 | 2.92 | .436 | -.006 | |

# APPENDIX O

## COFECHA PROGRAM OUTPUT FOR DONALDSON WOODS SITE CHRONOLOGY, *QUERCUS ALBA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
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 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   dwa_dated.txt

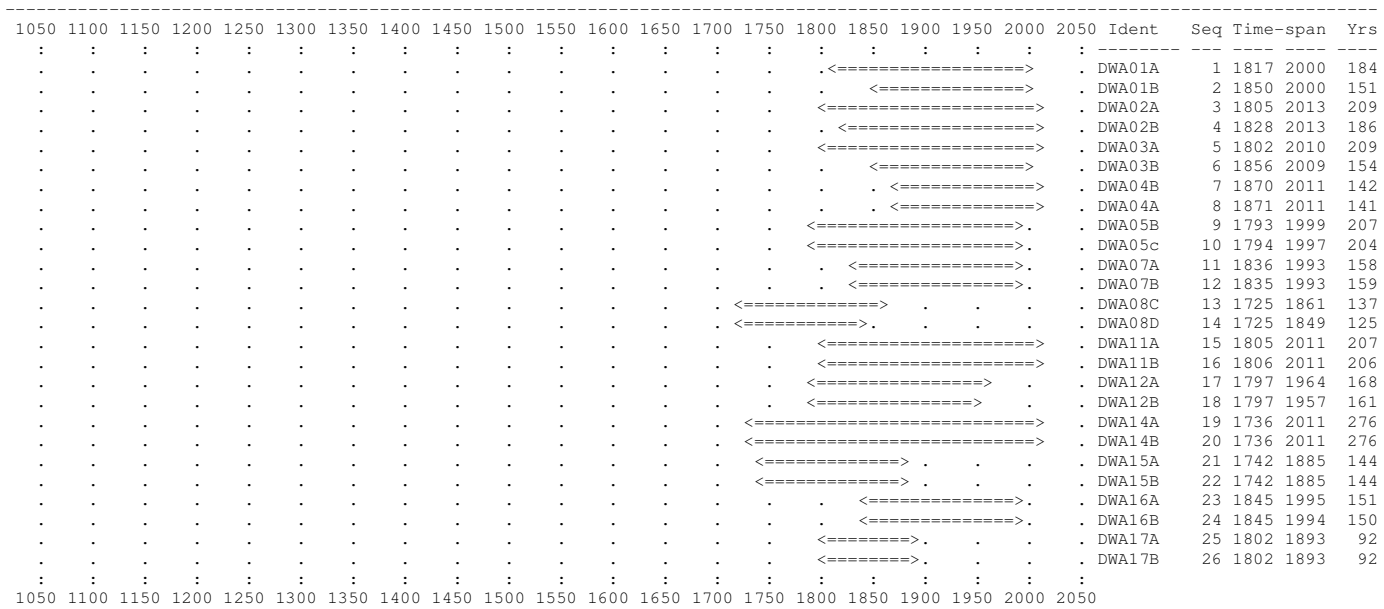
  Time span of Master dating series is  1725 to  2013   289 years
 Continuous time span is               1725 to  2013   289 years
 Portion with two or more series is    1725 to  2013   289 years


                                      ****************************************
                                      *C* Number of dated series        26 *C*
                                      *O* Master series 1725 2013  289 yrs *O*
                                      *F* Total rings in all series   4433 *F*
                                      *E* Total dated rings checked   4433 *E*
                                      *C* Series intercorrelation     .613 *C*
                                      *H* Average mean sensitivity    .213 *H*
                                      *A* Segments, possible problems   12 *A*
                                      *** Mean length of series      170.5 ***
                                      ****************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1750 | .745 | 6 | 1800 | -3.650 | 10 | 1850 | .357 | 22 | 1900 | .372 | 20 | 1950 | 1.889 | 20 |
| 1751 | .621 | 6 | 1801 | .548 | 10 | 1851 | -.350 | 22 | 1901 | -.011 | 20 | 1951 | .937 | 20 |
| 1752 | -.147 | 6 | 1802 | .860 | 13 | 1852 | -.285 | 22 | 1902 | .975 | 20 | 1952 | .162 | 20 |
| 1753 | -.323 | 6 | 1803 | .111 | 13 | 1853 | -.661 | 22 | 1903 | .386 | 20 | 1953 | -.578 | 20 |
| 1754 | .186 | 6 | 1804 | 1.394 | 13 | 1854 | -.413 | 22 | 1904 | -.171 | 20 | 1954 | -2.161 | 20 |
| 1755 | -2.038 | 6 | 1805 | .809 | 15 | 1855 | .066 | 22 | 1905 | -.529 | 20 | 1955 | -.087 | 20 |
| 1756 | 1.569 | 6 | 1806 | -.639 | 16 | 1856 | -2.368 | 23 | 1906 | -.700 | 20 | 1956 | -.950 | 20 |
| 1757 | -.783 | 6 | 1807 | -.002 | 16 | 1857 | .003 | 23 | 1907 | 1.358 | 20 | 1957 | 1.056 | 20 |
| 1758 | -.537 | 6 | 1808 | -.030 | 16 | 1858 | -1.017 | 23 | 1908 | .064 | 20 | 1958 | 1.358 | 19 |
| 1759 | 1.063 | 6 | 1809 | .027 | 16 | 1859 | -.431 | 23 | 1909 | .529 | 20 | 1959 | -.658 | 19 |
| 1760 | .109 | 6 | 1810 | .097 | 16 | 1860 | .617 | 23 | 1910 | .127 | 20 | 1960 | .764 | 19 |
| 1761 | .731 | 6 | 1811 | -.199 | 16 | 1861 | .745 | 23 | 1911 | -1.235 | 20 | 1961 | .195 | 19 |
| 1762 | -.806 | 6 | 1812 | .636 | 16 | 1862 | 1.214 | 22 | 1912 | 1.325 | 20 | 1962 | -.155 | 19 |
| 1763 | .579 | 6 | 1813 | -.171 | 16 | 1863 | .685 | 22 | 1913 | -1.504 | 20 | 1963 | -.302 | 19 |
| 1764 | .343 | 6 | 1814 | .296 | 16 | 1864 | -.511 | 22 | 1914 | -2.764 | 20 | 1964 | -.784 | 19 |
| 1765 | .250 | 6 | 1815 | -1.834 | 16 | 1865 | .389 | 22 | 1915 | 1.768 | 20 | 1965 | .632 | 18 |
| 1766 | 1.391 | 6 | 1816 | .096 | 16 | 1866 | .279 | 22 | 1916 | 1.365 | 20 | 1966 | -.106 | 18 |
| 1767 | -2.020 | 6 | 1817 | .308 | 17 | 1867 | .122 | 22 | 1917 | -.360 | 20 | 1967 | -.697 | 18 |
| 1768 | 1.018 | 6 | 1818 | 1.152 | 17 | 1868 | .021 | 22 | 1918 | -1.000 | 20 | 1968 | -.251 | 18 |
| 1769 | .310 | 6 | 1819 | .715 | 17 | 1869 | 1.752 | 22 | 1919 | -.082 | 20 | 1969 | -.391 | 18 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1770 | -1.489 | 6 | 1820 | -.269 | 17 | 1870 | -.419 | 23 | 1920 | .073 | 20 | 1970 | -1.185 | 18 |
| | | | 1771 | -2.768 | 6 | 1821 | -1.437 | 17 | 1871 | -1.192 | 24 | 1921 | -.316 | 20 | 1971 | -.175 | 18 |
| | | | 1772 | -.483 | 6 | 1822 | -2.033 | 17 | 1872 | 1.301 | 24 | 1922 | .459 | 20 | 1972 | -2.337 | 18 |
| | | | 1773 | -.480 | 6 | 1823 | -.091 | 17 | 1873 | .421 | 24 | 1923 | .166 | 20 | 1973 | 1.434 | 18 |
| | | | 1774 | -1.004 | 6 | 1824 | .471 | 17 | 1874 | -1.063 | 24 | 1924 | 1.175 | 20 | 1974 | 1.436 | 18 |
| 1725 | -2.087 | 2 | 1775 | .823 | 6 | 1825 | .114 | 17 | 1875 | -.091 | 24 | 1925 | -1.557 | 20 | 1975 | .262 | 18 |
| 1726 | -.112 | 2 | 1776 | 1.269 | 6 | 1826 | .369 | 17 | 1876 | .046 | 24 | 1926 | -.244 | 20 | 1976 | 1.294 | 18 |
| 1727 | -.702 | 2 | 1777 | -.483 | 6 | 1827 | -.495 | 17 | 1877 | -.507 | 24 | 1927 | .810 | 20 | 1977 | -.402 | 18 |
| 1728 | 1.936 | 2 | 1778 | 1.334 | 6 | 1828 | 1.285 | 18 | 1878 | -.474 | 24 | 1928 | 1.627 | 20 | 1978 | .700 | 18 |
| 1729 | 1.640 | 2 | 1779 | 1.445 | 6 | 1829 | -.270 | 18 | 1879 | -.832 | 24 | 1929 | .380 | 20 | 1979 | .224 | 18 |
| 1730 | .002 | 2 | 1780 | .134 | 6 | 1830 | 1.003 | 18 | 1880 | .415 | 24 | 1930 | -.731 | 20 | 1980 | -.004 | 18 |
| 1731 | .245 | 2 | 1781 | 1.265 | 6 | 1831 | .534 | 18 | 1881 | -.098 | 24 | 1931 | -.411 | 20 | 1981 | -.887 | 18 |
| 1732 | .626 | 2 | 1782 | .677 | 6 | 1832 | -1.221 | 18 | 1882 | .541 | 24 | 1932 | .960 | 20 | 1982 | 1.232 | 18 |
| 1733 | 1.229 | 2 | 1783 | -.945 | 6 | 1833 | -.167 | 18 | 1883 | .926 | 24 | 1933 | -1.234 | 20 | 1983 | -.167 | 18 |
| 1734 | 1.875 | 2 | 1784 | -1.669 | 6 | 1834 | -.001 | 18 | 1884 | .561 | 24 | 1934 | -.942 | 20 | 1984 | -.970 | 18 |
| 1735 | -.145 | 2 | 1785 | -1.218 | 6 | 1835 | .883 | 19 | 1885 | -.426 | 24 | 1935 | 1.570 | 20 | 1985 | .495 | 18 |
| 1736 | -1.332 | 4 | 1786 | -.352 | 6 | 1836 | .426 | 20 | 1886 | -1.225 | 22 | 1936 | -1.339 | 20 | 1986 | .031 | 18 |
| 1737 | .546 | 4 | 1787 | .351 | 6 | 1837 | .272 | 20 | 1887 | -1.900 | 22 | 1937 | -.633 | 20 | 1987 | .739 | 18 |
| 1738 | 1.096 | 4 | 1788 | 1.690 | 6 | 1838 | -.734 | 20 | 1888 | -1.223 | 22 | 1938 | 1.186 | 20 | 1988 | -2.842 | 18 |
| 1739 | .926 | 4 | 1789 | .256 | 6 | 1839 | -3.469 | 20 | 1889 | 1.126 | 22 | 1939 | .590 | 20 | 1989 | .777 | 18 |
| 1740 | .968 | 4 | 1790 | .942 | 6 | 1840 | .493 | 20 | 1890 | -.121 | 22 | 1940 | -1.418 | 20 | 1990 | .327 | 18 |
| 1741 | -2.823 | 4 | 1791 | -.186 | 6 | 1841 | -.388 | 20 | 1891 | .441 | 22 | 1941 | -1.003 | 20 | 1991 | -.802 | 18 |
| 1742 | -.873 | 6 | 1792 | .600 | 6 | 1842 | .724 | 20 | 1892 | .651 | 22 | 1942 | 1.035 | 20 | 1992 | 1.013 | 18 |
| 1743 | -1.635 | 6 | 1793 | .007 | 7 | 1843 | .815 | 20 | 1893 | -.056 | 22 | 1943 | .360 | 20 | 1993 | .121 | 18 |
| 1744 | -1.489 | 6 | 1794 | -1.055 | 8 | 1844 | .330 | 20 | 1894 | .298 | 20 | 1944 | -2.107 | 20 | 1994 | -.327 | 16 |
| 1745 | .503 | 6 | 1795 | -.320 | 8 | 1845 | .644 | 22 | 1895 | .222 | 20 | 1945 | 1.223 | 20 | 1995 | .013 | 15 |
| 1746 | -.281 | 6 | 1796 | -.647 | 8 | 1846 | -.209 | 22 | 1896 | .925 | 20 | 1946 | -.385 | 20 | 1996 | -1.002 | 14 |
| 1747 | .546 | 6 | 1797 | .981 | 10 | 1847 | .215 | 22 | 1897 | 1.400 | 20 | 1947 | .048 | 20 | 1997 | -.447 | 14 |
| 1748 | .951 | 6 | 1798 | .916 | 10 | 1848 | .004 | 22 | 1898 | -.946 | 20 | 1948 | .622 | 20 | 1998 | .384 | 13 |
| 1749 | .032 | 6 | 1799 | -.853 | 10 | 1849 | 1.414 | 22 | 1899 | -.467 | 20 | 1949 | .701 | 20 | 1999 | -.704 | 13 |
| 2000 | 1.123 | 12 | | | | | | | | | | | | | | | |
| 2001 | 1.402 | 10 | | | | | | | | | | | | | | | |
| 2002 | .837 | 10 | | | | | | | | | | | | | | | |
| 2003 | -.527 | 10 | | | | | | | | | | | | | | | |
| 2004 | .232 | 10 | | | | | | | | | | | | | | | |
| 2005 | 1.072 | 10 | | | | | | | | | | | | | | | |
| 2006 | 1.503 | 10 | | | | | | | | | | | | | | | |
| 2007 | -.554 | 10 | | | | | | | | | | | | | | | |
| 2008 | -.230 | 10 | | | | | | | | | | | | | | | |
| 2009 | -.047 | 10 | | | | | | | | | | | | | | | |
| 2010 | -.229 | 9 | | | | | | | | | | | | | | | |
| 2011 | -1.666 | 8 | | | | | | | | | | | | | | | |
| 2012 | -.936 | 2 | | | | | | | | | | | | | | | |
| 2013 | -1.482 | 2 | | | | | | | | | | | | | | | |

---

PART 4: Master Bar Plot:

---

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1750--------C | 1800o | 1850------A | 1900------A | 1950----------H | 2000---------D | |
| | 1751-------B | 1801-------B | 1851---a | 1901-----@ | 1951---------D | 2001----------F | |
| | 1752----a | 1802--------C | 1852---a | 1902---------D | 1952-----A | 2002--------C | |
| | 1753---a | 1803-----@ | 1853--c | 1903------B | 1953--b | 2003--b | |
| | 1754------A | 1804----------F | 1854---b | 1904----a | 1954i | 2004------A | |

```
                1755h           1805--------C   1855-----@       1905--b         1955----@       2005---------D
                1756----------F 1806--c         1856i           1906--c         1956-d          2006----------F
                1757--c         1807-----@      1857-----@      1907----------E 1957---------D  2007--b
                1758--b         1808----@       1858-d          1908-----@      1958----------E 2008----a
                1759---------D  1809-----@      1859---b        1909-------B    1959--c         2009----@
                1760-----@      1810-----@      1860-------B    1910-----A      1960--------C   2010----a
                1761--------C   1811----a        1861--------C   1911-e          1961------A     2011g
                1762--c         1812-------C    1862---------E  1912----------E 1962----a       2012-d
                1763-------B    1813----a       1863--------C   1913-f          1963---a        2013-f
                1764------A     1814------A     1864--b         1914k           1964--c
                1765------A     1815g           1865------B     1915----------G 1965-------C
                1766----------F 1816-----@      1866------A     1916----------E 1966----@
                1767h           1817------A     1867-----@      1917---a        1967--c
                1768---------D  1818---------E  1868-----@      1918-d          1968---a
                1769------A     1819--------C   1869----------G 1919----@       1969---b
                1770-f          1820---a        1870---b        1920-----@      1970-e
                1771k           1821-f          1871-e          1921---a        1971----a
                1772---b        1822h           1872----------E 1922-------B    1972i
                1773---b        1823----@       1873-------B    1923-----A      1973----------F
                1774-d          1824-------B    1874-d          1924---------E  1974----------F
  1725h         1775--------C   1825-----@      1875----@       1925f           1975------A
  1726----@     1776----------E 1826------A     1876-----@      1926---a        1976----------E
  1727--c       1777---b        1827---b        1877--b         1927--------C   1977---b
  1728----------H 1778----------E 1828----------E 1878---b        1928----------G 1978--------C
  1729----------G 1779----------F 1829---a        1879-c          1929------B     1979------A
  1730-----@    1780-----A      1830---------D  1880------B     1930--c         1980-----@
  1731------A   1781---------E  1831-------B    1881----@       1931---b        1981-d
  1732-------C  1782--------C   1832-e          1882-------B    1932----------D  1982----------E
  1733---------E 1783-d         1833----a       1883--------D   1933-e          1983----a
  1734----------G 1784g         1834-----@      1884-------B    1934-d          1984-d
  1735----a     1785-e          1835--------D   1885---b        1935----------F 1985-------B
  1736-e        1786---a        1836-------B    1886-e          1936-e          1986-----@
  1737-------B  1787------A     1837------A     1887h           1937--c         1987--------C
  1738---------D 1788----------G 1838--c         1888-e          1938---------E  1988k
  1739--------D 1789------A     1839n           1889---------E  1939-------B    1989--------C
  1740---------D 1790---------D  1840-------B    1890----@       1940-f          1990------A
  1741k         1791----a       1841---b        1891-------B    1941-d          1991--c
  1742-c        1792-------B    1842--------C   1892-------C    1942---------D  1992----------D
  1743g         1793-----@      1843--------C   1893----@       1943------A     1993-----@
  1744-f        1794-d          1844------A     1894------A     1944h           1994---a
  1745-------B  1795---a        1845-------C    1895------A     1945---------E  1995-----@
  1746---a      1796--c         1846----a       1896--------D   1946---b        1996-d
  1747-------B  1797---------D  1847------A     1897----------F 1947-----@      1997---b
  1748---------D 1798--------D   1848-----@      1898-d          1948-------B    1998------B
  1749-----@    1799-c          1849----------F 1899---b        1949--------C   1999--c
```

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1725 | 1750 | 1775 | 1800 | 1825 | 1850 | 1875 | 1900 | 1925 | 1950 | 1975 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1774 | 1799 | 1824 | 1849 | 1874 | 1899 | 1924 | 1949 | 1974 | 1999 | 2024 |
| 1 | DWA01A | 1817 2000 | | | .67 | .68 | .65 | .71 | .76 | .65 | .51 | .47 | |
| 2 | DWA01B | 1850 2000 | | | | | .67 | .70 | .75 | .70 | .43 | .41 | |
| 3 | DWA02A | 1805 2013 | | | .71 | .72 | .55 | .67 | .79 | .83 | .80 | .79 | |
| 4 | DWA02B | 1828 2013 | | | | | .51B | .26A | .51 | .69 | .77 | .81 | .81 |

```
   5 DWA03A   1802 2010                  .59  .44  .45  .70  .74  .66  .39  .30A
   6 DWA03B   1856 2009                       .70  .81  .86  .76  .61  .47
   7 DWA04B   1870 2011                       .33  .35  .64  .52  .50  .51
   8 DWA04A   1871 2011                       .26A .32A .65  .60  .65  .65
   9 DWA05B   1793 1999             .38  .43  .65  .68  .78  .80  .69  .56
  10 DWA05c   1794 1997             .63  .69  .82  .67  .74  .80  .56  .47
  11 DWA07A   1836 1993                  .56  .55  .37  .48  .56  .69
  12 DWA07B   1835 1993                  .60  .55  .40B .59  .71  .76
  13 DWA08C   1725 1861   .79  .80  .83  .73  .55
  14 DWA08D   1725 1849   .67  .63  .74  .32A
  15 DWA11A   1805 2011                  .54  .72  .72  .78  .82  .82  .80  .80
  16 DWA11B   1806 2011                  .65  .70  .62  .74  .82  .75  .74  .72
  17 DWA12A   1797 1964             .79  .79  .73  .77  .74  .80  .84
  18 DWA12B   1797 1957             .83  .83  .76  .81  .82  .83  .84
  19 DWA14A   1736 2011   .56  .57  .44  .59  .73  .63  .54  .65  .74  .70  .74
  20 DWA14B   1736 2011   .43  .30A .45  .40  .40  .51  .61  .74  .68  .73  .80
  21 DWA15A   1742 1885   .66  .72  .81  .81  .58  .59
  22 DWA15B   1742 1885   .62  .66  .76  .71  .50  .43
  23 DWA16A   1845 1995                       .44  .45  .37  .53  .75  .51
  24 DWA16B   1845 1994                  .24A .26A .33  .44  .63  .43
  25 DWA17A   1802 1893                  .55  .55  .31B
  26 DWA17B   1802 1893                  .51  .51  .28A
 Av segment correlation   .62  .61  .67  .62  .59  .53  .60  .71  .70  .62  .62

PART 6:  POTENTIAL PROBLEMS:
--------------------------------------------------------------------------------------------------------------------------------------------

 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

 [B] Effect of those data values which most lower or raise correlation with master series
     Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

 [C] Year-to-year changes very different from the mean change in other series

 [D] Absent rings (zero values)

 [E] Values which are statistical outliers from mean for the year
============================================================================================================================================

 DWA01A    1817 to  2000     184 years                                                                                    Series   1

 [B] Entire series, effect on correlation (  .633) is:
       Lower   1988> -.019   1862< -.014   2000< -.007   1962> -.006   1870> -.006   1958< -.006  Higher   1839  .025   1856  .017

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

 DWA01B    1850 to  2000     151 years                                                                                    Series   2

 [B] Entire series, effect on correlation (  .596) is:
       Lower   1988> -.036   1962< -.025   1865< -.016   1981> -.014   1949< -.011   1987< -.008  Higher   1972  .022   1856  .016

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1981 +3.2 SD
============================================================================================================================================
```

DWA02A  1805 to  2013  209 years  Series  3

[B] Entire series, effect on correlation (  .721) is:
Lower  1898> -.012  1820> -.009  1852< -.008  1856> -.007  1916< -.007  1866< -.006  Higher  1839  .033  1988  .009

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1820 +3.2 SD

---

DWA02B  1828 to  2013  186 years  Series  4

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1828 1877 | 7 | .25 | .00 | -.05 | .32 | -.02 | .10 | -.23 | -.20 | -.22 | -.33 | .51\|-.15 | -.07 | .13 | -.12 | .03 | -.08 | .51* | .08 | -.05 | .08 | |
| 1850 1899 | 0 | .16 | -.07 | .04 | .14 | -.05 | -.11 | -.29 | -.06 | -.07 | .04 | .26* | .09 | .05 | .25 | .03 | -.21 | -.15 | .11 | -.19 | -.05 | .00 |

[B] Entire series, effect on correlation (  .631) is:
Lower  1856> -.029  1884< -.015  1898> -.015  1889< -.012  1863< -.009  1942< -.008  Higher  1988  .037  1839  .012
1828 to 1877 segment:
Lower  1856> -.109  1863< -.034  1849< -.026  1848< -.026  1841> -.010  1838> -.009  Higher  1839  .115  1869  .024
1850 to 1899 segment:
Lower  1856> -.110  1884< -.062  1898> -.058  1889< -.051  1863< -.038  1897< -.020  Higher  1887  .047  1869  .047

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1856 +3.7 SD

---

DWA03A  1802 to  2010  209 years  Series  5

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961 2010 | 0 | -.01 | .11 | .01 | .05 | -.13 | .19 | .00 | -.08 | .05 | -.15 | .30* | .08 | -.16 | .09 | - | - | - | - | - | - | - |

[B] Entire series, effect on correlation (  .527) is:
Lower  1856> -.025  1959< -.015  1988> -.014  1829< -.014  2006< -.014  1831< -.011  Higher  1839  .033  1914  .019
1961 to 2010 segment:
Lower  2006< -.060  1987< -.033  2008< -.024  1970> -.023  1992< -.020  1981> -.019  Higher  1972  .129  1973  .033

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
1814 +3.6 SD;  1856 +3.7 SD

---

DWA03B  1856 to  2009  154 years  Series  6

[B] Entire series, effect on correlation (  .677) is:
Lower  2008< -.031  1996> -.015  1970> -.011  1989< -.009  1987< -.009  1977< -.007  Higher  1988  .030  1914  .016

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1996 +3.2 SD

---

DWA04B  1870 to  2011  142 years  Series  7

[B] Entire series, effect on correlation (  .505) is:
Lower  1972> -.042  1886> -.026  1879> -.021  1900< -.021  1887> -.012  1982< -.012  Higher  1988  .042  1944  .024

[E] Outliers  3  3.0 SD above or -4.5 SD below mean for year
1879 +4.5 SD;  1886 +3.6 SD;  1972 +4.2 SD

```
==========================================================================================================================================

 DWA04A    1871 to  2011     141 years                                                                                    Series   8

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1871 1920    0   -.12 -.33  .06 -.04 -.07  .18 -.08  .03  .00 -.11  .26*-.03 -.32  .10  .05  .04  .10 -.14 -.10 -.12 -.15
    1875 1924    0   -.21 -.29  .09  .02 -.11  .18 -.07  .02 -.01 -.09  .32*-.13 -.31  .11  .11  .05  .09 -.15 -.05 -.14 -.16

 [B] Entire series, effect on correlation (  .548) is:
       Lower   1886> -.028   1900< -.017   1962< -.015   1871> -.013   1887> -.012   1879> -.011  Higher   1988  .050   1954  .020
     1871 to 1920 segment:
       Lower   1886> -.075   1900< -.040   1871> -.036   1879> -.030   1882< -.029   1887> -.024  Higher   1913  .062   1915  .043
     1875 to 1924 segment:
       Lower   1886> -.081   1900< -.043   1879> -.033   1882< -.030   1887> -.028   1919< -.021  Higher   1913  .060   1915  .037

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1886 +3.8 SD
==========================================================================================================================================

 DWA05B    1793 to  1999     207 years                                                                                    Series   9

 [B] Entire series, effect on correlation (  .578) is:
       Lower   1815> -.020   1818< -.014   1800> -.013   1829> -.010   1795< -.010   1827> -.008  Higher   1839  .051   1972  .014

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1815 +3.2 SD;    1829 +3.3 SD
==========================================================================================================================================

 DWA05c    1794 to  1997     204 years                                                                                    Series  10

 [B] Entire series, effect on correlation (  .631) is:
       Lower   1960< -.018   1962> -.017   1800> -.015   1799> -.010   1981> -.008   1961< -.008  Higher   1839  .042   1972  .008

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1961 1962   4.2 SD

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1962 +4.5 SD
==========================================================================================================================================

 DWA07A    1836 to  1993     158 years                                                                                    Series  11

 [B] Entire series, effect on correlation (  .576) is:
       Lower   1959> -.017   1910< -.012   1911> -.011   1909< -.011   1937< -.008   1850< -.007  Higher   1988  .049   1856  .015

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1959 +3.6 SD
==========================================================================================================================================

 DWA07B    1835 to  1993     159 years                                                                                    Series  12

 [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   -.08 -.07 -.13  .10  .03  .09  .15  .07 -.31 -.11  .40|-.05 -.26  .12 -.13 -.05  .15  .11  .48* .11 -.09

 [B] Entire series, effect on correlation (  .630) is:
       Lower   1905< -.011   1882< -.010   1959> -.007   1886> -.007   1903< -.006   1934> -.006  Higher   1988  .028   1972  .020
```

```
    1875 to 1924 segment:
      Lower   1882< -.033   1905< -.022   1886> -.020   1903< -.019   1898> -.018   1888> -.016  Higher   1887  .049   1914  .037

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

 DWA08C    1725 to  1861     137 years                                                                                          Series  13

 [B] Entire series, effect on correlation (  .720) is:
      Lower   1853> -.013   1839> -.013   1744< -.010   1860< -.009   1844< -.007   1849< -.006  Higher   1800  .031   1741  .014

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

 DWA08D    1725 to  1849     125 years                                                                                          Series  14

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1800 1849    0   -.15 -.20 -.08  .04  .22  .05 -.09 -.29 -.07  .08  .32* .18 -.14 -.12 -.19  .20  .21  .15 -.14 -.17  .08

 [B] Entire series, effect on correlation (  .541) is:
      Lower   1839> -.140   1771> -.011   1840< -.009   1757> -.008   1760> -.008   1794> -.007  Higher   1741  .030   1800  .024
     1800 to 1849 segment:
      Lower   1839> -.333   1840< -.021   1809> -.009   1810< -.008   1847< -.007   1845< -.007  Higher   1800  .124   1815  .086

 [C] Year-to-year changes diverging by over 4.0 std deviations:
      1838 1839   5.0 SD    1839 1840  -5.4 SD

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1839 +7.3 SD
================================================================================================================================================

 DWA11A    1805 to  2011     207 years                                                                                          Series  15

 [B] Entire series, effect on correlation (  .718) is:
      Lower   1809< -.025   1815> -.016   1981< -.006   1868< -.006   1984> -.004   1864> -.004  Higher   1988  .026   1972  .011

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

 DWA11B    1806 to  2011     206 years                                                                                          Series  16

 [B] Entire series, effect on correlation (  .709) is:
      Lower   1868< -.013   1815> -.011   1972> -.011   1810> -.005   1861< -.005   1984> -.004  Higher   1988  .024   1839  .021

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

 DWA12A    1797 to  1964     168 years                                                                                          Series  17

 [B] Entire series, effect on correlation (  .778) is:
      Lower   1834< -.006   1905> -.006   1833< -.006   1817< -.005   1851< -.005   1835< -.005  Higher   1800  .022   1839  .009

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

 DWA12B    1797 to  1957     161 years                                                                                          Series  18

 [B] Entire series, effect on correlation (  .819) is:
      Lower   1833< -.009   1851< -.006   1806< -.005   1834< -.005   1866< -.004   1885< -.004  Higher   1800  .022   1856  .009

================================================================================================================================================
```

DWA14A  1736 to  2011  276 years  Series 19

[B] Entire series, effect on correlation (  .611) is:
Lower  1909< -.014  1743> -.009  1800> -.009  1767> -.008  1819< -.008  1815> -.007  Higher  1839  .032  1988  .020

---

DWA14B  1736 to  2011  276 years  Series 20

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1750 1799 | 0 | .09 | -.03 | -.29 | -.03 | -.04 | .05 | -.11 | .09 | .09 | .10 | .30* | .00 | -.29 | .00 | -.04 | -.26 | -.18 | .10 | -.14 | .13 | .15 |

[B] Entire series, effect on correlation (  .551) is:
Lower  1754< -.038  1815> -.024  1954> -.009  1828< -.006  1756< -.006  1840< -.006  Higher  1988  .029  1800  .019
1750 to 1799 segment:
Lower  1754< -.189  1756< -.019  1776< -.016  1765> -.015  1790< -.014  1752> -.009  Higher  1771  .038  1767  .038

[E] Outliers  2  3.0 SD above or -4.5 SD below mean for year
1754 -6.3 SD;  1815 +4.5 SD

---

DWA15A  1742 to  1885  144 years  Series 21

[B] Entire series, effect on correlation (  .664) is:
Lower  1865< -.046  1833< -.012  1822> -.009  1758< -.008  1743< -.007  1852> -.005  Higher  1839  .049  1800  .047

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1865 -4.6 SD

---

DWA15B  1742 to  1885  144 years  Series 22

[B] Entire series, effect on correlation (  .611) is:
Lower  1754> -.015  1837< -.010  1808< -.010  1851> -.010  1863< -.009  1854> -.008  Higher  1800  .046  1839  .014

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1754 +3.4 SD

---

DWA16A  1845 to  1995  151 years  Series 23

[B] Entire series, effect on correlation (  .501) is:
Lower  1988> -.049  1923< -.046  1882< -.027  1990< -.011  1959> -.011  1886> -.009  Higher  1972  .032  1954  .014

[E] Outliers  1  3.0 SD above or -4.5 SD below mean for year
1988 +4.1 SD

---

DWA16B  1845 to  1994  150 years  Series 24

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1845 1894 | 0 | -.27 | -.07 | .18 | .00 | -.11 | .15 | -.07 | .05 | -.06 | .10 | .24* | .09 | -.21 | .08 | -.03 | .16 | .13 | -.02 | -.02 | -.13 | -.17 |
| 1850 1899 | 0 | -.23 | -.13 | .17 | -.04 | -.12 | .12 | -.09 | .02 | -.11 | .10 | .26* | .09 | -.22 | .05 | -.04 | .19 | .17 | .15 | .03 | -.16 | -.19 |

[B] Entire series, effect on correlation (  .364) is:
Lower  1882< -.047  1990< -.017  1856> -.016  1923< -.014  1851< -.014  1855< -.011  Higher  1972  .030  1954  .016

```
     1845 to 1894 segment:
       Lower   1882< -.113   1856> -.058   1855< -.024   1886> -.014   1871> -.013   1854> -.012  Higher   1887  .054   1869  .039
     1850 to 1899 segment:
       Lower   1882< -.112   1856> -.061   1855< -.024   1886> -.015   1871> -.014   1851< -.014  Higher   1887  .049   1869  .039

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1882 -4.7 SD
================================================================================================================================================

 DWA17A    1802 to  1893      92 years                                                                                          Series  25

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1844 1893   -2   -.13  .00 -.01 -.18 -.09 -.04 -.20  .24  .32*-.06  .31| .02 -.08 -.01  .06  .08 -.04 -.21  .10 -.04  .02

 [B] Entire series, effect on correlation (  .458) is:
       Lower   1885> -.025   1804< -.024   1838> -.019   1873< -.017   1887> -.015   1869< -.013  Higher   1839  .126   1856  .037
     1844 to 1893 segment:
       Lower   1885> -.048   1873< -.030   1887> -.029   1869< -.024   1851> -.018   1880< -.011  Higher   1856  .114   1872  .038

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1885 +3.9 SD
================================================================================================================================================

 DWA17B    1802 to  1893      92 years                                                                                          Series  26

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1844 1893    0    .02 -.01 -.05 -.19 -.17 -.04 -.16  .26  .22  .05  .28*-.16  .05 -.10  .10  .15 -.13 -.03  .14 -.09  .16

 [B] Entire series, effect on correlation (  .437) is:
       Lower   1869< -.032   1803< -.024   1885> -.023   1827< -.017   1849< -.014   1838> -.014  Higher   1839  .120   1856  .023
     1844 to 1893 segment:
       Lower   1869< -.069   1885> -.048   1849< -.030   1848< -.016   1854< -.015   1887> -.013  Higher   1856  .086   1872  .036

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1885 +3.9 SD
================================================================================================================================================
PART 7:  DESCRIPTIVE STATISTICS:
------------------------------------------------------------------------------------------------------------------------------------------------

                                                Corr   //-------- Unfiltered --------\\  //---- Filtered -----\\
                          No.    No.    No.     with   Mean    Max     Std    Auto   Mean   Max     Std    Auto  AR
 Seq Series   Interval   Years  Segmt  Flags   Master  msmt    msmt     dev    corr   sens  value    dev    corr  ()
 --- -------- ---------  -----  -----  -----   ------ -----   -----   -----  -----  -----  -----  -----  -----  --
   1 DWA01A   1817 2000    184      8      0    .633   1.64    4.27    .536   .556   .231   2.72   .418   .016   1
   2 DWA01B   1850 2000    151      6      0    .596   1.70    4.42    .724   .639   .285   2.70   .517   .030   1
   3 DWA02A   1805 2013    209      8      0    .721   1.59    2.79    .388   .360   .215   2.58   .363   .004   1
   4 DWA02B   1828 2013    186      7      2    .631   1.58    2.88    .413   .404   .226   2.50   .333  -.013   1
   5 DWA03A   1802 2010    209      8      1    .527   1.52    3.32    .591   .831   .183   2.72   .415  -.037   2
   6 DWA03B   1856 2009    154      6      0    .677   1.71    2.43    .308   .194   .185   2.61   .496   .087   1
   7 DWA04B   1870 2011    142      6      0    .505   1.62    3.63    .727   .821   .231   2.84   .521  -.007   2
   8 DWA04A   1871 2011    141      6      2    .548   1.71    3.42    .784   .838   .229   2.62   .442   .021   2
   9 DWA05B   1793 1999    207      8      0    .578   1.36    3.02    .454   .728   .190   2.52   .325   .024   1
  10 DWA05c   1794 1997    204      8      0    .631   1.37    3.15    .480   .680   .207   2.80   .369   .042   2
  11 DWA07A   1836 1993    158      6      0    .576   1.29    2.81    .550   .875   .175   2.79   .407  -.005   1
  12 DWA07B   1835 1993    159      6      1    .630   1.37    2.68    .500   .832   .171   2.71   .510  -.047   1
  13 DWA08C   1725 1861    137      5      0    .720   1.24    3.24    .527   .736   .241   2.42   .326   .022   1
```

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | DWA08D | 1725 | 1849 | 125 | 4 | 1 | .541 | 1.27 | 4.31 | .601 | .748 | .225 | 2.75 | .391 | -.009 | 1 |
| 15 | DWA11A | 1805 | 2011 | 207 | 8 | 0 | .718 | 1.30 | 2.70 | .507 | .697 | .252 | 2.52 | .394 | -.033 | 1 |
| 16 | DWA11B | 1806 | 2011 | 206 | 8 | 0 | .709 | 1.29 | 3.01 | .490 | .660 | .244 | 2.58 | .365 | -.024 | 1 |
| 17 | DWA12A | 1797 | 1964 | 168 | 7 | 0 | .778 | 1.58 | 3.25 | .490 | .583 | .216 | 2.60 | .467 | -.011 | 2 |
| 18 | DWA12B | 1797 | 1957 | 161 | 7 | 0 | .819 | 1.58 | 3.26 | .504 | .577 | .222 | 2.64 | .455 | -.022 | 1 |
| 19 | DWA14A | 1736 | 2011 | 276 | 11 | 0 | .611 | 1.19 | 2.61 | .452 | .804 | .193 | 2.49 | .289 | -.007 | 1 |
| 20 | DWA14B | 1736 | 2011 | 276 | 11 | 1 | .551 | 1.17 | 2.82 | .495 | .855 | .170 | 2.63 | .311 | .005 | 1 |
| 21 | DWA15A | 1742 | 1885 | 144 | 6 | 0 | .664 | 1.08 | 2.86 | .408 | .764 | .203 | 2.64 | .437 | .010 | 1 |
| 22 | DWA15B | 1742 | 1885 | 144 | 6 | 0 | .611 | 1.08 | 2.77 | .415 | .742 | .238 | 2.56 | .367 | .034 | 1 |
| 23 | DWA16A | 1845 | 1995 | 151 | 6 | 0 | .501 | 1.94 | 3.43 | .573 | .662 | .179 | 2.69 | .423 | .003 | 1 |
| 24 | DWA16B | 1845 | 1994 | 150 | 6 | 2 | .364 | 1.98 | 3.69 | .560 | .613 | .193 | 2.61 | .450 | -.009 | 5 |
| 25 | DWA17A | 1802 | 1893 | 92 | 3 | 1 | .458 | .67 | 2.51 | .442 | .811 | .281 | 2.78 | .499 | -.055 | 1 |
| 26 | DWA17B | 1802 | 1893 | 92 | 3 | 1 | .437 | .71 | 2.90 | .482 | .843 | .265 | 2.79 | .532 | -.086 | 1 |
| Total or mean: | | | | 4433 | 174 | 12 | .613 | 1.42 | 4.42 | .510 | .684 | .213 | 2.84 | .404 | -.001 | |

# APPENDIX P

## COFECHA PROGRAM OUTPUT FOR PIONEER MOTHERS SITE CHRONOLOGY, *QUERCUS RUBRA*, INDIANA, U.S.A.

```
P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
------------------------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   dwr_dated.txt

 Time span of Master dating series is  1827 to  2013   187 years
 Continuous time span is               1827 to  2013   187 years
 Portion with two or more series is    1827 to  2013   187 years


                                    ***************************************
                                    *C* Number of dated series        14 *C*
                                    *O* Master series 1827 2013  187 yrs *O*
                                    *F* Total rings in all series   1914 *F*
                                    *E* Total dated rings checked   1914 *E*
                                    *C* Series intercorrelation     .607 *C*
                                    *H* Average mean sensitivity    .193 *H*
                                    *A* Segments, possible problems    0 *A*
                                    *** Mean length of series      136.7 ***
                                    ***************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:

```
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050 Ident    Seq Time-span  Yrs
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>   . DWR01A     1 1949 2013   65
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <==============>   . DWR01B     2 1878 2013  136
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <=============>   . DWR03A     3 1880 2013  134
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>.    . DWR03B     4 1852 1999  148
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <=======>    . DWR04A     5 1924 2003   80
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <============>    . DWR04B     6 1872 2000  129
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <=============>   . DWE05A     7 1880 2013  134
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <==============>   . DWR05B     8 1878 2013  136
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>    . DWR06A     9 1855 2001  147
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>    . DWR06B    10 1855 2001  147
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===============> .    . DWR07A    11 1828 1986  159
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===============> .    . DWR07A    12 1828 1986  159
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <================>.    . DWR08A    13 1827 1996  170
  .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <================>.    . DWR08B    14 1827 1996  170
  :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 1650 1700 1750 1800 1850 1900 1950 2000 2050
```

PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1850 | -.942 | 4 | 1900 | -1.723 | 12 | 1950 | 1.617 | 14 | 2000 | -.329 | 9 | | | |
| | | | 1851 | -.686 | 4 | 1901 | -1.289 | 12 | 1951 | 1.253 | 14 | 2001 | 1.208 | 8 | | | |
| | | | 1852 | -.136 | 5 | 1902 | -.301 | 12 | 1952 | -.149 | 14 | 2002 | .899 | 6 | | | |
| | | | 1853 | -.577 | 5 | 1903 | -.789 | 12 | 1953 | -1.289 | 14 | 2003 | .686 | 6 | | | |
| | | | 1854 | -.539 | 5 | 1904 | -.591 | 12 | 1954 | -2.266 | 14 | 2004 | .271 | 5 | | | |
| | | | 1855 | -.880 | 7 | 1905 | .497 | 12 | 1955 | -1.174 | 14 | 2005 | -1.603 | 5 | | | |
| | | | 1856 | -.849 | 7 | 1906 | .373 | 12 | 1956 | -1.252 | 14 | 2006 | -.377 | 5 | | | |
| | | | 1857 | .368 | 7 | 1907 | 1.568 | 12 | 1957 | .909 | 14 | 2007 | .210 | 5 | | | |
| | | | 1858 | -.418 | 7 | 1908 | -.419 | 12 | 1958 | .531 | 14 | 2008 | .979 | 5 | | | |
| | | | 1859 | .452 | 7 | 1909 | 1.362 | 12 | 1959 | .810 | 14 | 2009 | .151 | 5 | | | |
| | | | 1860 | -.020 | 7 | 1910 | .572 | 12 | 1960 | 1.091 | 14 | 2010 | -.066 | 5 | | | |
| | | | 1861 | -.487 | 7 | 1911 | -1.047 | 12 | 1961 | .314 | 14 | 2011 | .660 | 5 | | | |
| | | | 1862 | 1.536 | 7 | 1912 | 1.345 | 12 | 1962 | .332 | 14 | 2012 | -.556 | 5 | | | |
| | | | 1863 | -.189 | 7 | 1913 | -1.550 | 12 | 1963 | .743 | 14 | 2013 | -.616 | 5 | | | |
| | | | 1864 | -1.468 | 7 | 1914 | -2.395 | 12 | 1964 | .635 | 14 | | | | | | |
| | | | 1865 | .761 | 7 | 1915 | 1.830 | 12 | 1965 | .459 | 14 | | | | | | |
| | | | 1866 | 1.256 | 7 | 1916 | 1.419 | 12 | 1966 | -.923 | 14 | | | | | | |
| | | | 1867 | -.202 | 7 | 1917 | -.176 | 12 | 1967 | -1.521 | 14 | | | | | | |
| | | | 1868 | -.404 | 7 | 1918 | -.342 | 12 | 1968 | -.242 | 14 | | | | | | |
| | | | 1869 | 1.291 | 7 | 1919 | .471 | 12 | 1969 | -.079 | 14 | | | | | | |
| | | | 1870 | -.965 | 7 | 1920 | .678 | 12 | 1970 | -1.037 | 14 | | | | | | |
| | | | 1871 | -1.138 | 7 | 1921 | .526 | 12 | 1971 | -.289 | 14 | | | | | | |
| | | | 1872 | .392 | 8 | 1922 | .493 | 12 | 1972 | -1.774 | 14 | | | | | | |
| | | | 1873 | .773 | 8 | 1923 | .105 | 12 | 1973 | 1.232 | 14 | | | | | | |
| | | | 1874 | -1.319 | 8 | 1924 | 1.297 | 13 | 1974 | 1.982 | 14 | | | | | | |
| | | | 1875 | .634 | 8 | 1925 | -1.127 | 13 | 1975 | .291 | 14 | | | | | | |
| | | | 1876 | .831 | 8 | 1926 | -.472 | 13 | 1976 | .611 | 14 | | | | | | |
| 1827 | 1.898 | 2 | 1877 | .861 | 8 | 1927 | -.350 | 13 | 1977 | -.520 | 14 | | | | | | |
| 1828 | -.477 | 4 | 1878 | .397 | 10 | 1928 | .951 | 13 | 1978 | -.434 | 14 | | | | | | |
| 1829 | .095 | 4 | 1879 | -.718 | 10 | 1929 | .327 | 13 | 1979 | .233 | 14 | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1830 | .246 | 4 | 1880 | -.269 | 12 | 1930 | -1.035 | 13 | 1980 | -.098 | 14 |
| 1831 | -.045 | 4 | 1881 | .642 | 12 | 1931 | -.365 | 13 | 1981 | -1.037 | 14 |
| 1832 | -2.101 | 4 | 1882 | -1.598 | 12 | 1932 | .858 | 13 | 1982 | 1.288 | 14 |
| 1833 | .448 | 4 | 1883 | .382 | 12 | 1933 | -1.554 | 13 | 1983 | .735 | 14 |
| 1834 | 1.041 | 4 | 1884 | .633 | 12 | 1934 | -1.563 | 13 | 1984 | -1.126 | 14 |
| 1835 | 1.090 | 4 | 1885 | -.448 | 12 | 1935 | .399 | 13 | 1985 | -.203 | 14 |
| 1836 | .699 | 4 | 1886 | .021 | 12 | 1936 | -1.990 | 13 | 1986 | .357 | 14 |
| 1837 | .466 | 4 | 1887 | -1.188 | 12 | 1937 | -.760 | 13 | 1987 | 1.203 | 12 |
| 1838 | -.469 | 4 | 1888 | -.918 | 12 | 1938 | 1.140 | 13 | 1988 | -2.224 | 12 |
| 1839 | -3.636 | 4 | 1889 | 1.231 | 12 | 1939 | 1.083 | 13 | 1989 | -.460 | 12 |
| 1840 | .458 | 4 | 1890 | .029 | 12 | 1940 | -1.110 | 13 | 1990 | -.009 | 12 |
| 1841 | -1.011 | 4 | 1891 | .545 | 12 | 1941 | -.135 | 13 | 1991 | .148 | 12 |
| 1842 | -.331 | 4 | 1892 | 1.022 | 12 | 1942 | 1.447 | 13 | 1992 | .632 | 12 |
| 1843 | -1.153 | 4 | 1893 | -.122 | 12 | 1943 | .726 | 13 | 1993 | .161 | 12 |
| 1844 | .272 | 4 | 1894 | .272 | 12 | 1944 | -1.830 | 13 | 1994 | .004 | 12 |
| 1845 | 1.423 | 4 | 1895 | .433 | 12 | 1945 | .157 | 13 | 1995 | .404 | 12 |
| 1846 | .611 | 4 | 1896 | 1.350 | 12 | 1946 | -.554 | 13 | 1996 | -.360 | 12 |
| 1847 | -.249 | 4 | 1897 | .869 | 12 | 1947 | .257 | 13 | 1997 | -1.191 | 10 |
| 1848 | 2.552 | 4 | 1898 | -1.283 | 12 | 1948 | .930 | 13 | 1998 | -.898 | 10 |
| 1849 | 2.410 | 4 | 1899 | -.826 | 12 | 1949 | .755 | 14 | 1999 | .330 | 10 |

---

PART 4: Master Bar Plot:

---

| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1850--d | 1900g | 1950----------F | 2000---a | | | |
| | 1851--c | 1901-e | 1951----------E | 2001----------E | | | |
| | 1852----a | 1902----a | 1952----a | 2002--------D | | | |
| | 1853---b | 1903--c | 1953-e | 2003--------C | | | |
| | 1854---b | 1904---b | 1954i | 2004------A | | | |
| | 1855--d | 1905-------B | 1955-e | 2005f | | | |
| | 1856--c | 1906------A | 1956-e | 2006---b | | | |
| | 1857------A | 1907----------F | 1957--------D | 2007-----A | | | |
| | 1858---b | 1908---b | 1958-------B | 2008----------D | | | |
| | 1859-------B | 1909----------E | 1959--------C | 2009-----A | | | |
| | 1860-----@ | 1910-------B | 1960---------D | 2010----@ | | | |
| | 1861---b | 1911-d | 1961------A | 2011--------C | | | |
| | 1862----------F | 1912----------E | 1962------A | 2012---b | | | |
| | 1863----a | 1913f | 1963--------C | 2013--b | | | |
| | 1864f | 1914j | 1964--------C | | | | |
| | 1865--------C | 1915----------G | 1965-------B | | | | |
| | 1866---------E | 1916----------F | 1966--d | | | | |
| | 1867----a | 1917----a | 1967f | | | | |
| | 1868---b | 1918---a | 1968----a | | | | |
| | 1869----------E | 1919-------B | 1969----@ | | | | |
| | 1870-d | 1920--------C | 1970-d | | | | |
| | 1871-e | 1921-------B | 1971----a | | | | |
| | 1872------B | 1922-------B | 1972g | | | | |
| | 1873--------C | 1923-----@ | 1973---------E | | | | |
| | 1874-e | 1924----------E | 1974----------H | | | | |
| | 1875--------C | 1925-e | 1975------A | | | | |
| | 1876--------C | 1926---b | 1976-------B | | | | |
| 1827----------H | 1877--------C | 1927---a | 1977---b | | | | |
| 1828---b | 1878------B | 1928---------D | 1978---b | | | | |
| 1829-----@ | 1879--c | 1929------A | 1979------A | | | | |
| 1830------A | 1880----a | 1930-d | 1980----@ | | | | |
| 1831-----@ | 1881--------C | 1931---a | 1981-d | | | | |
| 1832h | 1882f | 1932--------C | 1982----------E | | | | |

```
   1833-------B    1883------B     1933f           1983--------C
   1834---------D  1884-------C    1934f           1984-e
   1835---------D  1885---b        1935------B     1985----a
   1836--------C   1886-----@      1936h           1986------A
   1837-------B    1887-e          1937--c         1987---------E
   1838---b        1888--d         1938---------E  1988i
   1839o           1889---------E  1939---------D  1989---b
   1840-------B    1890-----@      1940-d          1990-----@
   1841-d          1891-------B    1941----a       1991-----A
   1842---a        1892---------D  1942----------F 1992-------C
   1843-e          1893----@       1943--------C   1993-----A
   1844------A     1894------A     1944g           1994-----@
   1845----------F 1895------B     1945-----A      1995------B
   1846-------B    1896----------E 1946---b        1996---a
   1847----a       1897--------C   1947------A     1997-e
   1848----------J 1898-e          1948---------D  1998--d
   1849----------J 1899--c         1949--------C   1999------A
```

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1825 1874 | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | DWR01A | 1949 2013 | | | | | .68 | .68 | .68 |
| 2 | DWR01B | 1878 2013 | | | .66 | .80 | .65 | .43 | .42 |
| 3 | DWR03A | 1880 2013 | | | .63 | .81 | .74 | .74 | .58 |
| 4 | DWR03B | 1852 1999 | | .37 | .67 | .82 | .66 | .39 | |
| 5 | DWR04A | 1924 2003 | | | | .67 | .67 | .53 | .53 |
| 6 | DWR04B | 1872 2000 | | .45 | .63 | .73 | .75 | .57 | .55 |
| 7 | DWE05A | 1880 2013 | | | .69 | .71 | .69 | .70 | .62 |
| 8 | DWR05B | 1878 2013 | | | .64 | .63 | .65 | .65 | .53 |
| 9 | DWR06A | 1855 2001 | | .41 | .71 | .78 | .75 | .68 | .61 |
| 10 | DWR06B | 1855 2001 | | .43 | .66 | .78 | .75 | .70 | .67 |
| 11 | DWR07A | 1828 1986 | .65 | .40 | .55 | .79 | .79 | .68 | |
| 12 | DWR07A | 1828 1986 | .52 | .34 | .39 | .75 | .80 | .65 | |
| 13 | DWR08A | 1827 1996 | .68 | .70 | .66 | .61 | .76 | .65 | |
| 14 | DWR08B | 1827 1996 | .57 | .60 | .62 | .56 | .68 | .56 | |
| Av segment correlation | | | .60 | .46 | .63 | .73 | .72 | .62 | .58 |

PART 6: POTENTIAL PROBLEMS: 19:21 Wed 27 May 2015 Page 5

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

[B] Effect of those data values which most lower or raise correlation with master series
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

```
 [E] Values which are statistical outliers from mean for the year
=================================================================================================================================

 DWR01A    1949 to  2013      65 years                                                                              Series   1

 [B] Entire series, effect on correlation (  .671) is:
      Lower   1972> -.019   1970> -.012   1996< -.012   1977> -.009   1969> -.009   1990> -.008  Higher   1988  .080   1967  .011

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

 DWR01B    1878 to  2013     136 years                                                                              Series   2

 [B] Entire series, effect on correlation (  .581) is:
      Lower   1958< -.037   1993< -.036   1889< -.027   2012> -.024   1984> -.015   1987< -.009  Higher   1988  .027   1913  .019

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      2012 +3.5 SD
=================================================================================================================================

 DWR03A    1880 to  2013     134 years                                                                              Series   3

 [B] Entire series, effect on correlation (  .661) is:
      Lower   2005> -.040   1900> -.014   1888> -.013   1966> -.011   2006> -.010   1893< -.009  Higher   1988  .028   1913  .015

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1964 +3.3 SD;    2005 +3.8 SD;    2006 +3.6 SD
=================================================================================================================================

 DWR03B    1852 to  1999     148 years                                                                              Series   4

 [B] Entire series, effect on correlation (  .517) is:
      Lower   1988> -.032   1972> -.016   1853< -.015   1998< -.012   1877< -.010   1966> -.007  Higher   1936  .021   1954  .019

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1964 +3.3 SD
=================================================================================================================================

 DWR04A    1924 to  2003      80 years                                                                              Series   5

 [B] Entire series, effect on correlation (  .632) is:
      Lower   1983< -.030   1972> -.023   1925> -.021   1966< -.011   1935< -.010   1967> -.009  Higher   1944  .025   1936  .023

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1987 +3.0 SD
=================================================================================================================================

 DWR04B    1872 to  2000     129 years                                                                              Series   6

 [B] Entire series, effect on correlation (  .563) is:
      Lower   1872< -.060   1996> -.020   1928< -.010   1874> -.008   1991> -.007   1901> -.007  Higher   1936  .022   1944  .018

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1872 -4.7 SD;    1991 +3.3 SD;    1996 +3.8 SD
=================================================================================================================================

 DWE05A    1880 to  2013     134 years                                                                              Series   7

 [B] Entire series, effect on correlation (  .652) is:
```

```
      Lower   1885< -.011   1957< -.008   2006< -.007   1888> -.007   2007> -.007   1941< -.007  Higher   1988  .023   1913  .008
================================================================================================================================================

 DWR05B    1878 to  2013     136 years                                                                                          Series   8

 [B] Entire series, effect on correlation (  .598) is:
      Lower   1998> -.015   2008< -.012   1948< -.012   1903> -.011   1940> -.007   1878< -.007  Higher   1988  .035   1913  .013

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1998 +3.3 SD
================================================================================================================================================

 DWR06A    1855 to  2001     147 years                                                                                          Series   9

 [B] Entire series, effect on correlation (  .614) is:
      Lower   1856> -.031   2001< -.017   1859< -.010   1883< -.010   1926< -.009   1993> -.009  Higher   1988  .029   1914  .010

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1856 +3.3 SD;    1993 +3.0 SD
================================================================================================================================================

 DWR06B    1855 to  2001     147 years                                                                                          Series  10

 [B] Entire series, effect on correlation (  .623) is:
      Lower   1855< -.032   1856> -.021   1884< -.010   1993> -.007   1914> -.007   1997< -.006  Higher   1988  .032   1972  .009

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

 DWR07A    1828 to  1986     159 years                                                                                          Series  11

 [B] Entire series, effect on correlation (  .640) is:
      Lower   1882> -.021   1856< -.012   1899> -.009   1895< -.008   1870> -.008   1962< -.008  Higher   1839  .039   1848  .010

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1882 +3.1 SD
================================================================================================================================================

 DWR07A    1828 to  1986     159 years                                                                                          Series  12

 [B] Entire series, effect on correlation (  .554) is:
      Lower   1895< -.019   1836< -.019   1856< -.017   1886< -.014   1828> -.014   1855> -.014  Higher   1839  .012   1848  .012

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

 DWR08A    1827 to  1996     170 years                                                                                          Series  13

 [B] Entire series, effect on correlation (  .662) is:
      Lower   1923< -.024   1828< -.020   1988> -.018   1900> -.011   1855> -.008   1853> -.005  Higher   1839  .033   1954  .008

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

 DWR08B    1827 to  1996     170 years                                                                                          Series  14

 [B] Entire series, effect on correlation (  .573) is:
      Lower   1923< -.035   1988> -.013   1836> -.011   1850> -.009   1900> -.008   1994< -.007  Higher   1972  .007   1915  .007

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
```

[*] All segments correlate highest as dated with correlation with master series over .3281



| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DWR01A | 1949 2013 | 65 | 3 | 0 | .671 | 3.09 | 5.78 | .937 | .687 | .197 | 2.57 | .399 | -.029 | 3 |
| 2 | DWR01B | 1878 2013 | 136 | 5 | 0 | .581 | 2.03 | 3.84 | .706 | .755 | .200 | 2.72 | .538 | -.040 | 2 |
| 3 | DWR03A | 1880 2013 | 134 | 5 | 0 | .661 | 2.46 | 4.90 | .636 | .542 | .176 | 2.77 | .465 | .000 | 2 |
| 4 | DWR03B | 1852 1999 | 148 | 5 | 0 | .517 | 2.01 | 4.09 | .709 | .797 | .166 | 2.74 | .446 | .000 | 1 |
| 5 | DWR04A | 1924 2003 | 80 | 4 | 0 | .632 | 2.49 | 4.46 | .909 | .790 | .188 | 2.95 | .572 | -.005 | 1 |
| 6 | DWR04B | 1872 2000 | 129 | 6 | 0 | .563 | 1.93 | 4.42 | .953 | .833 | .228 | 2.75 | .522 | .006 | 1 |
| 7 | DWE05A | 1880 2013 | 134 | 5 | 0 | .652 | 2.07 | 4.77 | .471 | .460 | .172 | 2.63 | .414 | -.004 | 1 |
| 8 | DWR05B | 1878 2013 | 136 | 5 | 0 | .598 | 2.30 | 5.46 | .801 | .770 | .180 | 2.67 | .435 | -.015 | 1 |
| 9 | DWR06A | 1855 2001 | 147 | 6 | 0 | .614 | 1.80 | 3.29 | .572 | .769 | .164 | 2.71 | .542 | .003 | 1 |
| 10 | DWR06B | 1855 2001 | 147 | 6 | 0 | .623 | 1.79 | 3.27 | .558 | .796 | .157 | 2.62 | .414 | -.061 | 4 |
| 11 | DWR07A | 1828 1986 | 159 | 6 | 0 | .640 | 1.83 | 5.22 | .775 | .808 | .218 | 2.69 | .408 | -.035 | 1 |
| 12 | DWR07A | 1828 1986 | 159 | 6 | 0 | .554 | 1.84 | 5.53 | .867 | .834 | .226 | 2.82 | .464 | -.056 | 4 |
| 13 | DWR08A | 1827 1996 | 170 | 6 | 0 | .662 | 1.80 | 3.28 | .569 | .679 | .202 | 2.63 | .465 | -.037 | 1 |
| 14 | DWR08B | 1827 1996 | 170 | 6 | 0 | .573 | 1.79 | 3.30 | .582 | .675 | .216 | 2.62 | .436 | -.020 | 1 |
| Total or mean: | | | 1914 | 74 | 0 | .607 | 2.02 | 5.78 | .699 | .729 | .193 | 2.95 | .464 | -.022 | |

# APPENDIX Q

## COFECHA PROGRAM OUTPUT FOR DONALDSON WOODS SITE CHRONOLOGY,

## *QUERCUS VELUTINA*, INDIANA, U.S.A

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P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
------------------------------------------------------------------------------------------------------------------------------------------
QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   DWV_DATED.TXT

 Time span of Master dating series is  1731 to  2013   283 years
 Continuous time span is               1731 to  2013   283 years
 Portion with two or more series is    1731 to  2012   282 years


                                     ***************************************
                                     *C* Number of dated series        22 *C*
                                     *O* Master series 1731 2013  283 yrs *O*
                                     *F* Total rings in all series   2987 *F*
                                     *E* Total dated rings checked   2986 *E*
                                     *C* Series intercorrelation     .635 *C*
                                     *H* Average mean sensitivity    .195 *H*
                                     *A* Segments, possible problems    3 *A*
                                     *** Mean length of series      135.8 ***
                                     ***************************************

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

              No ring measurements of zero value
```
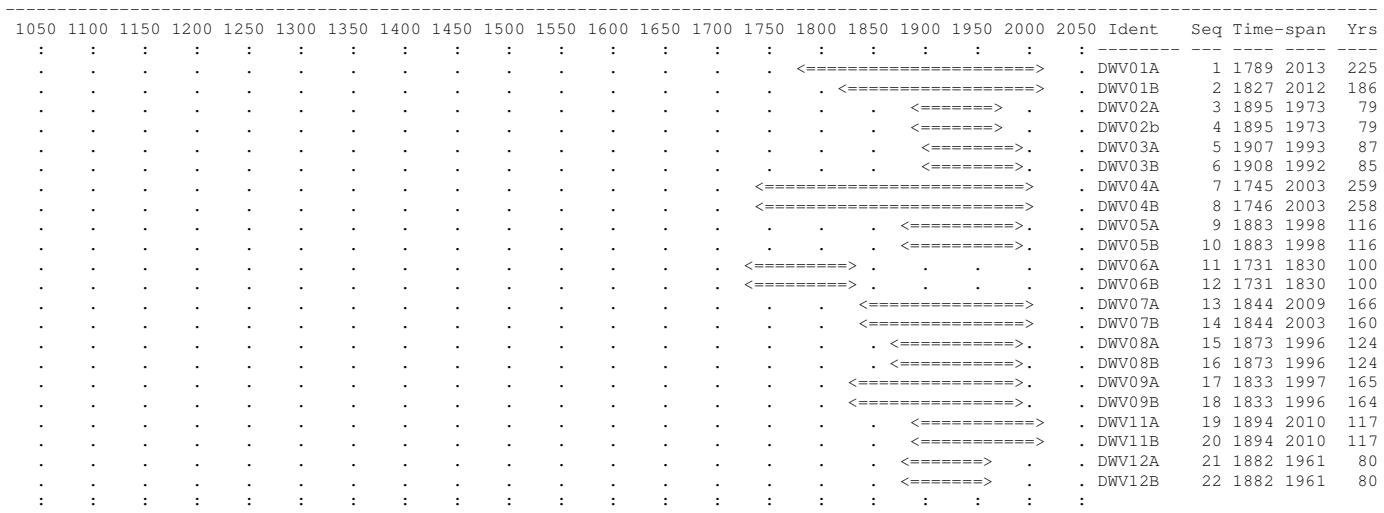

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1750 | .235 | 4 | 1800 | -2.762 | 5 | 1850 | .054 | 8 | 1900 | 1.150 | 18 | 1950 | 1.608 | 20 |
| | | | 1751 | 1.611 | 4 | 1801 | .273 | 5 | 1851 | -.739 | 8 | 1901 | -.191 | 18 | 1951 | .873 | 20 |
| | | | 1752 | -.883 | 4 | 1802 | 1.472 | 5 | 1852 | .166 | 8 | 1902 | 1.021 | 18 | 1952 | .108 | 20 |
| | | | 1753 | .770 | 4 | 1803 | -.618 | 5 | 1853 | .165 | 8 | 1903 | .222 | 18 | 1953 | -.843 | 20 |
| | | | 1754 | .857 | 4 | 1804 | 1.877 | 5 | 1854 | .716 | 8 | 1904 | -.752 | 18 | 1954 | -1.615 | 20 |
| | | | 1755 | -2.384 | 4 | 1805 | .889 | 5 | 1855 | 1.762 | 8 | 1905 | -.329 | 18 | 1955 | -.256 | 20 |
| | | | 1756 | -.211 | 4 | 1806 | -.636 | 5 | 1856 | -2.818 | 8 | 1906 | .025 | 18 | 1956 | -.638 | 20 |
| | | | 1757 | -.954 | 4 | 1807 | .048 | 5 | 1857 | -.191 | 8 | 1907 | 1.268 | 19 | 1957 | .981 | 20 |
| | | | 1758 | 1.326 | 4 | 1808 | -.370 | 5 | 1858 | -1.935 | 8 | 1908 | -.410 | 20 | 1958 | 1.129 | 20 |
| | | | 1759 | -.058 | 4 | 1809 | -1.139 | 5 | 1859 | -.403 | 8 | 1909 | .975 | 20 | 1959 | .051 | 20 |
| | | | 1760 | -.468 | 4 | 1810 | -.454 | 5 | 1860 | .387 | 8 | 1910 | .711 | 20 | 1960 | 1.235 | 20 |
| | | | 1761 | .328 | 4 | 1811 | -.290 | 5 | 1861 | .380 | 8 | 1911 | -.800 | 20 | 1961 | .592 | 20 |
| | | | 1762 | -.534 | 4 | 1812 | .768 | 5 | 1862 | .817 | 8 | 1912 | .912 | 20 | 1962 | .103 | 18 |
| | | | 1763 | -.057 | 4 | 1813 | -.492 | 5 | 1863 | .590 | 8 | 1913 | -1.284 | 20 | 1963 | .372 | 18 |
| | | | 1764 | -.366 | 4 | 1814 | .741 | 5 | 1864 | -.568 | 8 | 1914 | -2.816 | 20 | 1964 | -.539 | 18 |
| | | | 1765 | -3.092 | 4 | 1815 | -2.909 | 5 | 1865 | -.560 | 8 | 1915 | 1.182 | 20 | 1965 | .089 | 18 |
| | | | 1766 | .566 | 4 | 1816 | .285 | 5 | 1866 | .004 | 8 | 1916 | .885 | 20 | 1966 | -.457 | 18 |
| | | | 1767 | -1.258 | 4 | 1817 | -.310 | 5 | 1867 | .092 | 8 | 1917 | .138 | 20 | 1967 | -1.250 | 18 |
| | | | 1768 | 1.777 | 4 | 1818 | 1.850 | 5 | 1868 | .372 | 8 | 1918 | -.628 | 20 | 1968 | -.333 | 18 |
| | | | 1769 | -.187 | 4 | 1819 | .966 | 5 | 1869 | 1.862 | 8 | 1919 | .447 | 20 | 1969 | -.541 | 18 |
| | | | 1770 | .411 | 4 | 1820 | .746 | 5 | 1870 | .133 | 8 | 1920 | -.249 | 20 | 1970 | -1.412 | 18 |
| | | | 1771 | -1.371 | 4 | 1821 | -1.220 | 5 | 1871 | -.257 | 8 | 1921 | -.599 | 20 | 1971 | -.147 | 18 |
| | | | 1772 | .819 | 4 | 1822 | -1.838 | 5 | 1872 | 1.448 | 8 | 1922 | .440 | 20 | 1972 | -1.978 | 18 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1773 | -.564 | 4 | 1823 | .562 | 5 | 1873 | .916 | 10 | 1923 | .346 | 20 | 1973 | 1.244 | 18 |
| | | | 1774 | -2.078 | 4 | 1824 | .906 | 5 | 1874 | -2.239 | 10 | 1924 | .754 | 20 | 1974 | 1.119 | 16 |
| | | | 1775 | 1.900 | 4 | 1825 | -.142 | 5 | 1875 | .029 | 10 | 1925 | -1.432 | 20 | 1975 | .008 | 16 |
| | | | 1776 | 1.868 | 4 | 1826 | .001 | 5 | 1876 | .214 | 10 | 1926 | -.079 | 20 | 1976 | .860 | 16 |
| | | | 1777 | .323 | 4 | 1827 | -.505 | 6 | 1877 | -.063 | 10 | 1927 | .857 | 20 | 1977 | -.721 | 16 |
| | | | 1778 | .808 | 4 | 1828 | 1.518 | 6 | 1878 | -.353 | 10 | 1928 | 1.770 | 20 | 1978 | .010 | 16 |
| | | | 1779 | .627 | 4 | 1829 | .416 | 6 | 1879 | -1.202 | 10 | 1929 | .762 | 20 | 1979 | .405 | 16 |
| | | | 1780 | 1.678 | 4 | 1830 | -.339 | 6 | 1880 | .866 | 10 | 1930 | -.439 | 20 | 1980 | -.009 | 16 |
| 1731 | -.257 | 2 | 1781 | .356 | 4 | 1831 | .442 | 4 | 1881 | .327 | 10 | 1931 | -.170 | 20 | 1981 | .140 | 16 |
| 1732 | -1.750 | 2 | 1782 | .513 | 4 | 1832 | -2.190 | 4 | 1882 | .664 | 12 | 1932 | .322 | 20 | 1982 | 1.832 | 16 |
| 1733 | .592 | 2 | 1783 | -.866 | 4 | 1833 | .233 | 6 | 1883 | .287 | 14 | 1933 | -.918 | 20 | 1983 | -.011 | 16 |
| 1734 | .600 | 2 | 1784 | -1.520 | 4 | 1834 | -.120 | 6 | 1884 | .452 | 14 | 1934 | -1.142 | 20 | 1984 | -.523 | 16 |
| 1735 | .953 | 2 | 1785 | -1.451 | 4 | 1835 | 1.247 | 6 | 1885 | -.504 | 14 | 1935 | .990 | 20 | 1985 | .819 | 16 |
| 1736 | -1.794 | 2 | 1786 | -.832 | 4 | 1836 | .626 | 6 | 1886 | -1.515 | 14 | 1936 | -1.151 | 20 | 1986 | -.227 | 16 |
| 1737 | -.244 | 2 | 1787 | -.660 | 4 | 1837 | .964 | 6 | 1887 | -1.534 | 14 | 1937 | -1.031 | 20 | 1987 | .054 | 16 |
| 1738 | 1.036 | 2 | 1788 | .655 | 4 | 1838 | -1.325 | 6 | 1888 | -.242 | 14 | 1938 | .681 | 20 | 1988 | -2.733 | 16 |
| 1739 | 1.521 | 2 | 1789 | .065 | 5 | 1839 | -2.091 | 6 | 1889 | 1.621 | 14 | 1939 | .345 | 20 | 1989 | .023 | 16 |
| 1740 | 1.510 | 2 | 1790 | .047 | 5 | 1840 | 1.245 | 6 | 1890 | -.085 | 14 | 1940 | -1.058 | 20 | 1990 | .442 | 16 |
| 1741 | -3.540 | 2 | 1791 | .227 | 5 | 1841 | -.700 | 6 | 1891 | .766 | 14 | 1941 | -.252 | 20 | 1991 | -.208 | 16 |
| 1742 | .936 | 2 | 1792 | 1.117 | 5 | 1842 | 1.101 | 6 | 1892 | .179 | 14 | 1942 | 1.035 | 20 | 1992 | .286 | 16 |
| 1743 | -.495 | 2 | 1793 | .737 | 5 | 1843 | .368 | 6 | 1893 | -.214 | 14 | 1943 | .515 | 20 | 1993 | .028 | 15 |
| 1744 | .996 | 2 | 1794 | .386 | 5 | 1844 | -.984 | 8 | 1894 | -.688 | 16 | 1944 | -1.254 | 20 | 1994 | -.370 | 14 |
| 1745 | -.883 | 3 | 1795 | -.403 | 5 | 1845 | .585 | 8 | 1895 | -.851 | 18 | 1945 | .496 | 20 | 1995 | .718 | 14 |
| 1746 | 1.247 | 4 | 1796 | -.485 | 5 | 1846 | .172 | 8 | 1896 | .419 | 18 | 1946 | -.554 | 20 | 1996 | .104 | 14 |
| 1747 | .943 | 4 | 1797 | -.013 | 5 | 1847 | -.420 | 8 | 1897 | .789 | 18 | 1947 | .103 | 20 | 1997 | -.869 | 11 |
| 1748 | -.928 | 4 | 1798 | 1.415 | 5 | 1848 | .163 | 8 | 1898 | -.699 | 18 | 1948 | .146 | 20 | 1998 | .430 | 10 |
| 1749 | .151 | 4 | 1799 | -.561 | 5 | 1849 | 1.032 | 8 | 1899 | -.015 | 18 | 1949 | .452 | 20 | 1999 | 1.245 | 8 |
| 2000 | 1.163 | 8 | | | | | | | | | | | | | | | |
| 2001 | 1.186 | 8 | | | | | | | | | | | | | | | |
| 2002 | -.132 | 8 | | | | | | | | | | | | | | | |
| 2003 | -.032 | 8 | | | | | | | | | | | | | | | |
| 2004 | .132 | 5 | | | | | | | | | | | | | | | |
| 2005 | -.365 | 5 | | | | | | | | | | | | | | | |
| 2006 | -.871 | 5 | | | | | | | | | | | | | | | |
| 2007 | -1.003 | 5 | | | | | | | | | | | | | | | |
| 2008 | -1.556 | 5 | | | | | | | | | | | | | | | |
| 2009 | -.653 | 5 | | | | | | | | | | | | | | | |
| 2010 | .485 | 4 | | | | | | | | | | | | | | | |
| 2011 | .756 | 2 | | | | | | | | | | | | | | | |
| 2012 | -.284 | 2 | | | | | | | | | | | | | | | |
| 2013 | -.663 | 1 | | | | | | | | | | | | | | | |

Part 4: Master Bar Plot

| Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value | Year | Rel value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1750 | ------A | 1800 | k | 1850 | -----@ | 1900 | ---------E | 1950 | ----------F | 2000 | ---------E | | |
| | | 1751 | ----------F | 1801 | ------A | 1851 | --c | 1901 | ----a | 1951 | --------C | 2001 | ---------E | | |
| | | 1752 | -d | 1802 | ----------F | 1852 | -----A | 1902 | ---------D | 1952 | -----@ | 2002 | ----a | | |
| | | 1753 | --------C | 1803 | --b | 1853 | -----A | 1903 | ------A | 1953 | -c | 2003 | -----@ | | |
| | | 1754 | --------C | 1804 | ----------H | 1854 | ---------C | 1904 | --c | 1954 | f | 2004 | -----A | | |
| | | 1755 | j | 1805 | --------D | 1855 | ----------G | 1905 | ---a | 1955 | ---a | 2005 | ---a | | |
| | | 1756 | ----a | 1806 | --c | 1856 | k | 1906 | -----@ | 1956 | --c | 2006 | -c | | |
| | | 1757 | -d | 1807 | -----@ | 1857 | ----a | 1907 | ---------E | 1957 | ---------D | 2007 | -d | | |

```
                 1758----------E 1808---a        1858h           1908---b        1958---------E  2008f
                 1759----@       1809-e          1859---b        1909---------D  1959-----@      2009--c
                 1760---b        1810---b        1860------B     1910--------C   1960---------E  2010-------B
                 1761------A     1811---a        1861------B     1911--c         1961-------B    2011--------C
                 1762--b         1812--------C   1862--------C   1912---------D  1962-----@      2012---a
                 1763----@       1813---b        1863-------B    1913-e          1963------A     2013--c
                 1764---a        1814--------C   1864--b         1914k           1964--b
                 17651           18151           1865--b         1915---------E  1965-----@
                 1766-------B    1816------A     1866-----@      1916--------D   1966---b
                 1767-e          1817---a        1867-----@      1917-----A      1967-e
                 1768----------G 1818----------G 1868------A     1918--c         1968---a
                 1769----a       1819---------D  1869----------G 1919-------B    1969--b
                 1770-------B    1820--------C   1870-----A      1920---a        1970-f
                 1771-e          1821-e          1871---a        1921--b         1971----a
                 1772--------C   1822g           1872----------F 1922-------B    1972h
                 1773--b         1823-------B    1873---------D  1923------A     1973---------E
                 1774h           1824---------D  1874i           1924--------C   1974---------D
                 1775----------H 1825----a       1875-----@      1925-f          1975-----@
                 1776----------G 1826-----@      1876------A     1926----@       1976--------C
                 1777------A     1827--b         1877----@       1927--------C   1977--c
                 1778--------C   1828----------F 1878---a        1928----------G 1978-----@
                 1779-------C    1829-------B    1879-e          1929--------C   1979-------B
                 1780----------G 1830---a        1880--------C   1930---b        1980-----@
  1731---a       1781------A     1831-------B    1881------A     1931----a       1981-----A
  1732g          1782-------B    1832i           1882--------C   1932------A     1982----------G
  1733-------B   1783-c          1833------A     1883------A     1933-d          1983-----@
  1734-------B   1784f           1834----@       1884-------B    1934-e          1984--b
  1735---------D 1785-f          1835---------E  1885--b         1935---------D  1985--------C
  1736g          1786-c          1836-------C    1886f           1936-e          1986----a
  1737----a      1787--c         1837---------D  1887f           1937-d          1987-----@
  1738---------D 1788--------C   1838-e          1888----a       1938--------C   1988k
  1739----------F 1789-----@      1839h           1889----------F 1939------A     1989-----@
  1740----------F 1790-----@      1840---------E  1890----@       1940-d          1990-------B
  1741n          1791------A     1841--c         1891--------C   1941---a        1991----a
  1742---------D 1792---------D  1842---------D  1892------A     1942---------D  1992------A
  1743--b        1793--------C   1843------A     1893----a       1943-------B    1993-----@
  1744---------D 1794------B     1844-d          1894--c         1944-e          1994---a
  1745-d         1795---b        1845-------B    1895-c          1945-------B    1995--------C
  1746---------E 1796---b        1846-----A      1896-------B    1946--b         1996-----@
  1747---------D 1797-----@      1847---b        1897--------C   1947-----@      1997-c
  1748-d         1798----------F 1848-----A      1898--c         1948-----A      1998-------B
  1749-----A     1799--b         1849---------D  1899-----@      1949-------B    1999---------E
```

---

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1725 1774 | 1750 1799 | 1775 1824 | 1800 1849 | 1825 1874 | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DWV01A | 1789 2013 | | | .53 | .59 | .58 | .63 | .64 | .70 | .81 | .77 | .69 |
| 2 | DWV01B | 1827 2012 | | | | | .39 | .10B | .36 | .74 | .76 | .67 | .49 |
| 3 | DWV02A | 1895 1973 | | | | | | | .79 | .79 | .61 | | |
| 4 | DWV02b | 1895 1973 | | | | | | | .68 | .61 | .43 | | |
| 5 | DWV03A | 1907 1993 | | | | | | | | .69 | .76 | .54 | |
| 6 | DWV03B | 1908 1992 | | | | | | | | .66 | .65 | .66 | |
| 7 | DWV04A | 1745 2003 | .90 | .90 | .84 | .78 | .78 | .78 | .81 | .73 | .66 | .59 | .58 |
| 8 | DWV04B | 1746 2003 | .79 | .80 | .75 | .71 | .74 | .75 | .74 | .66 | .65 | .58 | .56 |

```
   9 DWV05A   1883 1998                                .77  .85  .75  .63
  10 DWV05B   1883 1998                                .73  .77  .69  .66
  11 DWV06A   1731 1830   .92  .77  .74  .72
  12 DWV06B   1731 1830   .90  .82  .77  .76
  13 DWV07A   1844 2009                      .79  .73  .64  .75  .77  .75  .62
  14 DWV07B   1844 2003                      .82  .77  .53  .58  .76  .77  .55
  15 DWV08A   1873 1996                           .57  .57  .74  .62  .41
  16 DWV08B   1873 1996                           .65  .63  .69  .57  .51
  17 DWV09A   1833 1997                      .56  .60  .42  .58  .71  .70
  18 DWV09B   1833 1996                      .56  .59  .53  .64  .72  .74
  19 DWV11A   1894 2010                                .68  .72  .77  .67  .57
  20 DWV11B   1894 2010                                .69  .76  .70  .67  .60
  21 DWV12A   1882 1961                                .50  .36  .28A
  22 DWV12B   1882 1961                                .38  .34  .24A
 Av segment correlation   .88  .82  .73  .71  .65  .62  .62  .67  .65  .64  .58
```

PART 6:  POTENTIAL PROBLEMS:

---

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

[B] Effect of those data values which most lower or raise correlation with master series
    Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

==========

DWV01A    1789 to  2013     225 years  Series   1

[*] Later part of series cannot be checked from 2013 to 2013 -- not matched by another series

[B] Entire series, effect on correlation (  .627) is:
      Lower   1803> -.011   1853< -.008   1858> -.007   1815> -.006   1985< -.006   1986< -.006  Higher   1988  .025   1874  .014

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1803 +3.4 SD

==========

DWV01B    1827 to  2012     186 years  Series   2

[A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
   ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1850 1899    9    .12 -.05  .01  .06 -.01 -.18 -.17  .12  .19 -.03  .10| .26 -.11 -.13 -.16  .01  .04 -.20  .07  .30*-.06

[B] Entire series, effect on correlation (  .450) is:
      Lower   1889< -.054   1869< -.015   1879> -.013   1856> -.013   2009< -.011   2006> -.010  Higher   1914  .043   1988  .030
    1850 to 1899 segment:
      Lower   1889< -.190   1869< -.043   1879> -.036   1873< -.021   1884< -.017   1851> -.008  Higher   1858  .063   1856  .034

[C] Year-to-year changes diverging by over 4.0 std deviations:
      1888 1889  -4.4 SD

```
 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1879 +3.8 SD;    1889 -6.0 SD;    2006 +3.2 SD
================================================================================================================================================

 DWV02A    1895 to  1973      79 years                                                                                          Series   3

 [B] Entire series, effect on correlation (  .683) is:
       Lower   1972> -.059   1953> -.013   1947< -.012   1960< -.012   1958< -.011   1913> -.009  Higher   1914  .061   1925  .015

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1972 +3.2 SD
================================================================================================================================================

 DWV02b    1895 to  1973      79 years                                                                                          Series   4

 [B] Entire series, effect on correlation (  .555) is:
       Lower   1947< -.049   1972> -.036   1953> -.014   1940> -.014   1942< -.013   1924< -.011  Higher   1914  .077   1925  .019

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

 DWV03A    1907 to  1993      87 years                                                                                          Series   5

 [B] Entire series, effect on correlation (  .599) is:
       Lower   1993< -.084   1956> -.012   1917< -.011   1910< -.010   1907< -.009   1979< -.008  Higher   1988  .014   1925  .013

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

 DWV03B    1908 to  1992      85 years                                                                                          Series   6

 [B] Entire series, effect on correlation (  .691) is:
       Lower   1953< -.031   1972> -.021   1954> -.013   1917< -.008   1986> -.008   1944> -.007  Higher   1988  .070   1925  .012

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

 DWV04A    1745 to  2003     259 years                                                                                          Series   7

 [B] Entire series, effect on correlation (  .756) is:
       Lower   1987< -.011   1988> -.010   1803< -.010   1938< -.007   1944> -.005   1885< -.004  Higher   1856  .009   1765  .009

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1985 +3.3 SD
================================================================================================================================================

 DWV04B    1746 to  2003     258 years                                                                                          Series   8

 [B] Entire series, effect on correlation (  .697) is:
       Lower   1988> -.013   1938< -.007   1841> -.005   1860< -.005   1965< -.004   1803< -.004  Higher   1856  .013   1800  .009

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1985 +3.1 SD
================================================================================================================================================

 DWV05A    1883 to  1998     116 years                                                                                          Series   9

 [B] Entire series, effect on correlation (  .700) is:
       Lower   1997< -.045   1886> -.027   1955< -.018   1964> -.011   1902< -.007   1984> -.006  Higher   1914  .025   1988  .019

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
```

1997 -4.5 SD

---

DWV05B 1883 to 1998 116 years Series 10

[B] Entire series, effect on correlation ( .695) is:
Lower 1997< -.022 1955< -.020 1901< -.019 1886> -.019 1964> -.010 1958< -.010 Higher 1988 .025 1972 .019

---

DWV06A 1731 to 1830 100 years Series 11

[B] Entire series, effect on correlation ( .823) is:
Lower 1791< -.015 1806< -.013 1797< -.010 1803> -.009 1796> -.007 1789< -.005 Higher 1741 .024 1815 .018

---

DWV06B 1731 to 1830 100 years Series 12

[B] Entire series, effect on correlation ( .835) is:
Lower 1803> -.008 1796> -.008 1785> -.006 1809< -.006 1814< -.005 1797< -.004 Higher 1765 .015 1741 .014

---

DWV07A 1844 to 2009 166 years Series 13

[B] Entire series, effect on correlation ( .703) is:
Lower 1899< -.018 1888< -.009 2009> -.009 1997> -.009 2008> -.007 2000< -.006 Higher 1856 .029 1988 .011

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
2009 +3.1 SD

---

DWV07B 1844 to 2003 160 years Series 14

[B] Entire series, effect on correlation ( .639) is:
Lower 2001< -.079 1906< -.012 1997> -.010 1977> -.009 1922< -.008 1865> -.008 Higher 1988 .039 1856 .021

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
2001 -7.1 SD

---

DWV08A 1873 to 1996 124 years Series 15

[B] Entire series, effect on correlation ( .527) is:
Lower 1893< -.029 1988> -.018 1956> -.013 1886> -.013 1887> -.012 1982< -.012 Higher 1914 .057 1925 .018

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1956 +3.3 SD

---

DWV08B 1873 to 1996 124 years Series 16

[B] Entire series, effect on correlation ( .584) is:
Lower 1886> -.018 1956> -.017 1984< -.014 1893< -.014 1937> -.012 1952< -.009 Higher 1914 .038 1988 .029

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1956 +3.7 SD

DWV09A  1833 to 1997  165 years  Series 17

[B] Entire series, effect on correlation ( .589) is:
Lower 1839> -.032 1886> -.016 1950< -.009 1856> -.009 1914> -.008 1844> -.008 Higher 1988 .031 1874 .023

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1839 +4.0 SD; 1886 +3.1 SD

---

DWV09B  1833 to 1996  164 years  Series 18

[B] Entire series, effect on correlation ( .620) is:
Lower 1856> -.024 1886> -.020 1839> -.014 1844> -.012 1950< -.008 1985< -.008 Higher 1988 .036 1874 .020

[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year
1886 +3.3 SD

---

DWV11A  1894 to 2010  117 years  Series 19

[B] Entire series, effect on correlation ( .653) is:
Lower 1975< -.040 2005< -.009 1897< -.008 1967> -.007 1907< -.006 1898> -.005 Higher 1972 .024 1988 .022

---

DWV11B  1894 to 2010  117 years  Series 20

[B] Entire series, effect on correlation ( .665) is:
Lower 1964< -.030 1897< -.013 1974< -.010 2008> -.008 1966> -.008 1903< -.007 Higher 1988 .031 1972 .023

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1981 +3.1 SD; 2001 +3.3 SD

---

DWV12A  1882 to 1961  80 years  Series 21

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1912 1961 | 0 | .17 | .16 | -.14 | .02 | .00 | .01 | -.17 | .13 | .14 | -.03 | .28*-.09 | .06 | .03 | -.03 | .00 | -.23 | -.09 | -.05 | .06 | .11 |

[B] Entire series, effect on correlation ( .355) is:
Lower 1925> -.040 1916< -.024 1937> -.022 1932< -.021 1959< -.016 1943< -.016 Higher 1914 .126 1886 .050
1912 to 1961 segment:
Lower 1925> -.057 1916< -.034 1937> -.031 1932< -.028 1943< -.022 1959< -.021 Higher 1914 .230 1944 .025

[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year
1925 +3.4 SD; 1937 +3.5 SD

---

DWV12B  1882 to 1961  80 years  Series 22

| [A] Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1912 1961 | 0 | .07 | .19 | .05 | -.03 | -.05 | -.12 | -.22 | .15 | .19 | .09 | .24*-.04 | .02 | -.01 | .04 | -.09 | -.19 | -.01 | -.09 | .07 | .09 |

[B] Entire series, effect on correlation ( .282) is:

```
      Lower   1925> -.057   1882< -.030   1957< -.027   1916< -.027   1945< -.016   1937> -.016  Higher   1914  .150   1886  .049
    1912 to 1961 segment:
      Lower   1925> -.085   1957< -.038   1916< -.038   1937> -.023   1945< -.022   1961< -.021  Higher   1914  .261   1944  .022

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1925 +4.4 SD;    1952 +3.7 SD
```

PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DWV01A | 1789 2013 | 225 | 9 | 0 | .627 | 1.44 | 3.14 | .571 | .767 | .227 | 2.60 | .426 | -.005 | 1 |
| 2 | DWV01B | 1827 2012 | 186 | 7 | 1 | .450 | 1.42 | 3.45 | .587 | .843 | .180 | 2.58 | .391 | .025 | 2 |
| 3 | DWV02A | 1895 1973 | 79 | 3 | 0 | .683 | 1.84 | 3.30 | .408 | .508 | .179 | 2.71 | .524 | -.073 | 1 |
| 4 | DWV02b | 1895 1973 | 79 | 3 | 0 | .555 | 1.84 | 3.27 | .449 | .379 | .220 | 2.64 | .564 | -.049 | 1 |
| 5 | DWV03A | 1907 1993 | 87 | 3 | 0 | .599 | 1.99 | 3.24 | .411 | .469 | .154 | 2.66 | .457 | -.035 | 2 |
| 6 | DWV03B | 1908 1992 | 85 | 3 | 0 | .691 | 2.02 | 3.68 | .432 | .441 | .177 | 2.49 | .400 | -.065 | 2 |
| 7 | DWV04A | 1745 2003 | 259 | 11 | 0 | .756 | 1.69 | 2.98 | .434 | .554 | .184 | 2.64 | .342 | .021 | 1 |
| 8 | DWV04B | 1746 2003 | 258 | 11 | 0 | .697 | 1.68 | 2.95 | .436 | .525 | .189 | 2.61 | .330 | .001 | 1 |
| 9 | DWV05A | 1883 1998 | 116 | 4 | 0 | .700 | 2.92 | 4.57 | .685 | .452 | .198 | 2.54 | .414 | .019 | 1 |
| 10 | DWV05B | 1883 1998 | 116 | 4 | 0 | .695 | 2.97 | 4.54 | .657 | .513 | .175 | 2.59 | .493 | .029 | 1 |
| 11 | DWV06A | 1731 1830 | 100 | 4 | 0 | .823 | 1.42 | 2.23 | .340 | .350 | .219 | 2.76 | .455 | -.062 | 1 |
| 12 | DWV06B | 1731 1830 | 100 | 4 | 0 | .835 | 1.43 | 2.27 | .327 | .331 | .209 | 2.56 | .435 | -.034 | 1 |
| 13 | DWV07A | 1844 2009 | 166 | 7 | 0 | .703 | 1.18 | 2.07 | .290 | .247 | .248 | 2.65 | .468 | .022 | 2 |
| 14 | DWV07B | 1844 2003 | 160 | 7 | 0 | .639 | 1.13 | 1.84 | .258 | .075 | .243 | 2.67 | .428 | -.008 | 1 |
| 15 | DWV08A | 1873 1996 | 124 | 5 | 0 | .527 | 2.88 | 5.24 | .930 | .785 | .164 | 2.72 | .464 | -.002 | 1 |
| 16 | DWV08B | 1873 1996 | 124 | 5 | 0 | .584 | 2.92 | 5.69 | .911 | .787 | .156 | 2.82 | .487 | .025 | 1 |
| 17 | DWV09A | 1833 1997 | 165 | 6 | 0 | .589 | 1.60 | 3.67 | .683 | .838 | .181 | 2.71 | .494 | -.053 | 1 |
| 18 | DWV09B | 1833 1996 | 164 | 6 | 0 | .620 | 1.58 | 3.51 | .646 | .801 | .189 | 2.73 | .459 | -.025 | 1 |
| 19 | DWV11A | 1894 2010 | 117 | 5 | 0 | .653 | 2.52 | 4.13 | .675 | .675 | .167 | 2.77 | .499 | -.006 | 1 |
| 20 | DWV11B | 1894 2010 | 117 | 5 | 0 | .665 | 2.53 | 4.32 | .681 | .645 | .163 | 2.85 | .505 | -.030 | 1 |
| 21 | DWV12A | 1882 1961 | 80 | 3 | 1 | .355 | 1.66 | 2.62 | .360 | .181 | .221 | 2.58 | .511 | -.015 | 1 |
| 22 | DWV12B | 1882 1961 | 80 | 3 | 1 | .282 | 1.66 | 2.59 | .376 | .063 | .230 | 2.71 | .479 | -.007 | 1 |
| Total or mean: | | | 2987 | 118 | 3 | .635 | 1.85 | 5.69 | .529 | .545 | .195 | 2.85 | .440 | -.009 | |

# APPENDIX R

## COFECHA PROGRAM OUTPUT FOR DONALDSON WOODS SITE CHRONOLOGY,

## *LIRIODENDRON TULIPIFERA*, INDIANA, U.S.A.

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P R O G R A M     C O F E C H A                                                                                    Version 6.06P    29368
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 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 File of DATED series:   dwt_dated.txt

 Time span of Master dating series is  1708 to  2013   306 years
 Continuous time span is               1708 to  2013   306 years
 Portion with two or more series is    1729 to  2013   285 years

 >> DWT01B      1938 absent in   1 of   16 series, but is not usually narrow: master index is  1.281

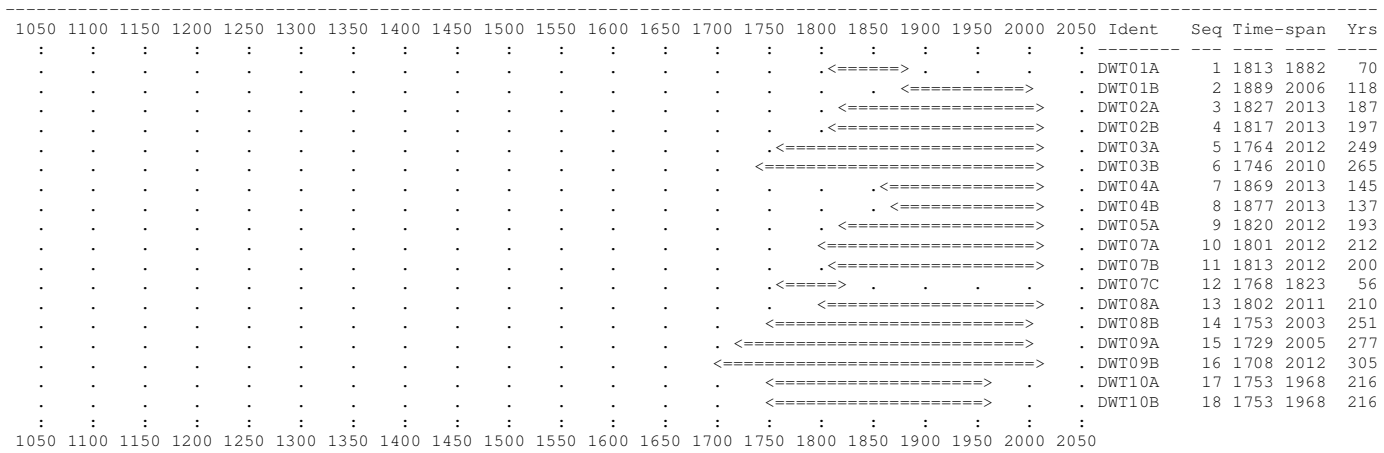
                                      ***************************************
                                      *C* Number of dated series        18 *C*
                                *O* Master series 1708 2013  306 yrs *O*
                                      *F* Total rings in all series   3504 *F*
                                      *E* Total dated rings checked   3483 *E*
                                      *C* Series intercorrelation     .598 *C*
                                      *H* Average mean sensitivity    .367 *H*
                                      *A* Segments, possible problems    5 *A*
                                      *** Mean length of series      194.7 ***
                                      ***************************************

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

 DWT01B      1 absent rings:   1938
 DWT03A      1 absent rings:   1838

             2 absent rings    .057%
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1750 | .478 | 3 | 1800 | -.944 | 8 | 1850 | -.323 | 14 | 1900 | .720 | 16 | 1950 | .965 | 16 |
| | | | 1751 | -.546 | 3 | 1801 | .946 | 9 | 1851 | -2.147 | 14 | 1901 | .893 | 16 | 1951 | 1.290 | 16 |
| | | | 1752 | -1.505 | 3 | 1802 | -1.152 | 10 | 1852 | .641 | 14 | 1902 | .184 | 16 | 1952 | -.176 | 16 |
| | | | 1753 | .321 | 6 | 1803 | 1.663 | 10 | 1853 | .196 | 14 | 1903 | .187 | 16 | 1953 | -1.086 | 16 |
| | | | 1754 | -.559 | 6 | 1804 | .470 | 10 | 1854 | .043 | 14 | 1904 | .883 | 16 | 1954 | -1.460 | 16 |
| | | | 1755 | -.209 | 6 | 1805 | -.167 | 10 | 1855 | .447 | 14 | 1905 | .072 | 16 | 1955 | -1.293 | 16 |
| | | | 1756 | -.044 | 6 | 1806 | 1.400 | 10 | 1856 | -.664 | 14 | 1906 | .009 | 16 | 1956 | -.712 | 16 |
| | | | 1757 | .011 | 6 | 1807 | -.458 | 10 | 1857 | -.426 | 14 | 1907 | .217 | 16 | 1957 | .765 | 16 |
| 1708 | .359 | 1 | 1758 | .139 | 6 | 1808 | 1.069 | 10 | 1858 | .317 | 14 | 1908 | .000 | 16 | 1958 | .839 | 16 |
| 1709 | 1.558 | 1 | 1759 | .506 | 6 | 1809 | .899 | 10 | 1859 | -.520 | 14 | 1909 | .455 | 16 | 1959 | -.792 | 16 |
| 1710 | .817 | 1 | 1760 | .445 | 6 | 1810 | -.473 | 10 | 1860 | 1.006 | 14 | 1910 | .962 | 16 | 1960 | 1.288 | 16 |
| 1711 | -5.733 | 1 | 1761 | -.015 | 6 | 1811 | -.116 | 10 | 1861 | 1.094 | 14 | 1911 | .134 | 16 | 1961 | -.077 | 16 |
| 1712 | 1.280 | 1 | 1762 | -.140 | 6 | 1812 | -.685 | 10 | 1862 | .883 | 14 | 1912 | -.014 | 16 | 1962 | -.006 | 16 |
| 1713 | -.408 | 1 | 1763 | -.209 | 6 | 1813 | .604 | 12 | 1863 | .661 | 14 | 1913 | -.699 | 16 | 1963 | -.098 | 16 |
| 1714 | .033 | 1 | 1764 | -.540 | 7 | 1814 | -2.490 | 12 | 1864 | -2.305 | 14 | 1914 | -1.685 | 16 | 1964 | .064 | 16 |
| 1715 | .084 | 1 | 1765 | -.247 | 7 | 1815 | -1.076 | 12 | 1865 | -.269 | 14 | 1915 | .065 | 16 | 1965 | -.643 | 16 |
| 1716 | 1.791 | 1 | 1766 | .596 | 7 | 1816 | -1.416 | 12 | 1866 | 1.112 | 14 | 1916 | 2.152 | 16 | 1966 | .353 | 16 |
| 1717 | 1.138 | 1 | 1767 | 1.018 | 7 | 1817 | .241 | 13 | 1867 | -.807 | 14 | 1917 | -.343 | 16 | 1967 | -.631 | 16 |
| 1718 | -2.384 | 1 | 1768 | .647 | 8 | 1818 | .662 | 13 | 1868 | .038 | 14 | 1918 | -.960 | 16 | 1968 | -.636 | 16 |
| 1719 | -.503 | 1 | 1769 | -.137 | 8 | 1819 | .524 | 13 | 1869 | .994 | 15 | 1919 | -.597 | 16 | 1969 | .741 | 14 |
| 1720 | .680 | 1 | 1770 | -.420 | 8 | 1820 | .441 | 14 | 1870 | .949 | 15 | 1920 | -.330 | 16 | 1970 | -1.074 | 14 |
| 1721 | -1.394 | 1 | 1771 | .834 | 8 | 1821 | -.288 | 14 | 1871 | -.995 | 15 | 1921 | -.398 | 16 | 1971 | -.151 | 14 |
| 1722 | .212 | 1 | 1772 | -.148 | 8 | 1822 | -.501 | 14 | 1872 | .152 | 15 | 1922 | 1.210 | 16 | 1972 | -1.602 | 14 |
| 1723 | -.325 | 1 | 1773 | -1.773 | 8 | 1823 | .208 | 14 | 1873 | -.023 | 15 | 1923 | .594 | 16 | 1973 | .535 | 14 |
| 1724 | -5.003 | 1 | 1774 | .389 | 8 | 1824 | .883 | 13 | 1874 | -.837 | 15 | 1924 | .410 | 16 | 1974 | .823 | 14 |
| 1725 | .112 | 1 | 1775 | .669 | 8 | 1825 | .738 | 13 | 1875 | .002 | 15 | 1925 | -.364 | 16 | 1975 | .528 | 14 |
| 1726 | -.266 | 1 | 1776 | -1.426 | 8 | 1826 | .076 | 13 | 1876 | .651 | 15 | 1926 | -.014 | 16 | 1976 | .604 | 14 |

| | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1727 | .270 | 1 | 1777 | -.066 | 8 | 1827 | .869 | 14 | | 1877 | -.996 | 16 | | 1927 | 1.070 | 16 | | 1977 | .910 | 14 | | | |
| 1728 | .311 | 1 | 1778 | -.530 | 8 | 1828 | -.139 | 14 | | 1878 | .832 | 16 | | 1928 | 1.095 | 16 | | 1978 | .650 | 14 | | | |
| 1729 | .030 | 2 | 1779 | -.420 | 8 | 1829 | .375 | 14 | | 1879 | -.768 | 16 | | 1929 | .864 | 16 | | 1979 | .129 | 14 | | | |
| 1730 | 1.043 | 2 | 1780 | 1.640 | 8 | 1830 | .676 | 14 | | 1880 | .233 | 16 | | 1930 | -.828 | 16 | | 1980 | -.244 | 14 | | | |
| 1731 | 2.089 | 2 | 1781 | 1.757 | 8 | 1831 | .625 | 14 | | 1881 | -.715 | 16 | | 1931 | -.347 | 16 | | 1981 | 1.025 | 14 | | | |
| 1732 | 1.785 | 2 | 1782 | -.433 | 8 | 1832 | .718 | 14 | | 1882 | .234 | 16 | | 1932 | .305 | 16 | | 1982 | 1.120 | 14 | | | |
| 1733 | 1.142 | 2 | 1783 | -.480 | 8 | 1833 | -.841 | 14 | | 1883 | .924 | 15 | | 1933 | -.274 | 16 | | 1983 | -.592 | 14 | | | |
| 1734 | -.966 | 2 | 1784 | .088 | 8 | 1834 | -1.075 | 14 | | 1884 | .782 | 15 | | 1934 | -1.236 | 16 | | 1984 | -1.204 | 14 | | | |
| 1735 | .461 | 2 | 1785 | .203 | 8 | 1835 | -.571 | 14 | | 1885 | .406 | 15 | | 1935 | -.602 | 16 | | 1985 | -.201 | 14 | | | |
| 1736 | -2.133 | 2 | 1786 | .089 | 8 | 1836 | -.108 | 14 | | 1886 | .078 | 15 | | 1936 | -2.372 | 16 | | 1986 | .571 | 14 | | | |
| 1737 | -1.741 | 2 | 1787 | -1.152 | 8 | 1837 | .332 | 14 | | 1887 | -.937 | 15 | | 1937 | -.302 | 16 | | 1987 | 1.812 | 14 | | | |
| 1738 | .090 | 2 | 1788 | -.845 | 8 | 1838 | -2.074 | 14 | 1 | 1888 | -1.203 | 15 | | 1938 | 1.281 | 16 | 1<< | 1988 | -2.027 | 14 | | | |
| 1739 | -.448 | 2 | 1789 | -.357 | 8 | 1839 | .467 | 14 | | 1889 | .345 | 16 | | 1939 | 2.178 | 16 | | 1989 | -1.277 | 14 | | | |
| 1740 | -2.179 | 2 | 1790 | .540 | 8 | 1840 | -.112 | 14 | | 1890 | .821 | 16 | | 1940 | -.255 | 16 | | 1990 | .246 | 14 | | | |
| 1741 | .894 | 2 | 1791 | 1.286 | 8 | 1841 | -.465 | 14 | | 1891 | 1.180 | 16 | | 1941 | -.224 | 16 | | 1991 | -.134 | 14 | | | |
| 1742 | -.401 | 2 | 1792 | .176 | 8 | 1842 | -.533 | 14 | | 1892 | .897 | 16 | | 1942 | .619 | 16 | | 1992 | -.886 | 14 | | | |
| 1743 | 1.162 | 2 | 1793 | .287 | 8 | 1843 | .213 | 14 | | 1893 | .358 | 16 | | 1943 | .513 | 16 | | 1993 | -.368 | 14 | | | |
| 1744 | -.011 | 2 | 1794 | -.980 | 8 | 1844 | .383 | 14 | | 1894 | -.664 | 16 | | 1944 | -1.275 | 16 | | 1994 | -.248 | 14 | | | |
| 1745 | -.289 | 2 | 1795 | -.360 | 8 | 1845 | .268 | 14 | | 1895 | -.989 | 16 | | 1945 | -.420 | 16 | | 1995 | .148 | 14 | | | |
| 1746 | 1.277 | 3 | 1796 | .929 | 8 | 1846 | .812 | 14 | | 1896 | -1.309 | 16 | | 1946 | .606 | 16 | | 1996 | -.043 | 14 | | | |
| 1747 | .066 | 3 | 1797 | 1.072 | 8 | 1847 | .558 | 14 | | 1897 | -.037 | 16 | | 1947 | .290 | 16 | | 1997 | -.883 | 14 | | | |
| 1748 | .903 | 3 | 1798 | .519 | 8 | 1848 | .771 | 14 | | 1898 | -1.727 | 16 | | 1948 | .327 | 16 | | 1998 | 1.197 | 14 | | | |
| 1749 | 1.930 | 3 | 1799 | -2.497 | 8 | 1849 | .180 | 14 | | 1899 | -1.213 | 16 | | 1949 | 1.039 | 16 | | 1999 | .416 | 14 | | | |
| 2000 | -.730 | 14 | | | | | | | | | | | | | | | | | | | | | |
| 2001 | .593 | 14 | | | | | | | | | | | | | | | | | | | | | |
| 2002 | .563 | 14 | | | | | | | | | | | | | | | | | | | | | |
| 2003 | -1.027 | 14 | | | | | | | | | | | | | | | | | | | | | |
| 2004 | .946 | 13 | | | | | | | | | | | | | | | | | | | | | |
| 2005 | .512 | 13 | | | | | | | | | | | | | | | | | | | | | |
| 2006 | 1.066 | 12 | | | | | | | | | | | | | | | | | | | | | |
| 2007 | -1.301 | 11 | | | | | | | | | | | | | | | | | | | | | |
| 2008 | .028 | 11 | | | | | | | | | | | | | | | | | | | | | |
| 2009 | .486 | 11 | | | | | | | | | | | | | | | | | | | | | |
| 2010 | .724 | 11 | | | | | | | | | | | | | | | | | | | | | |
| 2011 | 1.378 | 10 | | | | | | | | | | | | | | | | | | | | | |
| 2012 | -2.687 | 9 | | | | | | | | | | | | | | | | | | | | | |
| 2013 | .462 | 4 | | | | | | | | | | | | | | | | | | | | | |

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PART 4: Master Bar Plot:

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| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1750-------B | 1800-d | 1850---a | 1900--------C | 1950---------D | 2000--c | |
| | 1751--b | 1801---------D | 1851i | 1901---------D | 1951----------E | 2001-------B | |
| | 1752f | 1802-e | 1852--------C | 1902-----A | 1952----a | 2002-------B | |
| | 1753------A | 1803----------G | 1853-----A | 1903-----A | 1953-d | 2003-d | |
| | 1754--b | 1804-------B | 1854-----@ | 1904---------D | 1954f | 2004---------D | |
| | 1755----a | 1805----a | 1855-------B | 1905-----@ | 1955-e | 2005-------B | |
| | 1756----@ | 1806----------F | 1856--c | 1906-----@ | 1956--c | 2006---------D | |
| | 1757-----@ | 1807--b | 1857---b | 1907------A | 1957--------C | 2007-e | |
| 1708------A | 1758-----A | 1808---------D | 1858------A | 1908-----@ | 1958---------C | 2008-----@ | |
| 1709----------F | 1759-------B | 1809---------D | 1859--b | 1909-------B | 1959-c | 2009-------B | |
| 1710--------C | 1760-------B | 1810--b | 1860---------D | 1910---------D | 1960----------E | 2010--------C | |
| 1711w | 1761----@ | 1811----@ | 1861---------D | 1911-----A | 1961----@ | 2011----------F | |

```
1712----------E 1762----a       1812--c         1862---------D  1912----@       1962----@       2012k
1713---b        1763----a       1813-------B    1863--------C   1913--c         1963----@       2013-------B
1714-----@      1764--b         1814j           1864i           1914g           1964-----@
1715-----@      1765---a        1815-d          1865---a        1915-----@      1965--c
1716----------G 1766-------B    1816f           1866---------D  1916----------I 1966------A
1717----------E 1767---------D  1817------A     1867-c          1917---a        1967--c
1718j           1768--------C   1818--------C   1868-----@      1918-d          1968--c
1719--b         1769----a       1819-------B    1869---------D  1919--b         1969--------C
1720--------C   1770---b        1820-------B    1870---------D  1920---a        1970-d
1721f           1771--------C   1821---a        1871-d          1921---b        1971----a
1722------A     1772----a       1822--b         1872-----A      1922----------E 1972f
1723---a        1773g           1823------A     1873----@       1923-------B    1973-------B
1724t           1774------B     1824---------D  1874-c          1924------B     1974--------C
1725-----@      1775--------C   1825--------C   1875-----@      1925---a        1975-------B
1726---a        1776f           1826-----@      1876--------C   1926----@       1976-------B
1727------A     1777----@       1827---------C  1877-d          1927---------D  1977---------D
1728------A     1778--b         1828----a       1878--------C   1928---------D  1978--------C
1729-----@      1779---b        1829------A     1879--c         1929---------C  1979-----A
1730---------D  1780----------G 1830--------C   1880------A     1930-c          1980---a
1731----------H 1781----------G 1831--------B   1881--c         1931---a        1981---------D
1732----------G 1782---b        1832--------C   1882------A     1932------A     1982----------D
1733----------E 1783--b         1833-c          1883---------D  1933---a        1983--b
1734-d          1784-----@      1834-d          1884---------C  1934-e          1984-e
1735-------B    1785------A     1835--b         1885------B     1935--b         1985----a
1736i           1786-----@      1836----@       1886-----@      1936i           1986-------B
1737g           1787-e          1837------A     1887-d          1937---a        1987----------G
1738-----@      1788-c          1838h           1888-e          1938----------E 1988h
1739--b         1789---a        1839-------B    1889------A     1939----------I 1989-e
1740i           1790-------B    1840----@       1890--------C   1940---a        1990------A
1741---------D  1791----------E 1841--b         1891----------E 1941---a        1991----a
1742---b        1792-----A      1842--b         1892---------D  1942-------B    1992-d
1743----------E 1793------A     1843------A     1893------A     1943-------B    1993---a
1744----@       1794-d          1844------B     1894--c         1944-e          1994---a
1745---a        1795---a        1845------A     1895-d          1945---b        1995-----A
1746----------E 1796---------D  1846--------C   1896-e          1946-------B    1996----@
1747-----@      1797---------D  1847-------B    1897----@       1947------A     1997-d
1748---------D  1798-------B    1848--------C   1898g           1948------A     1998----------E
1749----------H 1799j           1849-----A      1899-e          1949---------D  1999-------B
```

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1725 1774 | 1750 1799 | 1775 1824 | 1800 1849 | 1825 1874 | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DWT01A | 1813 1882 | | | | .44 | .52 | .55 | | | | | |
| 2 | DWT01B | 1889 2006 | | | | | | | .58 | .56 | .56 | .63 | .63 |
| 3 | DWT02A | 1827 2013 | | | | | .29A | .51 | .61 | .69 | .75 | .71 | .76 |
| 4 | DWT02B | 1817 2013 | | | | .22B | .37 | .68 | .71 | .74 | .74 | .73 | .77 |
| 5 | DWT03A | 1764 2012 | | .49 | .57 | .64 | .67 | .56 | .31A | .54 | .63 | .56 | .56 |
| 6 | DWT03B | 1746 2010 | .43 | .50 | .64 | .52 | .58 | .59 | .35 | .47 | .43 | .49 | .52 |
| 7 | DWT04A | 1869 2013 | | | | | | .53 | .73 | .66 | .56 | .66 | .78 |
| 8 | DWT04B | 1877 2013 | | | | | | | .48 | .68 | .61 | .66 | .74 |
| 9 | DWT05A | 1820 2012 | | | | .39 | .44 | .48 | .41 | .74 | .77 | .79 | .66 |
| 10 | DWT07A | 1801 2012 | | | | .60 | .71 | .64 | .56 | .73 | .81 | .76 | .79 |
| 11 | DWT07B | 1813 2012 | | | | .71 | .73 | .78 | .72 | .71 | .83 | .77 | .73 |

```
  12 DWT07C   1768 1823        .64  .75
  13 DWT08A   1802 2011                  .67  .65  .47  .42  .81  .71  .55  .50
  14 DWT08B   1753 2003        .65  .80  .70  .59  .40  .32A .50  .57  .53  .52
  15 DWT09A   1729 2005   .63  .53  .81  .71  .61  .55  .60  .78  .74  .72  .76
  16 DWT09B   1708 2012   .66  .53  .74  .66  .47  .39  .45  .62  .68  .66  .67
  17 DWT10A   1753 1968        .46  .65  .56  .53  .72  .61  .67  .59
  18 DWT10B   1753 1968        .47  .66  .54  .32A .53  .62  .69  .59
 Av segment correlation   .57  .53  .70  .57  .53  .56  .53  .66  .66  .66  .67

PART 6:  POTENTIAL PROBLEMS:
-------------------------------------------------------------------------------------------------------------------------------------------

 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

 [B] Effect of those data values which most lower or raise correlation with master series
     Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

 [C] Year-to-year changes very different from the mean change in other series

 [D] Absent rings (zero values)

 [E] Values which are statistical outliers from mean for the year
===========================================================================================================================================

 DWT01A    1813 to  1882      70 years                                                                                    Series   1

 [B] Entire series, effect on correlation (  .492) is:
       Lower   1838> -.030   1819< -.025   1868< -.022   1839< -.017   1874> -.014   1882< -.012  Higher   1851  .056   1864  .018

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

 DWT01B    1889 to  2006     118 years                                                                                    Series   2

 [B] Entire series, effect on correlation (  .497) is:
       Lower   1938< -.137   1936> -.020   1934> -.019   1989> -.016   1899> -.010   1958< -.008  Higher   1916  .023   1939  .018

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1937 1938  -5.7 SD

 [D]    1 Absent rings:  Year   Master  N series Absent
                         1938    1.281      16       1  >> WARNING:  Ring is not usually narrow

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1938 -7.5 SD;    1989 +3.4 SD
===========================================================================================================================================

 DWT02A    1827 to  2013     187 years                                                                                    Series   3

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1827 1876    0   -.06  .06  .09  .13 -.16 -.35  .13  .16 -.21  .15  .29*-.09  .07 -.06  .15  .08 -.09  .13 -.08 -.16 -.07

 [B] Entire series, effect on correlation (  .623) is:
       Lower   1864> -.016   1833> -.014   1856> -.009   1836< -.009   1908< -.007   1885< -.007  Higher   2012  .032   1916  .011
     1827 to 1876 segment:
```

```
      Lower   1833> -.048   1856> -.032   1836< -.032   1864> -.028   1847< -.019   1872< -.018  Higher   1851  .065   1838  .025

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1833 +3.1 SD;    1972 -4.6 SD
================================================================================================================================================

 DWT02B    1817 to  2013     197 years                                                                                          Series   4

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1817 1866   -2   -.14 -.09  .23 -.09  .08 -.27 -.12  .17  .25* .02  .22| .12 -.21  .07 -.12 -.02 -.03 -.07  .03 -.13  .03

 [B] Entire series, effect on correlation (  .638) is:
      Lower   1838> -.039   1833> -.016   1970> -.009   1948< -.008   1823< -.005   1818< -.005  Higher   2012  .023   1988  .013
    1817 to 1866 segment:
      Lower   1838> -.121   1833> -.060   1823< -.021   1818< -.021   1817< -.018   1837< -.017  Higher   1851  .086   1864  .069

 [C] Year-to-year changes diverging by over 4.0 std deviations:
      1837 1838   4.2 SD

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1833 +3.5 SD;    1838 +4.1 SD
================================================================================================================================================

 DWT03A    1764 to  2012     249 years                                                                                          Series   5

 [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    0   -.14 -.05 -.16  .25  .09 -.27 -.15  .00  .03  .06  .31* .10 -.11 -.12 -.02  .15  .21 -.06  .02 -.01 -.04

 [B] Entire series, effect on correlation (  .539) is:
      Lower   2001< -.025   1916< -.022   1960< -.020   1776> -.019   1787< -.018   1773> -.013  Higher   1799  .018   1864  .015
    1875 to 1924 segment:
      Lower   1916< -.126   1887> -.069   1878< -.023   1893< -.015   1919> -.013   1905< -.012  Higher   1922  .042   1914  .036

 [D]    1 Absent rings:  Year   Master  N series Absent
                         1838   -2.074      14       1

 [E] Outliers     7   3.0 SD above or -4.5 SD below mean for year
      1773 +3.2 SD;    1776 +3.8 SD;    1787 -6.4 SD;    1887 +3.7 SD;    1916 -4.7 SD;    1960 -4.8 SD;    2001 -5.8 SD
================================================================================================================================================

 DWT03B    1746 to  2010     265 years                                                                                          Series   6

 [B] Entire series, effect on correlation (  .518) is:
      Lower   1969< -.028   1928< -.023   1838> -.012   1907< -.009   1888> -.007   1750> -.007  Higher   1988  .014   1864  .014

 [C] Year-to-year changes diverging by over 4.0 std deviations:
      1969 1970   4.4 SD

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1888 +3.1 SD;    1928 -5.5 SD;    1969 -6.6 SD
================================================================================================================================================

 DWT04A    1869 to  2013     145 years                                                                                          Series   7

 [B] Entire series, effect on correlation (  .659) is:
      Lower   1869< -.024   1871> -.015   1873> -.015   1979< -.012   1942< -.011   1954> -.007  Higher   1988  .034   2012  .028
```

```
 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1873 +3.7 SD
=================================================================================================================================

 DWT04B    1877 to  2013     137 years                                                                          Series   8

 [B] Entire series, effect on correlation (  .618) is:
       Lower   1881> -.020   1879> -.014   1959> -.013   1978< -.010   1922< -.008   1887> -.008  Higher   1988  .034   2012  .026

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1881 +3.4 SD;    1898 -5.7 SD
=================================================================================================================================

 DWT05A    1820 to  2012     193 years                                                                          Series   9

 [B] Entire series, effect on correlation (  .553) is:
       Lower   1838> -.017   1898> -.016   1886< -.013   1836< -.013   1844< -.011   1899< -.010  Higher   1988  .023   1936  .011

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1836 -4.8 SD;    1898 +3.0 SD
=================================================================================================================================

 DWT07A    1801 to  2012     212 years                                                                          Series  10

 [B] Entire series, effect on correlation (  .694) is:
       Lower   1833< -.014   1815> -.008   1806< -.008   1915< -.007   1897> -.007   1889< -.006  Higher   1838  .015   2012  .013

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1815 +3.2 SD;    1897 +3.4 SD
=================================================================================================================================

 DWT07B    1813 to  2012     200 years                                                                          Series  11

 [B] Entire series, effect on correlation (  .751) is:
       Lower   1978< -.013   1917> -.012   2000> -.010   1859> -.007   2003> -.006   1850< -.005  Higher   1988  .017   1838  .013

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

 DWT07C    1768 to  1823      56 years                                                                          Series  12

 [B] Entire series, effect on correlation (  .635) is:
       Lower   1773> -.058   1770< -.026   1800> -.019   1817< -.013   1769> -.013   1790< -.012  Higher   1814  .064   1799  .045

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1773 +3.1 SD
=================================================================================================================================

 DWT08A    1802 to  2011     210 years                                                                          Series  13

 [B] Entire series, effect on correlation (  .592) is:
       Lower   1877> -.018   1884< -.011   1972> -.011   1876< -.010   1878< -.009   1826< -.007  Higher   1988  .015   1838  .015

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1851 -4.8 SD;    1877 +3.2 SD
=================================================================================================================================

 DWT08B    1753 to  2003     251 years                                                                          Series  14
```

```
 [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    0   -.09  .09  .01 -.04  .11 -.03 -.13 -.10 -.26 -.02  .32*-.01  .28  .09  .09 -.11  .10  .01 -.16 -.17 -.02

 [B] Entire series, effect on correlation (  .549) is:
       Lower   1881> -.014   1898> -.011   1871> -.011   1867> -.009   1907< -.009   1998< -.009  Higher   1838  .020   1864  .018
     1875 to 1924 segment:
       Lower   1881> -.060   1898> -.051   1907< -.034   1888> -.026   1884< -.019   1910< -.018  Higher   1916  .062   1922  .031

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
       1871 +3.0 SD;    1881 +4.1 SD;    1896 -5.8 SD
==========================================================================================================================================

 DWT09A    1729 to  2005     277 years                                                                                  Series  15

 [B] Entire series, effect on correlation (  .672) is:
       Lower   1833< -.012   1891< -.009   1765> -.007   1755> -.006   1788> -.005   1953> -.005  Higher   1838  .012   1814  .009

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1833 -7.0 SD
==========================================================================================================================================

 DWT09B    1708 to  2012     305 years                                                                                  Series  16

 [*] Early part of series cannot be checked from 1708 to 1728 -- not matched by another series

 [B] Entire series, effect on correlation (  .604) is:
       Lower   1892< -.015   1906< -.012   1765> -.010   1851> -.009   1860< -.007   1817< -.007  Higher   1838  .013   1814  .009

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1765 +3.6 SD;    1906 -4.9 SD
==========================================================================================================================================

 DWT10A    1753 to  1968     216 years                                                                                  Series  17

 [B] Entire series, effect on correlation (  .568) is:
       Lower   1837< -.013   1851> -.008   1845< -.008   1769> -.008   1910< -.008   1784< -.007  Higher   1814  .019   1838  .016

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

 DWT10B    1753 to  1968     216 years                                                                                  Series  18

 [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   -.14  .08  .15 -.02  .01  .03  .13  .27  .16 -.25  .32* .10 -.31 -.16  .05 -.04  .00  .06 -.14 -.05  .01

 [B] Entire series, effect on correlation (  .524) is:
       Lower   1851> -.015   1951< -.009   1837< -.009   1827< -.008   1765< -.007   1874> -.006  Higher   1814  .016   1936  .016
     1825 to 1874 segment:
       Lower   1851> -.045   1837< -.030   1827< -.028   1844< -.024   1874> -.022   1873< -.020  Higher   1838  .065   1864  .046

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1753 +3.1 SD;    1851 +3.4 SD
==========================================================================================================================================
```

PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DWT01A | 1813 1882 | 70 | 3 | 0 | .492 | 2.11 | 4.84 | .840 | .439 | .314 | 2.77 | .552 | -.034 | 1 |
| 2 | DWT01B | 1889 2006 | 118 | 5 | 0 | .497 | 1.83 | 6.71 | 1.175 | .699 | .372 | 2.74 | .384 | -.111 | 1 |
| 3 | DWT02A | 1827 2013 | 187 | 7 | 1 | .623 | 1.54 | 5.96 | 1.026 | .665 | .332 | 2.85 | .406 | -.036 | 1 |
| 4 | DWT02B | 1817 2013 | 197 | 8 | 1 | .638 | 1.67 | 6.07 | 1.250 | .712 | .336 | 2.91 | .509 | -.011 | 3 |
| 5 | DWT03A | 1764 2012 | 249 | 10 | 1 | .539 | 1.22 | 3.37 | .591 | .235 | .509 | 2.68 | .399 | -.021 | 1 |
| 6 | DWT03B | 1746 2010 | 265 | 11 | 0 | .518 | 1.17 | 3.90 | .645 | .308 | .515 | 2.88 | .512 | .008 | 1 |
| 7 | DWT04A | 1869 2013 | 145 | 6 | 0 | .659 | 1.39 | 4.28 | .867 | .633 | .297 | 2.93 | .441 | -.050 | 1 |
| 8 | DWT04B | 1877 2013 | 137 | 5 | 0 | .618 | .85 | 2.80 | .556 | .678 | .282 | 2.79 | .386 | -.036 | 2 |
| 9 | DWT05A | 1820 2012 | 193 | 8 | 0 | .553 | 2.31 | 6.83 | 1.191 | .487 | .413 | 2.65 | .474 | -.031 | 1 |
| 10 | DWT07A | 1801 2012 | 212 | 8 | 0 | .694 | 2.24 | 6.21 | 1.213 | .696 | .330 | 2.74 | .454 | -.034 | 1 |
| 11 | DWT07B | 1813 2012 | 200 | 8 | 0 | .751 | 2.58 | 5.90 | 1.035 | .557 | .308 | 2.58 | .436 | -.001 | 1 |
| 12 | DWT07C | 1768 1823 | 56 | 2 | 0 | .635 | 1.61 | 4.55 | .856 | .445 | .431 | 2.73 | .563 | -.017 | 1 |
| 13 | DWT08A | 1802 2011 | 210 | 8 | 0 | .592 | 1.45 | 9.04 | 1.046 | .621 | .415 | 2.69 | .373 | -.021 | 1 |
| 14 | DWT08B | 1753 2003 | 251 | 10 | 1 | .549 | 1.25 | 4.58 | .807 | .530 | .431 | 2.74 | .446 | -.011 | 1 |
| 15 | DWT09A | 1729 2005 | 277 | 11 | 0 | .672 | 1.54 | 8.94 | 1.042 | .690 | .347 | 2.72 | .379 | -.032 | 1 |
| 16 | DWT09B | 1708 2012 | 305 | 11 | 0 | .604 | 1.58 | 6.83 | .977 | .587 | .361 | 2.81 | .374 | -.030 | 1 |
| 17 | DWT10A | 1753 1968 | 216 | 8 | 0 | .568 | 1.01 | 2.13 | .388 | .674 | .257 | 2.66 | .434 | -.020 | 1 |
| 18 | DWT10B | 1753 1968 | 216 | 8 | 1 | .524 | 1.00 | 2.19 | .391 | .684 | .254 | 2.73 | .482 | -.034 | 1 |
| Total or mean: | | | 3504 | 137 | 5 | .598 | 1.54 | 9.04 | .878 | .573 | .367 | 2.93 | .435 | -.026 | |

# APPENDIX S

## COFECHA PROGRAM OUTPUT FOR DONALDSON WOODS SITE CHRONOLOGY,

## *CARYA OVATA*, INDIANA, U.S.A

```
P R O G R A M     C O F E C H A                                          Version 6.06P    29368

QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

File of DATED series:   dwo_dated.txt

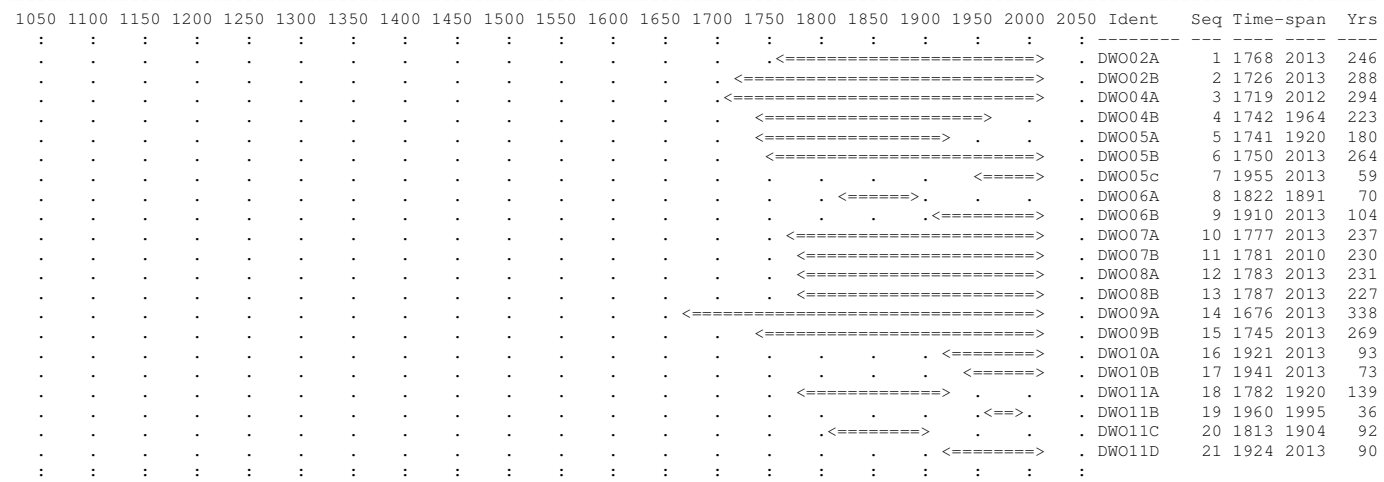
Time span of Master dating series is  1676 to  2013   338 years
Continuous time span is               1676 to  2013   338 years
Portion with two or more series is    1719 to  2013   295 years


                                    ***************************************
                                    *C* Number of dated series        21 *C*
                                    *O* Master series 1676 2013  338 yrs *O*
                                    *F* Total rings in all series   3783 *F*
                                    *E* Total dated rings checked   3740 *E*
                                    *C* Series intercorrelation     .618 *C*
                                    *H* Average mean sensitivity    .272 *H*
                                    *A* Segments, possible problems    4 *A*
                                    *** Mean length of series      180.1 ***
                                    ***************************************

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

              No ring measurements of zero value
```

PART 2: TIME PLOT OF TREE-RING SERIES:




PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1700 | 1.583 | 1 | 1750 | -.551 | 7 | 1800 | -1.070 | 13 | 1850 | .370 | 15 | 1900 | .052 | 14 |
| 1701 | -1.234 | 1 | 1751 | -.233 | 7 | 1801 | -.168 | 13 | 1851 | -.529 | 15 | 1901 | -.225 | 14 |
| 1702 | -.785 | 1 | 1752 | .295 | 7 | 1802 | 1.030 | 13 | 1852 | 1.188 | 15 | 1902 | .620 | 14 |
| 1703 | .137 | 1 | 1753 | -.027 | 7 | 1803 | -.723 | 13 | 1853 | .316 | 15 | 1903 | .350 | 14 |
| 1704 | -.891 | 1 | 1754 | .195 | 7 | 1804 | -.458 | 13 | 1854 | 1.062 | 15 | 1904 | .877 | 14 |
| 1705 | -.986 | 1 | 1755 | .025 | 7 | 1805 | .962 | 13 | 1855 | -2.995 | 15 | 1905 | .257 | 13 |
| 1706 | .775 | 1 | 1756 | .604 | 7 | 1806 | -.684 | 13 | 1856 | -1.439 | 15 | 1906 | .271 | 13 |
| 1707 | .523 | 1 | 1757 | -.169 | 7 | 1807 | -.780 | 13 | 1857 | -.555 | 15 | 1907 | .933 | 13 |
| 1708 | -1.415 | 1 | 1758 | .008 | 7 | 1808 | -1.155 | 13 | 1858 | -.002 | 15 | 1908 | -.611 | 13 |
| 1709 | -2.252 | 1 | 1759 | .586 | 7 | 1809 | .514 | 13 | 1859 | -1.162 | 15 | 1909 | -2.064 | 13 |
| 1710 | 1.942 | 1 | 1760 | 1.442 | 7 | 1810 | .587 | 13 | 1860 | .454 | 15 | 1910 | .753 | 14 |
| 1711 | 1.674 | 1 | 1761 | .592 | 7 | 1811 | .238 | 13 | 1861 | .499 | 15 | 1911 | -1.292 | 14 |
| 1712 | 1.121 | 1 | 1762 | -.208 | 7 | 1812 | 1.324 | 13 | 1862 | 1.704 | 15 | 1912 | .629 | 14 |
| 1713 | -.302 | 1 | 1763 | .169 | 7 | 1813 | .513 | 14 | 1863 | .226 | 15 | 1913 | -.661 | 14 |
| 1714 | .607 | 1 | 1764 | .525 | 7 | 1814 | 1.518 | 14 | 1864 | -.274 | 15 | 1914 | -1.447 | 14 |
| 1715 | -.834 | 1 | 1765 | .408 | 7 | 1815 | -1.645 | 14 | 1865 | -.749 | 15 | 1915 | 1.064 | 14 |
| 1716 | .972 | 1 | 1766 | .489 | 7 | 1816 | -1.147 | 14 | 1866 | .771 | 15 | 1916 | 2.370 | 14 |
| 1717 | .867 | 1 | 1767 | .103 | 7 | 1817 | -1.001 | 14 | 1867 | -.397 | 15 | 1917 | .662 | 14 |
| 1718 | -.337 | 1 | 1768 | .551 | 8 | 1818 | .140 | 14 | 1868 | -.136 | 15 | 1918 | -.479 | 14 |
| 1719 | 1.111 | 2 | 1769 | .916 | 8 | 1819 | .069 | 14 | 1869 | 1.110 | 15 | 1919 | -.768 | 14 |
| 1720 | .281 | 2 | 1770 | -.141 | 8 | 1820 | -.415 | 14 | 1870 | -.184 | 15 | 1920 | -.145 | 14 |
| 1721 | -1.701 | 2 | 1771 | -1.142 | 8 | 1821 | .071 | 14 | 1871 | -1.387 | 15 | 1921 | -.317 | 13 |
| 1722 | -.179 | 2 | 1772 | -.332 | 8 | 1822 | -.695 | 15 | 1872 | 1.352 | 15 | 1922 | .618 | 13 |
| 1723 | -.379 | 2 | 1773 | -.868 | 8 | 1823 | .566 | 15 | 1873 | .505 | 15 | 1923 | .724 | 13 |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1724 | -4.063 | 2 | 1774 | -1.917 | 8 | 1824 | 1.322 | 15 | 1874 | -1.317 | 15 | 1924 | 1.098 | 14 |
| | | | 1725 | .261 | 2 | 1775 | -.833 | 8 | 1825 | .638 | 15 | 1875 | .276 | 15 | 1925 | -.933 | 14 |
| 1676 | 1.568 | 1 | 1726 | .671 | 3 | 1776 | .207 | 8 | 1826 | .149 | 15 | 1876 | .807 | 15 | 1926 | .025 | 14 |
| 1677 | -.138 | 1 | 1727 | 1.133 | 3 | 1777 | .161 | 9 | 1827 | -2.247 | 15 | 1877 | .671 | 15 | 1927 | .357 | 14 |
| 1678 | -.170 | 1 | 1728 | 1.411 | 3 | 1778 | .178 | 9 | 1828 | .102 | 15 | 1878 | .868 | 15 | 1928 | 1.389 | 14 |
| 1679 | 1.279 | 1 | 1729 | -.430 | 3 | 1779 | .685 | 9 | 1829 | -.630 | 15 | 1879 | -.885 | 15 | 1929 | .044 | 14 |
| 1680 | -1.328 | 1 | 1730 | -1.414 | 3 | 1780 | -.209 | 9 | 1830 | 1.034 | 15 | 1880 | .401 | 15 | 1930 | -1.056 | 14 |
| 1681 | -1.128 | 1 | 1731 | -.738 | 3 | 1781 | -.287 | 10 | 1831 | -.030 | 15 | 1881 | -.386 | 15 | 1931 | -.924 | 14 |
| 1682 | -2.830 | 1 | 1732 | .908 | 3 | 1782 | .012 | 11 | 1832 | .696 | 15 | 1882 | -1.243 | 15 | 1932 | .260 | 14 |
| 1683 | .743 | 1 | 1733 | 1.070 | 3 | 1783 | -.369 | 12 | 1833 | .838 | 15 | 1883 | .576 | 15 | 1933 | -.191 | 14 |
| 1684 | .761 | 1 | 1734 | .685 | 3 | 1784 | -2.148 | 12 | 1834 | -.705 | 15 | 1884 | .835 | 15 | 1934 | -1.051 | 14 |
| 1685 | -.863 | 1 | 1735 | 1.096 | 3 | 1785 | .005 | 12 | 1835 | .857 | 15 | 1885 | -.295 | 15 | 1935 | .755 | 14 |
| 1686 | 1.321 | 1 | 1736 | -1.267 | 3 | 1786 | .497 | 12 | 1836 | 1.384 | 15 | 1886 | .522 | 15 | 1936 | -1.104 | 14 |
| 1687 | .986 | 1 | 1737 | .740 | 3 | 1787 | 1.117 | 13 | 1837 | .827 | 15 | 1887 | -.813 | 15 | 1937 | -1.398 | 14 |
| 1688 | 1.323 | 1 | 1738 | .844 | 3 | 1788 | .684 | 13 | 1838 | .124 | 15 | 1888 | -2.090 | 15 | 1938 | 1.641 | 14 |
| 1689 | .039 | 1 | 1739 | .431 | 3 | 1789 | .264 | 13 | 1839 | -3.398 | 15 | 1889 | 1.435 | 15 | 1939 | .481 | 14 |
| 1690 | .522 | 1 | 1740 | 1.064 | 3 | 1790 | .501 | 13 | 1840 | -2.266 | 15 | 1890 | 1.537 | 15 | 1940 | -.089 | 14 |
| 1691 | 1.364 | 1 | 1741 | -.787 | 4 | 1791 | -.105 | 13 | 1841 | -.859 | 15 | 1891 | -1.266 | 15 | 1941 | -.899 | 15 |
| 1692 | -.439 | 1 | 1742 | .364 | 5 | 1792 | .215 | 13 | 1842 | -.144 | 15 | 1892 | .768 | 14 | 1942 | 1.500 | 15 |
| 1693 | -3.424 | 1 | 1743 | -.859 | 5 | 1793 | .921 | 13 | 1843 | -.292 | 15 | 1893 | -.222 | 14 | 1943 | -.632 | 15 |
| 1694 | -1.177 | 1 | 1744 | -1.177 | 5 | 1794 | .462 | 13 | 1844 | .565 | 15 | 1894 | -.163 | 14 | 1944 | -1.559 | 15 |
| 1695 | 1.305 | 1 | 1745 | -.695 | 6 | 1795 | -1.908 | 13 | 1845 | .688 | 15 | 1895 | -1.234 | 14 | 1945 | 1.691 | 15 |
| 1696 | .468 | 1 | 1746 | -.189 | 6 | 1796 | -.643 | 13 | 1846 | .429 | 15 | 1896 | -.466 | 14 | 1946 | .408 | 15 |
| 1697 | .728 | 1 | 1747 | 1.461 | 6 | 1797 | 1.138 | 13 | 1847 | .514 | 15 | 1897 | 1.041 | 14 | 1947 | -.552 | 15 |
| 1698 | -1.100 | 1 | 1748 | -.758 | 6 | 1798 | 1.339 | 13 | 1848 | .249 | 15 | 1898 | -.789 | 14 | 1948 | .322 | 15 |
| 1699 | 1.231 | 1 | 1749 | -2.184 | 6 | 1799 | -.410 | 13 | 1849 | .843 | 15 | 1899 | -.095 | 14 | 1949 | .069 | 15 |

PART 3: Master Dating Series:

| Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab | Year | Value | No Ab |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1950 | .493 | 15 | 2000 | 1.151 | 15 | | | | | | | | | | | | |
| 1951 | .090 | 15 | 2001 | .075 | 15 | | | | | | | | | | | | |
| 1952 | -.334 | 15 | 2002 | .268 | 15 | | | | | | | | | | | | |
| 1953 | -1.634 | 15 | 2003 | -.728 | 15 | | | | | | | | | | | | |
| 1954 | -.472 | 15 | 2004 | .596 | 15 | | | | | | | | | | | | |
| 1955 | -.422 | 16 | 2005 | -.360 | 15 | | | | | | | | | | | | |
| 1956 | -.439 | 16 | 2006 | 1.126 | 15 | | | | | | | | | | | | |
| 1957 | -.611 | 16 | 2007 | -1.154 | 15 | | | | | | | | | | | | |
| 1958 | 1.361 | 16 | 2008 | -.284 | 15 | | | | | | | | | | | | |
| 1959 | .402 | 16 | 2009 | .330 | 15 | | | | | | | | | | | | |
| 1960 | 2.556 | 17 | 2010 | .575 | 15 | | | | | | | | | | | | |
| 1961 | -.840 | 17 | 2011 | .530 | 14 | | | | | | | | | | | | |
| 1962 | .137 | 17 | 2012 | -1.460 | 14 | | | | | | | | | | | | |
| 1963 | .564 | 17 | 2013 | .381 | 13 | | | | | | | | | | | | |
| 1964 | .201 | 17 | | | | | | | | | | | | | | | |
| 1965 | .366 | 16 | | | | | | | | | | | | | | | |
| 1966 | .050 | 16 | | | | | | | | | | | | | | | |
| 1967 | -.985 | 16 | | | | | | | | | | | | | | | |
| 1968 | -.433 | 16 | | | | | | | | | | | | | | | |
| 1969 | -1.046 | 16 | | | | | | | | | | | | | | | |
| 1970 | -.873 | 16 | | | | | | | | | | | | | | | |
| 1971 | -.740 | 16 | | | | | | | | | | | | | | | |
| 1972 | -.598 | 16 | | | | | | | | | | | | | | | |

```
 1973  1.135  16
 1974  1.342  16
 1975   .085  16
 1976  2.030  16
 1977  -.167  16
 1978   .802  16
 1979   .083  16

 1980  -.763  16
 1981 -2.092  16
 1982   .372  16
 1983   .259  16
 1984 -1.311  16
 1985   .264  16
 1986  1.494  16
 1987 -1.362  16
 1988 -1.706  16
 1989  -.043  16

 1990  1.583  16
 1991  -.227  16
 1992   .601  16
 1993   .557  16
 1994  -.269  16
 1995   .140  16
 1996  -.477  15
 1997  -.530  15
 1998  -.544  15
 1999   .874  15
```

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PART 4: Master Bar Plot:

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| Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value | Year Rel value |
|---|---|---|---|---|---|---|---|
| | 1700----------F | 1750---b | 1800-d | 1850------A | 1900-----@ | 1950-------B | 2000---------E |
| | 1701-e | 1751----a | 1801----a | 1851---b | 1901----a | 1951-----@ | 2001-----@ |
| | 1702--c | 1752------A | 1802---------D | 1852---------E | 1902-------B | 1952---a | 2002------A |
| | 1703-----A | 1753-----@ | 1803--c | 1853------A | 1903------A | 1953g | 2003--c |
| | 1704--d | 1754-----A | 1804---b | 1854---------D | 1904--------D | 1954---b | 2004-------B |
| | 1705-d | 1755-----@ | 1805---------D | 1855l | 1905------A | 1955---b | 2005---a |
| | 1706--------C | 1756-------B | 1806--c | 1856f | 1906------A | 1956---b | 2006---------E |
| | 1707-------B | 1757----a | 1807--c | 1857---b | 1907---------D | 1957--b | 2007-e |
| | 1708f | 1758-----@ | 1808-e | 1858-----@ | 1908--b | 1958----------E | 2008----a |
| | 1709i | 1759-------B | 1809-------B | 1859-e | 1909h | 1959------B | 2009------A |
| | 1710----------H | 1760----------F | 1810-------B | 1860-------B | 1910--------C | 1960----------J | 2010-------B |
| | 1711----------G | 1761-------B | 1811------A | 1861-------B | 1911-e | 1961--c | 2011-------B |
| | 1712---------D | 1762----a | 1812----------E | 1862----------G | 1912-------C | 1962-----A | 2012f |
| | 1713---a | 1763-----A | 1813-------B | 1863------A | 1913--c | 1963-------B | 2013------B |
| | 1714-------B | 1764-------B | 1814----------F | 1864----a | 1914f | 1964-----A | |
| | 1715--c | 1765------B | 1815g | 1865--c | 1915---------D | 1965------A | |
| | 1716---------D | 1766-------B | 1816-e | 1866--------C | 1916----------I | 1966-----@ | |
| | 1717--------C | 1767-----@ | 1817-d | 1867---b | 1917--------C | 1967-d | |
| | 1718---a | 1768-------B | 1818-----A | 1868----a | 1918---b | 1968---b | |
| | 1719---------D | 1769---------D | 1819-----@ | 1869---------D | 1919--c | 1969-d | |
| | 1720------A | 1770----a | 1820---b | 1870----a | 1920----a | 1970--c | |
| | 1721g | 1771-e | 1821-----@ | 1871-f | 1921---a | 1971--c | |
| | 1722----a | 1772---a | 1822--c | 1872----------E | 1922-------B | 1972--b | |
| | 1723---b | 1773--c | 1823-------B | 1873-------B | 1923--------C | 1973---------E | |
| | 1724p | 1774h | 1824----------E | 1874-e | 1924---------D | 1974----------E | |

```
                1725------A     1775--c         1825-------C    1875------A     1925-d          1975-----@
  1676----------F 1726--------C   1776-----A      1826-----A      1876--------C   1926-----@      1976----------H
  1677----a       1727---------E  1777-----A      1827i           1877--------C   1927------A     1977----a
  1678----a       1728----------F 1778-----A      1828-----@      1878--------C   1928----------F 1978--------C
  1679---------E  1729---b        1779--------C   1829--c         1879--d         1929-----@      1979-----@
  1680-e          1730f           1780----a       1830---------D  1880------B     1930-d          1980--c
  1681-e          1731--c         1781----a       1831-----@      1881---b        1931-d          1981h
  1682k           1732--------D   1782-----@      1832---------C  1882-e          1932------A     1982------A
  1683--------C   1733---------D  1783---a        1833--------C   1883-------B    1933----a       1983------A
  1684--------C   1734--------C   1784i           1834--c         1884--------C   1934-d          1984-e
  1685--c         1735---------D  1785-----@      1835---------C  1885---a        1935---------C  1985------A
  1686----------E 1736-e          1786-------B    1836----------F 1886-------B    1936-d          1986----------F
  1687---------D  1737--------C   1787---------D  1837--------C   1887--c         1937-f          1987-e
  1688----------E 1738--------C   1788--------C   1838-----@      1888h           1938----------G 1988g
  1689-----@      1739------B     1789------A     1839n           1889----------F 1939-------B    1989----@
  1690-------B    1740---------D  1790-------B    1840i           1890----------F 1940----@       1990----------F
  1691----------E 1741--c         1791----@       1841--c         1891-e          1941--d         1991----a
  1692---b        1742------A     1792-----A      1842----a       1892--------C   1942----------F 1992-------B
  1693n           1743--c         1793---------D  1843---a        1893----a       1943--c         1993-------B
  1694-e          1744-e          1794-------B    1844-------B    1894----a       1944f           1994----a
  1695----------E 1745--c         1795h           1845--------C   1895-e          1945----------G 1995-----A
  1696-------B    1746----a       1796--c         1846------B     1896---b        1946------B     1996---b
  1697--------C   1747----------F 1797---------E  1847-------B    1897---------D  1947---b        1997---b
  1698-d          1748--c         1798----------E 1848------A     1898--c         1948------A     1998---b
  1699---------E  1749i           1799---b        1849--------C   1899----@       1949-----@      1999--------C
```

PART 5: CORRELATION OF SERIES BY SEGMENTS:

Correlations of 50-year dated segments, lagged 25 years
Flags: A = correlation under .3281 but highest as dated; B = correlation higher at other than dated position

| Seq | Series | Time_span | 1700 1749 | 1725 1774 | 1750 1799 | 1775 1824 | 1800 1849 | 1825 1874 | 1850 1899 | 1875 1924 | 1900 1949 | 1925 1974 | 1950 1999 | 1975 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DWO02A | 1768 2013 | | | .47 | .50 | .61 | .78 | .70 | .71 | .82 | .69 | .67 | .51 |
| 2 | DWO02B | 1726 2013 | | .46 | .44 | .46 | .57 | .74 | .67 | .53 | .36 | .43 | .64 | .61 |
| 3 | DWO04A | 1719 2012 | .30A | .39 | .23A | .48 | .63 | .66 | .72 | .75 | .78 | .72 | .41 | .39 |
| 4 | DWO04B | 1742 1964 | | .39 | .37 | .56 | .81 | .65 | .64 | .81 | .74 | .62 | | |
| 5 | DWO05A | 1741 1920 | | .11B | .28A | .46 | .67 | .63 | .66 | .70 | | | | |
| 6 | DWO05B | 1750 2013 | | | .35 | .53 | .76 | .83 | .73 | .64 | .59 | .57 | .47 | .41 |
| 7 | DWO05c | 1955 2013 | | | | | | | | | | | .57 | .59 |
| 8 | DWO06A | 1822 1891 | | | | | .70 | .71 | .72 | | | | | |
| 9 | DWO06B | 1910 2013 | | | | | | | | | .59 | .61 | .66 | .72 |
| 10 | DWO07A | 1777 2013 | | | | .57 | .75 | .78 | .60 | .54 | .67 | .76 | .74 | .59 |
| 11 | DWO07B | 1781 2010 | | | | .69 | .72 | .76 | .71 | .64 | .72 | .68 | .54 | .48 |
| 12 | DWO08A | 1783 2013 | | | | .68 | .65 | .57 | .55 | .69 | .71 | .60 | .55 | .53 |
| 13 | DWO08B | 1787 2013 | | | | .67 | .67 | .73 | .75 | .80 | .80 | .75 | .77 | .73 |
| 14 | DWO09A | 1676 2013 | .44 | .59 | .64 | .74 | .63 | .59 | .54 | .42 | .55 | .75 | .66 | .50 |
| 15 | DWO09B | 1745 2013 | | .59 | .48 | .63 | .72 | .65 | .57 | .72 | .80 | .81 | .87 | .80 |
| 16 | DWO10A | 1921 2013 | | | | | | | | | .54 | .61 | .66 | .63 |
| 17 | DWO10B | 1941 2013 | | | | | | | | | | .70 | .59 | .53 |
| 18 | DWO11A | 1782 1920 | | | | .60 | .81 | .70 | .45 | .44 | | | | |
| 19 | DWO11B | 1960 1995 | | | | | | | | | | | .73 | |
| 20 | DWO11C | 1813 1904 | | | | | .83 | .82 | .70 | .70 | | | | |
| 21 | DWO11D | 1924 2013 | | | | | | | | | .65 | .67 | .71 | .64 |
| Av segment correlation | | | .37 | .42 | .41 | .58 | .70 | .71 | .65 | .65 | .67 | .66 | .64 | .58 |

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

[B] Effect of those data values which most lower or raise correlation with master series
Symbol following year indicates value in series is greater (>) or lesser (<) than master series value

[C] Year-to-year changes very different from the mean change in other series

[D] Absent rings (zero values)

[E] Values which are statistical outliers from mean for the year

---

DWO02A 1768 to 2013 246 years Series 1

[B] Entire series, effect on correlation ( .654) is:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower | 2006< -.010 | 1892< -.007 | 1818> -.006 | 1768< -.006 | 1894< -.006 | 1816> -.006 | Higher | 1855 | .025 | 1784 | .006 |

[E] Outliers 3 3.0 SD above or -4.5 SD below mean for year
1772 +3.3 SD; 1816 +3.1 SD; 1818 +3.8 SD

---

DWO02B 1726 to 2013 288 years Series 2

[B] Entire series, effect on correlation ( .553) is:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower | 1927< -.041 | 1914> -.012 | 1817> -.009 | 1819< -.009 | 1758< -.008 | 1762> -.007 | Higher | 1855 | .027 | 1827 | .009 |

[C] Year-to-year changes diverging by over 4.0 std deviations:
1926 1927 -4.4 SD

[E] Outliers 6 3.0 SD above or -4.5 SD below mean for year
1762 +3.5 SD; 1778 +3.6 SD; 1817 +3.9 SD; 1857 +3.1 SD; 1914 +4.2 SD; 1927 -6.7 SD

---

DWO04A 1719 to 2012 294 years Series 3

[A]

| Segment | High | -10 | -9 | -8 | -7 | -6 | -5 | -4 | -3 | -2 | -1 | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 | +10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1719 1768 | 0 | -.06 | -.13 | -.03 | .08 | .28 | -.08 | -.15 | -.20 | -.21 | .27 | .30* | .02 | .08 | .16 | -.13 | .01 | .10 | .12 | .21 | -.01 | -.26 |
| 1750 1799 | 0 | .03 | -.02 | .12 | .10 | -.01 | -.02 | .18 | -.15 | .06 | .21 | .23* | .12 | -.12 | -.04 | .11 | .01 | -.06 | .05 | .19 | .04 | -.23 |

[B] Entire series, effect on correlation ( .506) is:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower | 1724> -.045 | 1976< -.037 | 1748> -.017 | 1778< -.009 | 1776< -.008 | 1742< -.008 | Higher | 1855 | .020 | 1815 | .008 |
| 1719 to 1768 segment: | | | | | | | | | | | |
| Lower | 1748> -.071 | 1724> -.066 | 1742< -.042 | 1722< -.024 | 1729> -.011 | 1761< -.009 | Higher | 1749 | .041 | 1721 | .029 |
| 1750 to 1799 segment: | | | | | | | | | | | |
| Lower | 1778< -.066 | 1776< -.059 | 1784> -.032 | 1780> -.016 | 1761< -.013 | 1763< -.011 | Higher | 1760 | .043 | 1798 | .039 |

[C] Year-to-year changes diverging by over 4.0 std deviations:
1723 1724 5.0 SD 1724 1725 -5.0 SD 1975 1976 -4.4 SD

[E] Outliers 6 3.0 SD above or -4.5 SD below mean for year

```
      1724 +7.0 SD;    1748 +4.2 SD;    1870 +4.0 SD;    1940 +3.0 SD;    1975 +3.1 SD;    1976 -5.0 SD
================================================================================================================================================

 DWO04B    1742 to  1964     223 years                                                                                          Series   4

 [B] Entire series, effect on correlation (  .638) is:
      Lower   1784> -.007   1861< -.006   1795> -.006   1778< -.006   1770> -.005   1956< -.005  Higher   1839  .028   1815  .007

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

 DWO05A    1741 to  1920     180 years                                                                                          Series   5

 [A] Segment   High   -10   -9   -8   -7   -6   -5   -4   -3   -2   -1   +0   +1   +2   +3   +4   +5   +6   +7   +8   +9  +10
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1741 1790  -10    .20* .17  .12 -.01  .02 -.06  .11  .11 -.03  .14  .11| .04 -.13  .17  .05  .05 -.04 -.12 -.16 -.32 -.02
    1750 1799    0    .16  .03  .00  .03  .02 -.10  .18  .09 -.21 -.10  .28* .25 -.15 -.12  .19  .12 -.05 -.03 -.05 -.08 -.19

 [B] Entire series, effect on correlation (  .550) is:
      Lower   1873< -.013   1867< -.010   1775> -.009   1748> -.009   1754< -.008   1747< -.007  Higher   1855  .031   1795  .012
     1741 to 1790 segment:
      Lower   1775> -.033   1754< -.030   1761< -.023   1780> -.021   1747< -.019   1748> -.018  Higher   1784  .079   1749  .071
     1750 to 1799 segment:
      Lower   1775> -.043   1796> -.031   1780> -.028   1754< -.026   1763> -.023   1761< -.019  Higher   1795  .110   1784  .058

 [E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
      1742 +3.6 SD;    1763 +3.7 SD;    1775 +3.1 SD
================================================================================================================================================

 DWO05B    1750 to  2013     264 years                                                                                          Series   6

 [B] Entire series, effect on correlation (  .596) is:
      Lower   1988> -.008   1996> -.007   1982< -.007   2000< -.007   1775> -.007   1993< -.006  Higher   1839  .029   1855  .023

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1750 +3.1 SD;    1988 +3.0 SD
================================================================================================================================================

 DWO05c    1955 to  2013      59 years                                                                                          Series   7

 [B] Entire series, effect on correlation (  .616) is:
      Lower   1993< -.032   1996> -.031   1988> -.027   2003< -.020   1984> -.009   1987> -.008  Higher   1981  .040   2012  .027

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1996 +3.0 SD
================================================================================================================================================

 DWO06A    1822 to  1891      70 years                                                                                          Series   8

 [B] Entire series, effect on correlation (  .682) is:
      Lower   1830< -.019   1828< -.018   1882< -.012   1833< -.012   1877< -.011   1891> -.009  Higher   1855  .054   1839  .014

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 DWO06B    1910 to  2013     104 years                                                                                          Series   9

 [B] Entire series, effect on correlation (  .669) is:
      Lower   1950< -.042   1996< -.016   1926< -.012   2003> -.011   1929> -.008   1921> -.006  Higher   1981  .023   1960  .016
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 DWO07A    1777 to  2013     237 years                                                                                          Series  10

 [B] Entire series, effect on correlation (  .655) is:
       Lower   2012> -.012   1882> -.010   1780< -.009   1881< -.008   1825< -.007   1912< -.007  Higher   1839  .024   1855  .011

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1896 +3.4 SD;    2012 +3.2 SD
================================================================================================================================================

 DWO07B    1781 to  2010     230 years                                                                                          Series  11

 [B] Entire series, effect on correlation (  .673) is:
       Lower   1997> -.009   1979< -.009   1961> -.008   1817> -.008   1823< -.008   1869< -.008  Higher   1839  .021   1855  .017

 [C] Year-to-year changes diverging by over 4.0 std deviations:
       1839 1840   4.2 SD

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
       1839 -7.1 SD;    1997 +3.3 SD
================================================================================================================================================

 DWO08A    1783 to  2013     231 years                                                                                          Series  12

 [B] Entire series, effect on correlation (  .605) is:
       Lower   1797< -.016   1855> -.012   1863< -.011   2003> -.011   1860< -.008   1882> -.007  Higher   1784  .009   1827  .008

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       2003 +3.5 SD
================================================================================================================================================

 DWO08B    1787 to  2013     227 years                                                                                          Series  13

 [B] Entire series, effect on correlation (  .718) is:
       Lower   1882> -.012   1788< -.008   1845< -.007   1803> -.006   1981> -.006   1851> -.005  Higher   1855  .014   1827  .006

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 DWO09A    1676 to  2013     338 years                                                                                          Series  14

 [*] Early part of series cannot be checked from 1676 to 1718 -- not matched by another series

 [B] Entire series, effect on correlation (  .556) is:
       Lower   1724< -.021   1906< -.020   1982< -.014   1876< -.009   1882> -.006   1722> -.005  Higher   1960  .009   1840  .005

 [E] Outliers     4   3.0 SD above or -4.5 SD below mean for year
       1722 +3.2 SD;    1724 -7.0 SD;    1906 -6.0 SD;    1982 -5.0 SD
================================================================================================================================================

 DWO09B    1745 to  2013     269 years                                                                                          Series  15

 [B] Entire series, effect on correlation (  .692) is:
       Lower   1882> -.012   1748< -.007   1866< -.007   1795> -.007   1835< -.006   1852< -.005  Higher   1839  .012   1960  .006

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1882 +3.2 SD
================================================================================================================================================
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DWO10A    1921 to  2013      93 years                                                                                    Series  16

[B] Entire series, effect on correlation (  .610) is:
      Lower   1961> -.031   2007> -.017   1970> -.015   2010< -.014   1922< -.013   1998> -.013  Higher   1981  .032   1953  .014

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1961 +3.1 SD
=================================================================================================================================

DWO10B    1941 to  2013      73 years                                                                                    Series  17

[B] Entire series, effect on correlation (  .524) is:
      Lower   2010< -.052   1961> -.038   2012> -.036   1998> -.034   1958< -.019   2011< -.015  Higher   1981  .033   1987  .024

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1961 +3.3 SD;    1998 +3.9 SD
=================================================================================================================================

DWO11A    1782 to  1920     139 years                                                                                    Series  18

[B] Entire series, effect on correlation (  .587) is:
      Lower   1897< -.041   1792< -.014   1896> -.014   1855> -.013   1902< -.011   1890< -.010  Higher   1839  .050   1888  .011

[C] Year-to-year changes diverging by over 4.0 std deviations:
      1896 1897  -4.4 SD

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1896 +3.8 SD;    1897 -4.6 SD
=================================================================================================================================

DWO11B    1960 to  1995      36 years                                                                                    Series  19

[B] Entire series, effect on correlation (  .735) is:
      Lower   1995< -.090   1994> -.024   1965< -.009   1977> -.009   1978< -.007   1964> -.005  Higher   1981  .051   1976  .024

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DWO11C    1813 to  1904      92 years                                                                                    Series  20

[B] Entire series, effect on correlation (  .736) is:
      Lower   1882< -.043   1895> -.021   1899< -.015   1874> -.008   1896> -.007   1817> -.006  Higher   1855  .024   1815  .010

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1882 -4.8 SD
=================================================================================================================================

DWO11D    1924 to  2013      90 years                                                                                    Series  21

[B] Entire series, effect on correlation (  .649) is:
      Lower   1996< -.029   1935< -.020   2004< -.011   1945< -.011   1988> -.009   1924< -.009  Higher   1981  .027   1976  .015

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1948 +3.2 SD
=================================================================================================================================
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PART 7: DESCRIPTIVE STATISTICS:

| Seq | Series | Interval | No. Years | No. Segmt | No. Flags | Corr with Master | Unfiltered Mean msmt | Unfiltered Max msmt | Unfiltered Std dev | Unfiltered Auto corr | Filtered Mean sens | Filtered Max value | Filtered Std dev | Filtered Auto corr | AR () |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DWO02A | 1768 2013 | 246 | 10 | 0 | .654 | .97 | 3.43 | .454 | .436 | .291 | 2.67 | .348 | .025 | 1 |
| 2 | DWO02B | 1726 2013 | 288 | 11 | 0 | .553 | .93 | 3.10 | .388 | .536 | .286 | 2.63 | .382 | -.011 | 1 |
| 3 | DWO04A | 1719 2012 | 294 | 12 | 2 | .506 | .88 | 2.29 | .440 | .669 | .287 | 2.88 | .543 | .022 | 1 |
| 4 | DWO04B | 1742 1964 | 223 | 9 | 0 | .638 | .73 | 2.00 | .384 | .727 | .282 | 2.61 | .463 | -.016 | 2 |
| 5 | DWO05A | 1741 1920 | 180 | 7 | 2 | .550 | .62 | 3.10 | .324 | .737 | .256 | 2.88 | .569 | .011 | 1 |
| 6 | DWO05B | 1750 2013 | 264 | 10 | 0 | .596 | .82 | 2.76 | .353 | .664 | .256 | 2.70 | .412 | -.017 | 1 |
| 7 | DWO05c | 1955 2013 | 59 | 2 | 0 | .616 | .80 | 1.69 | .261 | .623 | .212 | 2.61 | .569 | -.020 | 1 |
| 8 | DWO06A | 1822 1891 | 70 | 3 | 0 | .682 | 1.03 | 2.19 | .416 | .595 | .313 | 2.72 | .525 | .050 | 1 |
| 9 | DWO06B | 1910 2013 | 104 | 4 | 0 | .669 | 1.96 | 4.45 | .733 | .063 | .365 | 2.93 | .578 | .136 | 1 |
| 10 | DWO07A | 1777 2013 | 237 | 9 | 0 | .655 | 1.04 | 2.48 | .451 | .659 | .252 | 2.85 | .469 | -.015 | 1 |
| 11 | DWO07B | 1781 2010 | 230 | 9 | 0 | .673 | .93 | 2.34 | .418 | .598 | .277 | 2.58 | .287 | -.018 | 1 |
| 12 | DWO08A | 1783 2013 | 231 | 9 | 0 | .605 | 1.06 | 2.57 | .474 | .774 | .219 | 2.56 | .391 | -.003 | 2 |
| 13 | DWO08B | 1787 2013 | 227 | 9 | 0 | .718 | 1.31 | 3.25 | .501 | .611 | .236 | 2.81 | .445 | .010 | 1 |
| 14 | DWO09A | 1676 2013 | 338 | 12 | 0 | .556 | .81 | 2.44 | .402 | .698 | .260 | 2.69 | .324 | .006 | 1 |
| 15 | DWO09B | 1745 2013 | 269 | 11 | 0 | .692 | 1.03 | 2.72 | .375 | .512 | .264 | 2.89 | .476 | .026 | 1 |
| 16 | DWO10A | 1921 2013 | 93 | 4 | 0 | .610 | 1.76 | 3.79 | .755 | .681 | .277 | 2.73 | .501 | .102 | 1 |
| 17 | DWO10B | 1941 2013 | 73 | 3 | 0 | .524 | 1.87 | 4.03 | .876 | .685 | .293 | 2.84 | .550 | .119 | 1 |
| 18 | DWO11A | 1782 1920 | 139 | 5 | 0 | .587 | 1.05 | 2.66 | .429 | .559 | .284 | 2.66 | .447 | -.007 | 4 |
| 19 | DWO11B | 1960 1995 | 36 | 1 | 0 | .735 | 1.24 | 3.84 | .654 | .245 | .325 | 3.20 | .612 | .031 | 1 |
| 20 | DWO11C | 1813 1904 | 92 | 4 | 0 | .736 | 1.01 | 2.19 | .400 | .522 | .299 | 2.55 | .413 | .016 | 1 |
| 21 | DWO11D | 1924 2013 | 90 | 4 | 0 | .649 | 1.80 | 4.38 | .699 | .126 | .346 | 2.91 | .540 | .116 | 1 |
| Total or mean: | | | 3783 | 148 | 4 | .618 | 1.03 | 4.45 | .447 | .597 | .272 | 3.20 | .440 | .014 | |

# REFERENCES

Akaike H (1974) A new look at the statistical model identification. IEEE Trans. Autom. Control, AC 19:716-723

Biondi F, Waikul K (2004) DENDROCLIM2002: A C++ program for statistical calibration of climate signals in tree-ring chronologies. Compute Geosciences 30:303-311

Carrer M, Urbinati C (2004) Age-Dependent Tree-Ring Growth Responses to Climate in Larix decidua and Pinus cembra. Ecology 85(3):730-740

Chai T, Draxler RR (2014) Root mean square error (RMSE) or mean absolute error (MAE)?- Arguments against avoiding RMSE in the literature. Geoscientific Model Development 7:1247-1250

Chartfield C (2004) The Analysis of Time Series: An Introduction. Sixth edition. Chapman and Hall/CRC Press, Boca Raton, Florida

Cook ER, Jacoby GC (1977) Tree-Ring-Drought Relationships in the Hudson Valley, New York. Science 198(4315):399-401

Cook ER (1985) A time-series analysis approach to tree-ring standardization. PhD Dissertation, University of Arizona, Tucson.

Cook ER, Peters K (1997) Calculating unbiased tree-ring indices for the study of climatic and environmental change. Holocene 7(3):361-370

Cook ER, Meko DM, Stahle DW (1999) Drought Reconstructions for the Continental U.S. Journal of Climate 12: 1145-1161

Cook ER, Buckley BM, D'Arrigo RD, Peterson MJ (2000) Warm-season temperatures since 1600 BC reconstructed from Tasmanian tree rings and their relationship to large-scale sea surface temperature anomalies. Climate Dynamics 16:79-91

Cook ER, Kairiukstis (1990) Methods of Dendrochronology: Applications in the Environmental Sciences. Kluwer Academic, Dordrecht, The Netherlands.

Cook, ER, Krusic PJ (2004) North American summer PDSI reconstruction. IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series No. 2004-045, NOAA/NGDC Paleoclimatology Program, Boulder, CO 22pp.

Cook, E.R., Seager, R., Cane MA, Stahle DW (2007) North American Drought: Reconstructions, causes and consequences. Earth-Science Reviews 81: 93-134.

Copenheaver CA, Crawford CJ, Fearer TM (2011) Age-specific responses to climate identified in the growth of Quercus alba. Trees 25:647-653.

Darbee L (1994) Recent Articles, Books,Pamphlets, Dissertations, and Other Publications in Indiana History. Indiana Magazine of History 90(1):92-104

Delong KL, Quinn TM, Taylor FW, Lin K, Sen, C (2012) Sea surface temperature variability in the southwest tropical Pacific since AD 1649. Nature Climate Change 2: 799-804

Delcourt HR, Delcourt PA (1980) Pollen preservation and quaternary environmental history in the Southeastern United States. Palynology 4 (1):215-231

Dominik Fleitmann D, Burns SJ, Mudelsee M, Neff U, Kramers J, Mangini A, Matter A (2003) Holocene Forcing of the Indian Monsoon Recorded in a Stalagmite from Southern Oman. Science 300 (5626): 1737-1739

Franzmeier DP, Steinhardt GC, Schulze DG (2004) Indiana Soil and Landscapes Evaluation Manual. Department of Agronomy, Purdue University

Frelich LE (2002) Forest dynamics and disturbance regimes, studies from temperate evergreen-deciduous forests. Cambridge University Press, Cambridge, U.K.

Fritts H (1976) Tree-Rings and Climate. New York: Academic Press

Fritts HC, Lofgren R, Gordon A (1980) Past Climate Reconstructed from Tree Rings. The Journal of Interdisciplinary History 10 (4): 773-793

Fuller L, Baker A, Fairchild I J, Spot C, Marca-Bell A, Rowe P, Dennis PF (2008) Isotope hydrology of dripwaters in a Scottish cave and implications for stalagmite palaeoclimate research, Hydrology, Earth Syst. Science 12: 1065-1074

Gehrels RW (1999) Middle and Late Holocene Sea-Level Changes in Eastern Maine Reconstructed form Foraminiferal Saltmarsh Stratigraphy and AMS $^{14}$C Dates on Basal Peat. Quaternary Research 52: 350-359

Hatfield J (2012) Agriculture in the Midwest. In: U.S. National Climate Assessment Midwest Technical Input Report. J. Winkler, J. Andresen, J. Hatfield, D. Bidwell, and D. Brown, coordinators. Available from the Great Lakes Integrated Sciences and Assessments (GLISA) Center hhtp://glisa.msu.edu/docs/NCA/MTIT_Agriculture.pdf.

Henderson JP, Grissino-Mayer HD (2009). Climate–tree growth relationships of longleaf pine (Pinus palustris Mill.) in the Southeastern Coastal Plain, USA. Dendrochronologia 27:31- 43

Herweijer C, Seager R, Cook ER, Emile-Geay J (2007) North American Droughts of the Last Millennium from a Gridded Network of Tree-ring Data. Journal of Climate 20: 1353-1376

Hessl A, Pederson N (2012) Hemlock Legacy Project (HeLP): A paleoecological requiem for eastern hemlock. Progress in Physical Geography 37 (1): 114-129

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

International Tree Ring Data Bank (2015). World Data Center for Paleoclimatology, NOAA/NCDC Paleoclimatology Program, Boulder, Colo. "https://www.ncdc.noaa.gov/paleo/study/3016"

Jeffrey A. Dorale JA, Lawrence Edwards R, Ito E, González LA (1998) Climate and Vegetation History of the Midcontinent from 75 to 25 ka: A Speleothem Record from Crevice Cave, Missouri, USA. Science 282 (5295):1871-1874

Lamarche VC, Fritts HC (1970) Anomaly Patterns of Climate over the Western U.S., 1700-1930, Derived from Principal Component Analysis of Tree-Ring Data. Monthly Weather Review 99(2):138-142

LeBlanc DC, Terrell MA (2009) Radial growth response of white oak to climate in eastern North America. Canada Journal for Reseach 39:2180-2192

Leland C, Pederson N, Hessl A, Nachin B, Davi N, D'Arrigo R, Jacoby G (2013) A hydroclimatic regionalization of central Mongolia as inferred from tree rings. Dendrochronologia 31:205-215

Lindsey AA, Schmelz DV, Nichols SA (1969) Natural Areas in Indiana and their Preservation. Indiana Natural Areas Survey, Dept. of Biological Sciences, Purdue University

MacDonald GM, Tingstad AH (2007) Recent and Multicentennial Precipitation Variability and Drought Occurrence in the Uinta Mountains Region, Utah. Artic, Antarctic, and Alpine Research 39(4): 549-555

Mann ME (2002) The value of multiple proxies. Science 297: 1481–1482

Maxwell SR, Hessl AE, Edward CR, Pederson N (2011) A Multispecies tree ring reconstruction of Potomac River streamflow (950-2001). Water Resources Research 47:1-12

Maxwell JT, Harley GL, Matheus TJ (2014). Dendroclimatic reconstructions from multiple co-occurring species: a case study from an old-growth deciduous forest in Indiana, USA. International Journal of Climatology 35(6):860-870

McManus JF, Bond GC, Broecker WS, Johnson S, Labeyrie L, Higgins S (1994). High-resolution climate records from the North Atlantic during the last interglacial. Letters to Nature 371:326-329

Meko DM (1997) Dendroclimatic reconstruction with time varying subsets of tree indices. Journal of Climate 10: 1069-1079

Nash JE, Sultcliffe JV (1971) Riverflow forecasting through conceptual models. a discussion of principles. Journal of Hydrology 10:282-290

NOAA, National Climatic Data Center (2015) User Guide to COFECHA output files. NOAA Paleoclimatology. Accessed June 2, 2015. http://www.ncdc.noaa.gov/paleo/treering/cofecha/userguide.html#cofecha

Orvis KH, Grissino-Mayer HD (2002) Standardizing the reporting of abrasive papers used to surface tree-ring samples. Tree-Ring Research 58:47-50

Palmer W (1965) Meteorological drought. Weather Bureau Research Paper 45. U.S. Department of Commerce, Washington DC.

Pederson N, Jacoby GC, Cook ER, Buckley BM (2001) Hydrometeorological Reconstruction of Northeastern Mongolia Deriver from Tree Rings: 1651-1995. Journal of Climate 14:872-881

Pederson N, Cook ER, Jacoby GC, Peteet DM, Griffin KL (2004) The influence of winter temperatures on the annual radial growth of six northern range margin tree species. Dendrochronologia 22:7-29

Pederson N, Tackett K, McEwan W, Clark S, Cooper A, Brosi G, Eaton R, Stockwell RD (2012a). Long-term drought sensitivity of trees in second-growth forests in a humid region. Environmental Research Letters 7:1-8

Pederson N, Bell AR, Knight TA, Leland C, Malcomb N, Anchukaitis KJ, Tackett K, Scheff J, Brice A, Catron B, Blozan W, Riddle J (2012b) A long-term perspective on a modern drought in the American Southeast. Environmental Research Letters 7: 1-8

Pederson N, Bell AR, Cook ER, Lall U, Devineni N, Seager R, Eggleston K, Vranes KP (2013). Is an Epic Pluvial Masking the Water Insecurity of the Greater New York City Region? Journal of Climate 26:1339-1350

Petty RO, Lindsey AA (1961) Hoot Woods, A Remnant of Virgin Timber, Owen County, Indiana. Proceedings of the Indiana Academy of Science 71: 320-326

Quinn TM, Taylor FW, Crowley TJ (1993) A 173-year stable isotope record from a tropical South Pacific coral. Quaternary Science Review 12: 407–418

Ramirez E, Hoffman G, Taupin JD, Francou B, Ribstein P, Caillon N, Ferron FA, Landais A, Petit JR, Pouyaud B, Schotterer U, Simoes JC, Stievneard M (2003). A new Andean deep ice core from Nevada Illimani, Bolivia. Earth and Planetary Science Letters 212: 337–350

Richman MB (1986) Rotation of principal components. Journal of Climate 6:293-335

Ross T, Lott N (2003) A climatology of 1980-2003 extreme weather and climate events. National Climatic Data Center Technical Report No. 2003-01. NOAA/NESDIS. National Climate Data Center, Asheville, NC

Rubino DL, McCarthy BC (2000) Dendroclimatological analysis of white oak (Quercus alba, L. Fagaceae) from an old-growth forest of southeastern Ohio, USA. Journal of the Torrey Botanical Society 127 (3): 240-250

Speer JH (2010) Fundamentals of Tree-Ring Research. Tucson Arizona: The University of Arizona Press.

Stokes MA, Smiley TL (1968) An Introduction to Tree-Ring Dating. University of Chicago Press. Chicago, IL

Schlesinger, R.C., Funk, D.T., Roth, P.L., Myers, C.C. 1991. Pioneer Mothers' Memorial Forest Revisited. In: McCormick, LH, Gottschalk KW, eds. Proceedings, 8th Central Hardwood Forest Conference 1991 March 4-6. Department of Agricultural, Forest Service, Northeastern Forest Ecperiment Station 594-595

Schubert SD, Suarez MJ, Region JP, Koster RD, Bacmeister JT (2004) Causes of long-term drought in the U.S. Great Plains. Journal of Climate 17:485-503

Schulman E (1954) Tree-Rings and History in the Western U.S. Economic Botany 8(3): 234-250

Seager R, Harnik N, Robinson WA, Kushnir Y, Ting M, and Huang JVHP (2005) Mechanisms of ENSO-forcing of hemispherically symmetric precipitation variability. Quart. J. Roy. Meteor. Soc. 131:1501-1527

Stahle DW, Cook ER, White JWC (1985) Tree-Ring Dating of Baldcypress and the Potential for Millennia-Long Chronologies in the Southeast. American Antiquity 50(4): 796-802

Stahle DW, Cleaveland MK (1992) Reconstruction and Analysis of Spring Rainfall over the Southeastern U.S. for the Past 1000 years. American Meteorological Society 73(12): 1947-1961

Stambaugh MC, Guyette RP, McMurry, ER, Cook ER, Meko DM, Lupo AR (2011) Drought duration and frequency in the U.C. Corn Belt during the last millennium

(AD 922-2004). Agriculture and Forest Meteorology and Forest Meteorology 151:154-162

Trouet V, Coppin P, Beeckman H (2006) Annual Growth Ring Patterns in Brachystegia spiciformis Reveal Influence of Precipitation on Tree Growth. Biotropica 38(3):375-382

Trouet V, Diaz HF, Wahl ER, Viau AE, Graham R, Graham N, Cook ER (2013) A 1500-year reconstruction of annual mean temperature for temperate North America on decadal-to-multidecadal time scales. Environmental Research Letters 8:1-10

United States Department of Agricultural (USDA) (2015) Farm income and wealth statistics. http://www.ers.usda.gov

Willard DA, Weimer LM, Riegel WL (2001) Pollen assemblages as paleoenvironmental proxies in the Florida Everglades. Review of Paleobotany and Palynology 113:213-235