Inter-annual Rainfall Variability and Hardwood Growth in Black Rock Forest: Comparing Tree-ring and Climate Model Results for the Chestnut Oak

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ABSTRACT

The study of tree-rings, or dendrochronology, is used to reconstruct paleoclimate data or develop a climate history where measured records do not exist. This approach was tested on Chestnut oak (Quercus prinus)trees at Black Rock Forest (B.F.) in Cornwall, New York. The objectives of the study were to gage the strength of the correlation between tree-ring width of chestnut oak and the surrounding climate at B.F. and to investigate integrating the use of a tree growth model with tree-ring analysis.

The sampling sites were confined to the three long term growth plots that have been set aside at B.F. for research and annual monitoring of tree growth. In total, thirty trees were cored with two samples taken at breast height (BH) from each, and a third basel area sample taken from approximately every fourth tree. These cores were then measured and analyzed and compared to pre-existing climate data from West Point, New York. Correlations were established between tree-ring width and temperature, precipitation and the Palmer Drought Severity Index.

The dendrochronology results show a strong precipitation signal for the chestnut oak tree. This reflects the fact that the tree's are growing on thin soils with high drainage and on steep slopes and growth is highly dependent on the precipitation

and general moisture content of the area. Because of this dependency the modeling of moisture stress in a tree is especially relevant to chestnut oak growth.

Two sites, Mt. Misery and Arthur's Brook, were selected for growth simulations because of their contrasting soil water holding capacity and difference in tree ring growth. From the dendrochronology analysis, Mount Misery was chosen as the stressed site while Arthur's Brook was chosen as the non-stressed site. Growth was simulated for the years 1977-1987. The simulated monthly plant stress, expressed as the ratio of actual transpiration over potential transpiration, was recorded for each site. Arthur's Brook was only slightly less stressed than Mount Misery, however, this corresponds with the type of growing environment at Black Rock.

The stress index levels were then compared to the normalized ring width data and precipitation data from West Point. As expected, the stress index in general followed the precipitation fluctuations. In agreement with the ring width data, in both sites, there was a regressive element to the relationship of precipitation and stress. A strong stress signal in the previous year would effect growth in the next season. This corresponds with the positive correlation between September precipitation values of the previous growth season and current June precipitation values for annual tree-ring growth found in the dendrochronology analysis.

Further research into the use of a simulation modeler for forest growth is needed to justify it's use as a tool in dendrochronology studies. However, a strong enough relationship was established in this thesis between soil composition and the physiological stress of a tree that would warrant additional research in this area. The relevance of water stress in a soil should not be overlooked when trying to determine the relationship between climate and tree-ring width.

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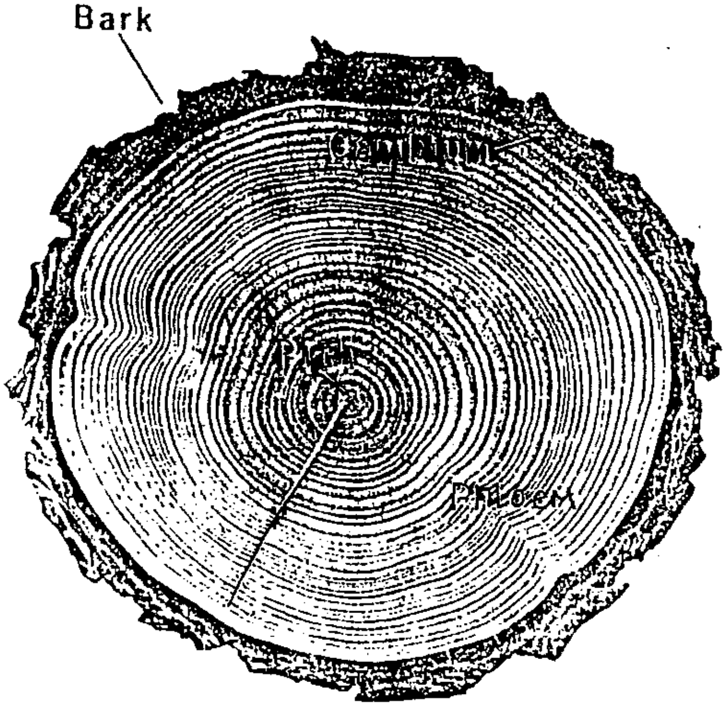
I. INTRODUCTION

Dendrochronology, or the study of tree-rings, was developed by Andrew E. Douglass in the 1900's, and is primarily used for expanding paleoclimatic records (Stokes, 1968). In the past, it could only be hypothesized what climate existed before temperature and precipitation data was kept. However, now there are many methods to reconstructing paleoclimate. Ice cores, deep sea sediment cores, and coral rings all can be analyzed to extrapolate past climate conditions. Out of these various means, tree-rings are unique because they form new rings each year and numerous cores can be sampled and compared. Based on this annual correlation between ring width and climate we can now investigate what temperature and precipitation conditions were and establish records for areas where one did not previously exist, as well as providing some evidence about anthropogenic affects on the environment.

A.Ring Development

Trees are good indicators of their surrounding climates because their development varies with the seasonality of the area. To understand dendrochronology one must have a general understanding of tree physiology. Each growing season a tree experiences primary growth in the apical meristem which increases tree height and secondary growth in the lateral meristem which increases tree width (Kozlowski, et.al, 1991). Cell division which occurs in the lateral meristem then produces the vascular cambium which divides into the xylem and phloem (Fig.1).

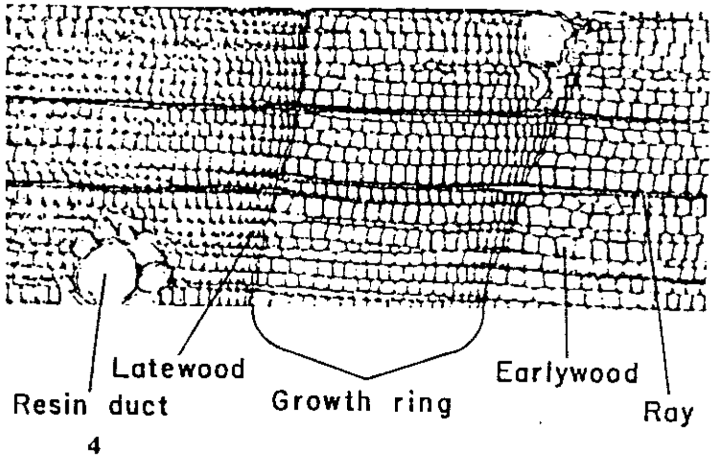
Figure 1



From Stokes and Smiley 1968

It is this xylem or woody growth that forms tree-rings. Each spring new xylem tissue on the inner face of the vascular cambium constructs large thin-walled tracheid cells. This lighter, ring porous layer is known as the early wood (Maeglin, 1979). As growth slows later in the season, cells become smaller and thicker. This diffuse porous, darker colored wood is identified as late wood. The contact between these two layers of cells is what forms the boundary of each tree-ring (Figure 2).

Figure 2



Stokes and Smiley 1968

B.Role of Moisture Stress

The width of each ring is highly dependent on site water balance. The soil moisture content at the site is the available sub-surface water minus that lost through evaporation and run-off (Stokes, 1968). Water is distributed throughout the tree by negative pressure that exists at the surface of the leaves. Air dries the exterior of the leaves from evaporation and water is transported up from the roots through the xylem cells to fulfill the disparity. Only ten percent of the water traveling through the tree is actually used for growth processes; the rest is lost through transpiration-- water evaporation from stems, leaves, and other pant parts (Starr, 1994). This process is to important dendrochronology because when actual transpiration falls below potential transpiration of the plant metabolic process begin to slow, in turn forming narrower rings (Figure 3) (Kozlowski et.al, 1991).

Figure 3

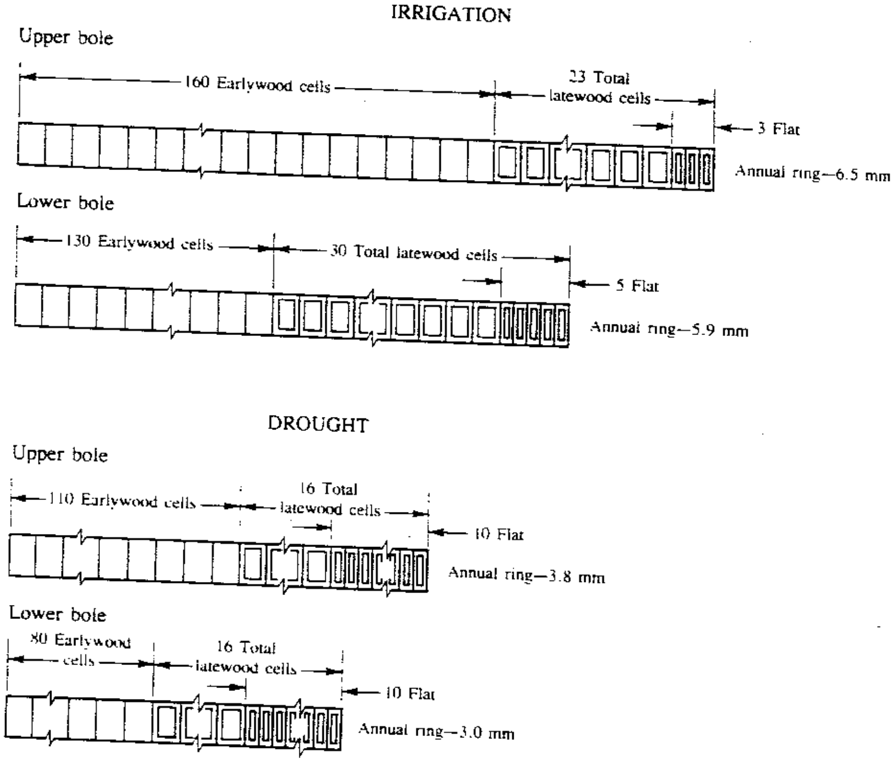


Figure 7.8 Difference in width of tracheids and in proportion of latewood in xylem rings of red pine grown with irrigation and under water stress. Also note differences between upper and lower bole. (From Zahner, 1968.)

Zahner, 1968

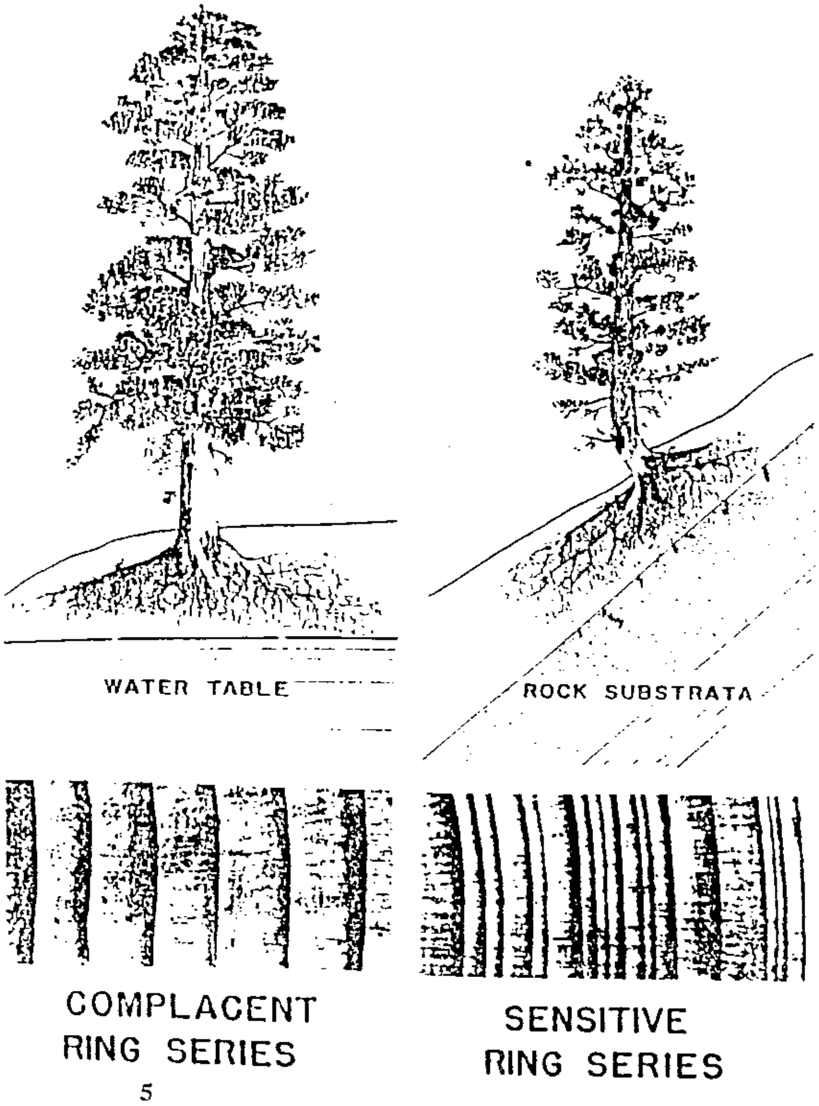
C. Regional Variations

Historically, most dendrochronology studies were limited to Southwest areas composed of large conifer populations. Conifers, in general, are characterized by their high ring width correlation to seasonal variabilities. Southwestern climate has predictable contrasting seasonal trends; cold, wet winters and hot, dry summers. This later factor makes summer growth in the trees highly dependent on precipitation. In contrast, east coast species, hardwoods and conifers, were known for showing signs of complacent growth (ring width showing little representation of climatic differences in the surrounding environment) because there is not these contrasting trends in precipitation. For example, here we frequently experience wet summers. Also species suffer stress due to competition over limited space. However, in the past twenty years these factors have been addressed by putting more emphasis on site selection and by testing the climate dependency of the rings by comparing them with pre-existing weather data for the areas. Nonetheless, there is a need to develop tree-ring records in the Northeast where conifers are not as present in the hardwood forests.

Black Rock Forest (B.F.) in the southern Hudson Valley is a oak-hickory forest that can be used to test the use of Northeast hardwoods in dendrochronology studies. Black Rock represents a cross-section of the general ecology of the area. It is divided between old growth areas and areas of recovery which underwent intense land clearing and exploitation, which peaked in the 1800's (D'Arrigo, 1994). The young age of many of the trees in B.F. makes it difficult to judge any real stresses on their growth. Young trees, unless there is competition for sunlight from the canopy, generally expend all of their nutrients and energy in laying down wood. Their rings usually are very thick and do not indicate any of the surrounding climatic variables. However, B.F. does have pristine tree stands or sites where old growth is present and the trees are limited in their development due to climate. This, combined with one of the longest climatic records in the country at West Point Military Academy, which lies adjacent to B.F., allows for a real test of tree-ring data.

An optimal site for a dendrochronologist exists where ground water is unavailable, soil drainage is good and there is little competition in the canopy for sunlight (Stokes, 1968). This type of site is considered stressed, and is ideal for study because radial growth in the trees will be in proportion to the limiting climatic factors of interest. In comparison, a site which was abundant in nutrients and water; ie. soil had poor drainage or site was near a water source, would not be a favorable choice for study except as a comparison, because the tree would not be experiencing any stress; it would be considered complacent. Figure 4 illustrates the differences between a complacent versus stressed site.

Figure 4



Stokes and Smiley, 1968

A site meeting the previously mentioned stressed criteria in dendrochronology would be said to have a strong precipitation signal and/or temperature signal. A "signal" is the terminology used to describe what is the main limiting factors to growth of the samples. These above criteria are determined from first reviewing the soil type and slope of the area before commencing any coring. In many cases, a few exploratory cores might be taken to preview. If rings are of relatively similar width and do not show any seasonal variability another site might be chosen.

C. Analytical Methods

After coring, tree ring widths are established as indices and compared to temperature, precipitation, and the Palmer Drought Severity Index (PDSI) numbers for the area. The PDSI is an autoregressive component that reflects soil moisture deficits and surpluses from previous and current months into a weighted average reflecting drought (Hughes, 1982). In general, less than -4.0, is interpreted as extremely dry and +4.0 is extremely wet. COFECHA, a statistical program used by dendrochronologists for quality control, cross dates each of the cores and establishes an exact year-date to each ring of every tree sampled. These measurements are then processed into a master chronology that places an average ring width for each year. The level of correlation between the master chronology and the existing data for the area establish the accuracy of utilizing the tree-rings to predict the paleo-climatic record. A strong relationship would indicate tree-ring width could be used to establish data where none existed in the past. However, because of the low correlation that often results in dendrochronology analysis between temperature and/ or precipitation and tree-ring width, there sometimes is a high level of uncertainty.

In the second phase of this research I tested the hypothesis that this uncertainty can be reduced by using a forest simulation model to work in conjunction with tree-ring data. The model simulates different metabolic activities of the tree and outputs a stress index level based on the water uptake in a plant and the demand for water from the atmosphere. This ratio of estimated actual transpiration over potential transpiration data is based on climatic variables, soil composition and water uptake by the tree. From the simulation, actual transpiration (AT) over potential transpiration (PT) outputs an index number corresponding to the growth stress a tree is under. Potential transpiration is the water demand from the atmosphere while actual transpiration is what the tree could supply given the soil-water status. If the maximum AT is equal to the PT than the tree can meet the demand from the atmosphere and the ratio of actual/potential would be one. However, when actual is less than potential the ratio falls below one and the tree is stressed trying to meet the demand. This relative stress index can then be compared with the actual tree-ring width.

The use of the model in combination with the ring data can help evaluate the range of climatic patterns and identify the role of soil in tree growth. Soil variabilities are not fully accounted for in dendrochronology studies. When they are analyzed with tree-ring width indices it may provide some improvement in accuracy for the dendro analysis. The model accounts for soil stresses and may further our understanding of the physiological response to water stress of a tree as well as aid in constructing paleo-climatic records on the micro-level between tree and soil. If tree-rings are able to construct paleo-climatic conditions, than from that data a model could potentially be used to understand what was happening during each year in the soil. The model is not a substitution for dendrochronology but rather something that can work in conjunction with tree-ring analysis to further both areas of research.

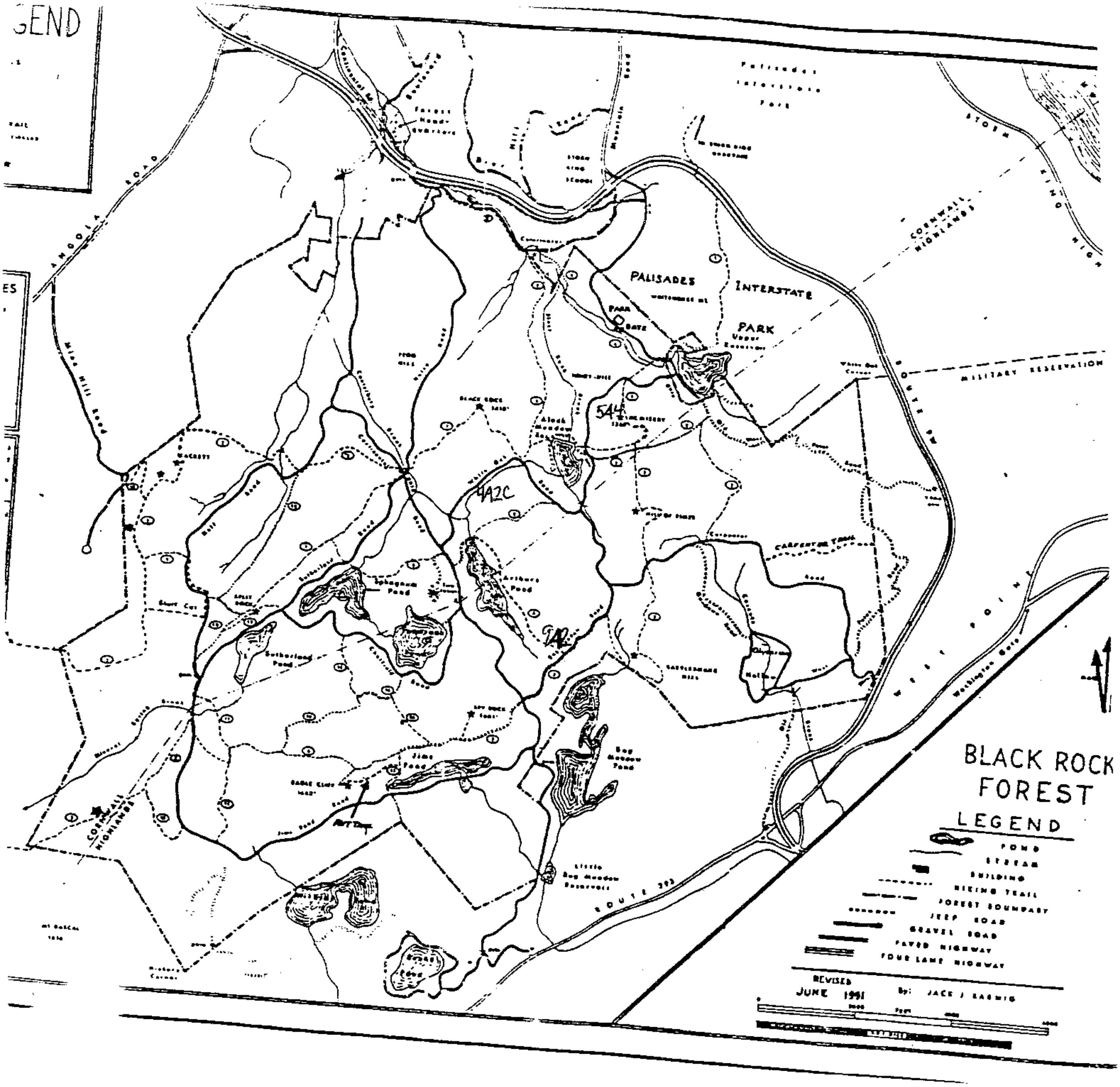
The research undertaken for this thesis is essentially divided into two parts spanning two summers. The first part is dendrochronology analysis and field work conducted on chestnut oak trees, updating of long term growth plots, and soil sampling during the summer of 1995 at B.F., with analysis done on data at Lamont Doherty Earth Observatory (LDEO) Tree Ring Lab. This research was conducted under a fellowship from the Northeast Institute for Global Environmental Change (NIGEC) under the advisory of Dr. Bill Schuster, the forest director at B.F., and Dr. Roseanne D'Arrigo and David Lawrence at LDEO. The second part was conducted during the summer and fall of 1996 under the advisory of Dr. Jennifer Phillips at Goddard Institute for Space Studies (GISS). Precipitation, temperature, and soil data was used to drive a model, GAPS, of forest water balance, developed at Cornell University (Riha et.al.,1994), to model the ratio of actual versus potential evapotranspiration for a period of ten years from 1977-1987. These two sets of data: tree-ring width and potential versus actual evapotranspiration were plotted against each other and analyzed with respect to climate-growth interactions.

II. METHODS

All of the data collection and field work was completed at Black Rock Forest (Map 1). BRF is a 3,750 acre privately owned forest in Cornwall, New York devoted to research. It is predominantly an oak-hickory forest and has a growing season from mid-April to mid-October. West Point Military Academy shares neighboring land with BRF and was used as a climatic data source.

A. Dendrochronology

Preliminary factors must be considered when choosing a site and species before coring and analysis can occur. For our purposes, chestnut oak trees (Quercus prinus) were an adequate choice: they lay annual rings, there are limiting factors to growth in the area (specifically precipitation), temperature and precipitation vary yearly, and their distribution is consistent over a large area. Other climate and age records had been developed up until 1995 at B.F. (D'Arrigo and Jacoby, 1990 and Lawrence) for conifers, specifically the eastern hemlock (Tsuga canadensis). It was hoped that hardwood, deciduous trees would have an alternate signal. The chestnut oak is characterized by dark brown, highly furrowed bark with leaves that slightly resemble that of a chestnut tree (they are narrower and coarsely toothed),



Map 1

Sites

4A2C- Arthur's Brook
5A4- Mount Misery
9A2- Bog Meadow

with a range throughout the Northeast and predominant along the banks of the lower Hudson River. They are found on hillsides and high rocky banks in rich or sometimes sterile (nutrient poor) soil with broad, open and rather irregular canopies (Sargent, 1965). Because Quercus prinus is characterized by its ability to live in stressed areas: thin soils and rocky slops, as mentioned earlier, the sampling often ventured off the long term plots to find samples that had a signal.

Data collection took pace in July and August of 1995 on the long term growth plots in B.F. to establish a record of growth. The long term growth plots are four pairs of differing size that include a controlled and a thinned plot and were set aside for research in the 1930's. The control plots are essentially areas that have been left untouched; no evasive research has been conducted on them and traffic on the plots is kept to a minimum. The thinned plots were forested to increase timber yield. Thus, the smaller and less profitable trees were harvested (B.F. notes). The records for these plots are updated each year by measuring the diameter of the trees and rating their canopy.

The plots sampled in this study are the Arthur's Brook control plot, 4A2C, between White Oak Trail and Arthur's Brook; Mount Misery plot, 5A4, and Bog Meadow, 9A2. Cores were taken from the perimeter of these sites to eliminate introducing any anthropogenic involvement or unaccounted stress on the actual plots. Data collection on Mount Misery ventured some distance away from the long term plot (heading up the Northeast face of the mountain) in order to find trees that were older and growing under stressed conditions (Map 1).

A.i. Data Collection

Materials: 1/8 inch increment borer, tree ID tags, large straws, diameter tape, slope reader, wooden mounts, microscope with moveable stage, and sand paper

Approximately ten to twelve Chestnut Oak trees were chosen within a site in close proximity to one another. They were then tagged and their breast height diameter taken and recorded along with the slope for the area. Trees were cored using an 1/8 inch increment borer (for a thorough description of standard coring procedure consult Maeglin, 1979). Two samples were taken at breast height adjacent to one another and approximately every fourth specimen a basal core was taken to age the tree. Cores were then extracted, labeled, and stored for transport in large straws.

Once dried, tree cores were mounted and analyzed at Lamont Doherty Tree-Ring Laboratory. Cores were glued, cells facing up in wooden mounts and finely sanded. They were then dated and each ring measured using an Acurite program, a fixed microscope that is attached to a precise micrometer moveable stage (Maeglin, 1978) that downloads the measurements to an attached computer. Measurements are taken at the end of each ring by pressing a button as the ring passes the cross hairs in the microscope and then stored.

Initially cores are cross-dated with other cores for quality control. Cores are usually compared with other specimens to establish trends in years to accurately date the cores. Cross dating, places an exact year to each ring and accounts for missing or double rings. For example, the majority of trees at B.F. have narrow rings from 1960 to 1965 when a severe drought in New York State depleted the reservoir system in the area by 45% (Hughes, 1982). Raw measurements were analyzed by COFECHA, a computer program that detects anomalies in the measurements commonly used by dendrochronologists at Lamont.

The master chronology consists of two or more cores from 10+ trees of a single species at a site. The ring widths are standardized by curve fitting techniques designed by Ed Cook, called Arstan, and averaged each year to produce a mean value series (Cook, 1977). Lastly, once the percent error is minor between the correlation factor of the cores, the final chronology was compared with precipitation, temperature, PDSI data.

B. Simulations

GAPS is a dynamic forest model that represents soil, plant, and atmospheric processes in a variety of ways (Riha et. al, 1994). It is designed to be user-friendly and allows manipulation of parameters and view graphs to make the program site specific. Three profiles: site, tree and soil, were amended in the model so the simulations would be specific to Black Rock Forest. These separate files go into creating a simulation of metabolic activities in the tree for each year's data entered. Two separate plots were modeled; one considered stressed and the other non-stressed. The differing factor between each site is mainly the soil profile in each. The pore space and composition of the soil is the variable factor. The Arthur's Brook plot, 4A2C, was chosen as the non-stressed site: the trees show a complacent signal, the soil adequately holds water, canopy is open, and there is little competition amongst trees. The Mount Misery site, 5A4, in comparison is our stressed sight: soils are shallow, run-off is high, and the majority of the trees are growing on steep, rocky inclines.

B.i. Site Characteristics

The location file was designed for Black Rock by Dr. Jennifer Phillips (table 1). Black Rock Forest is located at 41.23 degrees latitude and it's elevation is approximately 350 meters. For both plots, the site profiles are the same.

TABLE 1-- BRF LOCATION FILE FOR GAPS 3.0

```
Black Rock Forest    # LocationName     (s70)
41.23                # Latitude         (s) [°N or S]
43200.0              # TSN              (s) [s]
1.10                 # Alpha            (s) (Priestly-Taylor coefficient)
20.000               # BLC              (s) [W/m2 K]
1                    # RainFirst        (I) [h]
24                   # RainLast         (I) [h]
2.000                # WindHeight       (s) [m]
350.0                # Elevation        (s) [m]
0.050                # Depth_of_evap    (s) [m]
```

B.ii. Climate Processes

The climate data, like the tree-ring analysis was based on data from West Point. However, my data was downloaded from the Lamont Doherty Web Site, www.ingrid.ldeo.columbia.edu, from their link to the National Climate Data Center (NCDC)(10/4/96). NCDC's precipitation and temperature data is recorded as monthly averages for West Point, while GAPS is based on daily analysis of growth. temperature data was averaged into highs and lows and spread through out the month. Precipitation data was spread throughout each month in balance with the average number of days it rains each month at BRF. Corresponding solar radiation values were then added from averages measured in Millbrook, New York. This weather station is the closest to BRF, approximately forty miles northeast, that had pre-existing solar radiation data at the time this research was undertaken.

Potential evapotranspiration, the total potential water loss from the soil, including evaporation and plant transpiration is calculated using an equation developed by Priestley and Taylor (1972). This equation is ideal for our model because it does not require wind speed data, relative humidity or vapor density. The equation is:

```
sim.ETP=loca.ALPHA*(NetRad-G)*(SSVD/(SSVD+PSYCON))/LAMB
```

Where sim.ETP is the simulated evapotranspiration (kg/m2), loca.ALPHA is the Priestly-Taylor factor (1.08-1.50), NetRad is the net radiation (W/m2), G is the soil heat flux (W/m2), SSVD is the slope of the saturation vapor density function (kg/m3 K), PSYCON is the psychrometric constant (0.494 g m-3 K-1), and LAMB is the latent heat of vaporization of water (2450 J), (Riha et. al, 1994).

B.iii. Canopy Transpiration

Growth begins on April 15 and ends on October 15, a typical growing season in BRF. The leaf-area index (LAI) is constant at 3.5 m2/m2. LAI does not fluctuate during the growing season, instead a constant canopy model was used. Thus, there is no account of budding in the Spring or slow defoliation in the fall.

Table 2-- Tree Profile for GAPS 3.0

```
CONSTANT         # crop.PlantName      (s70) []
105              # crop.SowingDate     (I)  [d]
288              # crop.HarvestDate    (I)  [d]
0.0020           # crop.RootRad        (s)  [m]roof radius
2.5E+0010        # crop.RootRes        (s)  [m4/kg s]root resistance
2                # crop.FRoot          (I)  []first layer w/ roots
7                # crop.NRoot          (I)  []last layer w/roots
50000            # crop.RootDens[2]    (s)  [m/m3]; for n:= FRoot to NRoot
130000           # crop.RootDens[3]         Root density in each layer
160000           # crop.RootDens[4]
150000           # crop.RootDens[5]
12000            # crop.RootDens[6]
5000             # crop.RootDens[7]
0.75             # crop.AS             (s)  []short wave absorption
3.50             # plant.LAI           (s)  []leaf area index
```

The LAI was measured using a spectrometer. Approximately 600 readings were taken at low and high LAI locations along the perimeter and criss-crossing the sites. The data obtained from low and high LAI deciduous sites were averaged to make one combined number to represent an average site in BRF.

The Potential plant transpiration (EP) is based on potential evapotranspiration (EO) from above and an assumed relationship between LAI and light interception, written as:

$$EP=EO^{*}\ (1.0-EXP(-K^{*}LAI))$$

Where K is assumed equal to 0.5. The actual transpiration is the water uptake by the tree. At a minimum that water uptake is proportional to root density in each soil layer and soil water content.

B.iv. Soil Characteristics and Water Flow

The difference between the sites is based on the soil profiles. Soil sampling was conducted in the long term plots, during the summer of 1995, along two transects that ran along the axis of the plots. Six samples were taken in each plot equadistance from each other using a flat-edged shovel. Samples ranged from 6-10 inches in length and approximately one inch in width. Organic layer was removed and the sample was measured by distinctions in organic layer, top soil, and sub-soil. The six samples were combined to make one composite sample of the area. Samples were then dried, weighed and sifted.

The results from these sampling went into constructing the Soil file for GAPS. The factors used to distinguish between stressed and non-stressed soils are the drained upper limit (DUL), and the lower limit (DLL) which are defined for each layer with units of m3 water/m3 soil volume. The DUL, or field capacity, defines the amount of water held in a layer after drainage by gravity has more or less stopped. DLL is the water content remaining in the profile after the plants have removed all the water they can with root uptake. The table below defines the values used for each of the soil layers for stressed and non stressed simulations. As can be seen in Table 3, both soils are characterized as having a depth of 0.185 meter. However, the distinction is made with DUL. For Mount Misery, it is lower than Arthur's Brook to reflect the low water content at field capacity of glacial till.

Table 3-- Soil File for GAPS 3.0
Site 4A2C **Site 5A4**
non-stressed soil (m3/m3) **stressed soil profile (m3/m3)**

Depth (m)	DUL	DLL		Depth (m)	DUL	DLL
0.01	0.340	0.1800		0.01	0.340	0.1800
0.027	0.340	0.1800		0.027	0.340	0.1800
0.07	0.330	0.1800		0.07	0.290	0.1800
0.105	0.330	0.1800		0.105	0.290	0.1800
0.14	0.280	0.1900		0.14	0.260	0.1900
0.185	0.280	0.1900		0.185	0.260	0.1900

Water flow through each of these layers is depicted using a Tipping Bucket model. It is easiest to understand if briefly one imagines each soil layer as a bucket, with holes somewhere below the rim. Saturation is represented when the bucket is full; DUL after draining to below the holes; DLL after plants have removed what they can. In this model water only flows downward.

The soil in the 5A4, Arthur's Brook (stressed), site is classified as Rocky outcrop-Hollis complex (ROD), steep to moderately steep and excessively to well-drained(Orange County Soil Survey). It is characterized by exposed bedrock with a thin mantle of glacial till over a schist, gneiss or granite bedrock and available water capacity is low or very low with rapid run-off. ROD composes the majority of the soil at BRF. Our non-stressed site, 4A2C, has only slightly better conditions. It is described as Hollis soil, sloping (HLC). This surface soil is fine sandy loam and commonly gravely with areas that have a thicker soil mantle over the bedrock. Permeability is moderate here with medium run-off. In general standards this would still be considered a stressed soil, but thin, gravely soils dominate most of BRF thus any upgrade from the ROD is an improvement. For example, very porous soil and larger grain size will be very well-drained and provide little soil-water retention, this would be a stressed site. A non-stressed site would have a high soil-moisture content, good retention, and low porosity. It's composition could be a sandy loam where water is retained and roots have access to it.

IV. RESULTS

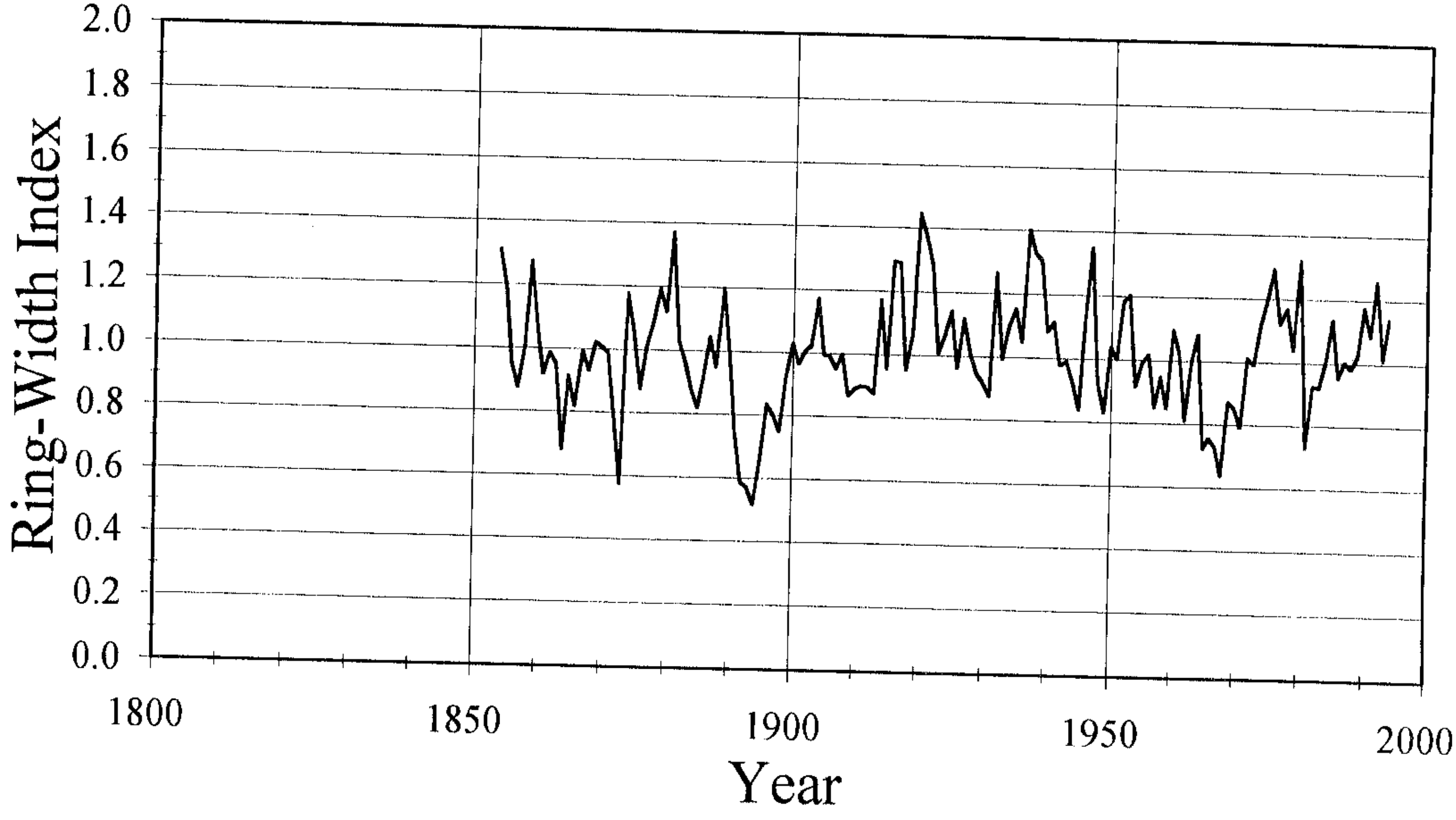
A. Dendrochronology

The three sites at B.F. showed varying results in their comparison with temperature, precipitation and PDSI and they are of different ages. The COFECHA and Arstan normalized ring width data is included in Appendix A.

A.i. Arthur's Brook

The Arthur's Brook plot is characterized by two sets of long term plots in front of one another. The coring occurred midway between the two sets of plots. Sampling began near Arthur's Brook, which flows at the base of the plot, and continued up a slight slope towards White Oak Trail. The majority of samples were taken away from the water source where the landscape plateaus, soils become shallower, and the land is pocked by gneiss outcrops.

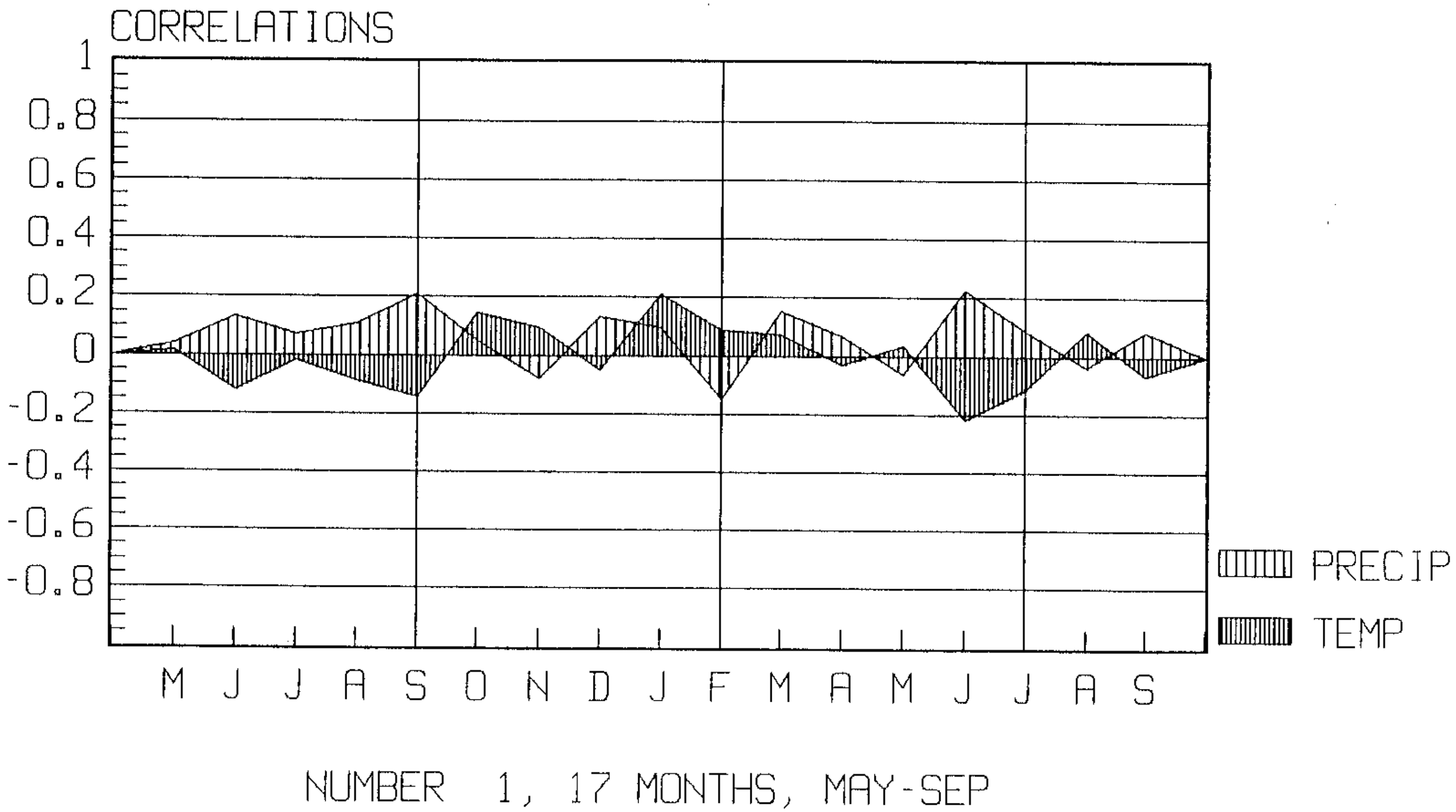
In Arthur's Brook plot, 4A2C, there were 44 cores measured, with the oldest dating back to 1851. The ARSTAN master chronology, Figure 6, depicts the ring-width index for the site with a series intercorrelation of .633. Widths range between a high of 1.45 for the growth year of 1881 and a low of 0.54 for 1854. It should be noted even though the oldest core dated back to 1851, the correlations are made from 1891-1990. This shortening of the master chronology time series is to decrease statistical uncertainty. The later the time series begins the higher the number of cores that can be included in it. Figure 7 is the correlations of ring-width to temperature and precipitation for a denrochronological year from May of the preceding summer to September of the growth year; a year and a half. Correlations are significant above +0.2 and below -0.2. Correlations exceeding approximately .20 are significant at the 95% level, using a two-tailed test. For temperature, there was a high positive correlation with the preceding January and a high negative correlation for the current June. For precipitation, the strongest correlations were with September of the preceding year and with June of the current year. In agreement with the precipitation results, the PDSI of the September before the growth year is highest, indicating that stresses in the late summer affect growth for the following Spring.



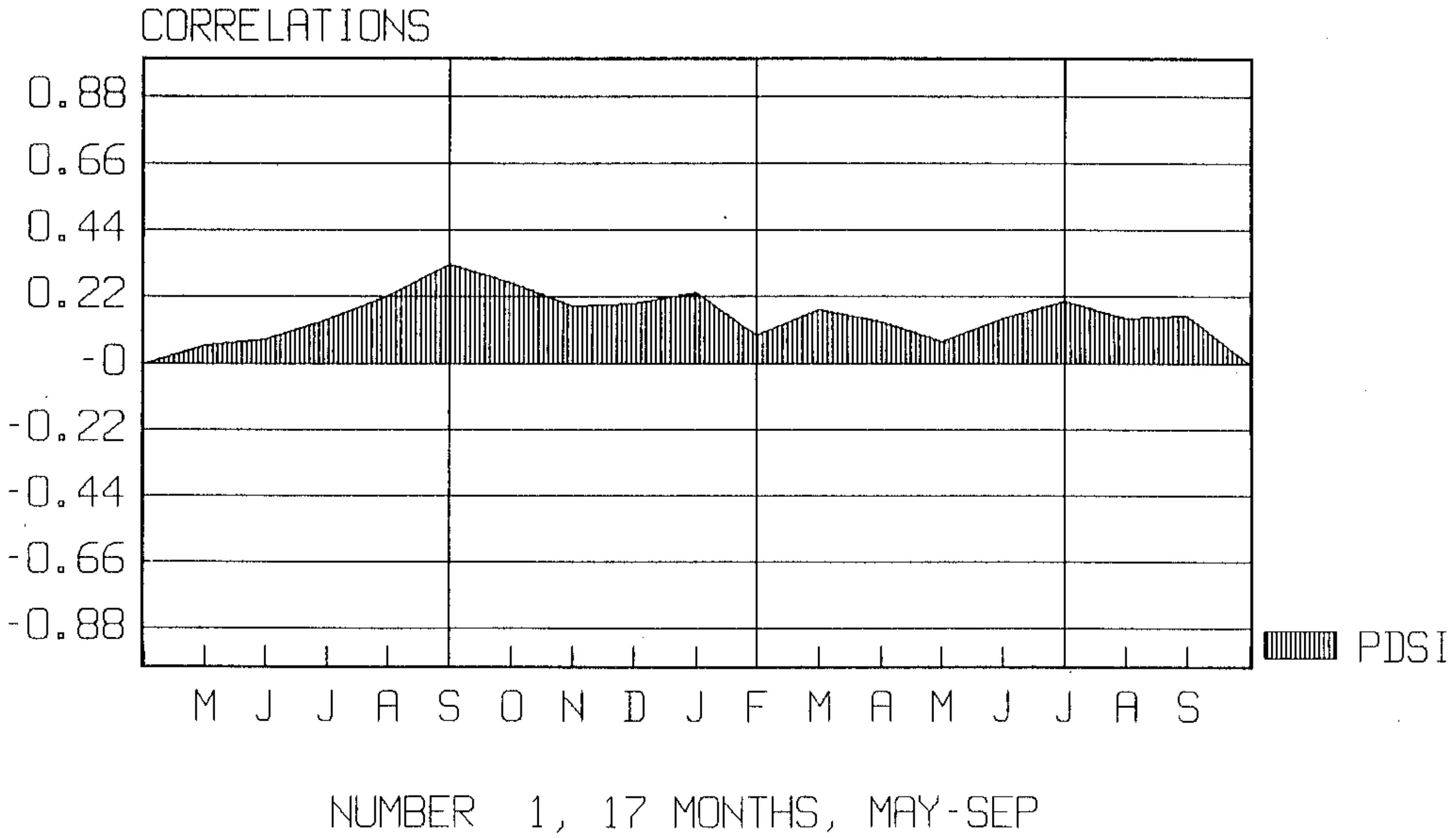
Arthur's Brook -- Quercus prinus

ARSTAN Chronology

ARTHUR'S BROOK
TEMP & PRECIP, 1891-1990
FOR MAY - SEP, N:100
SIG SIMPLE R: .200



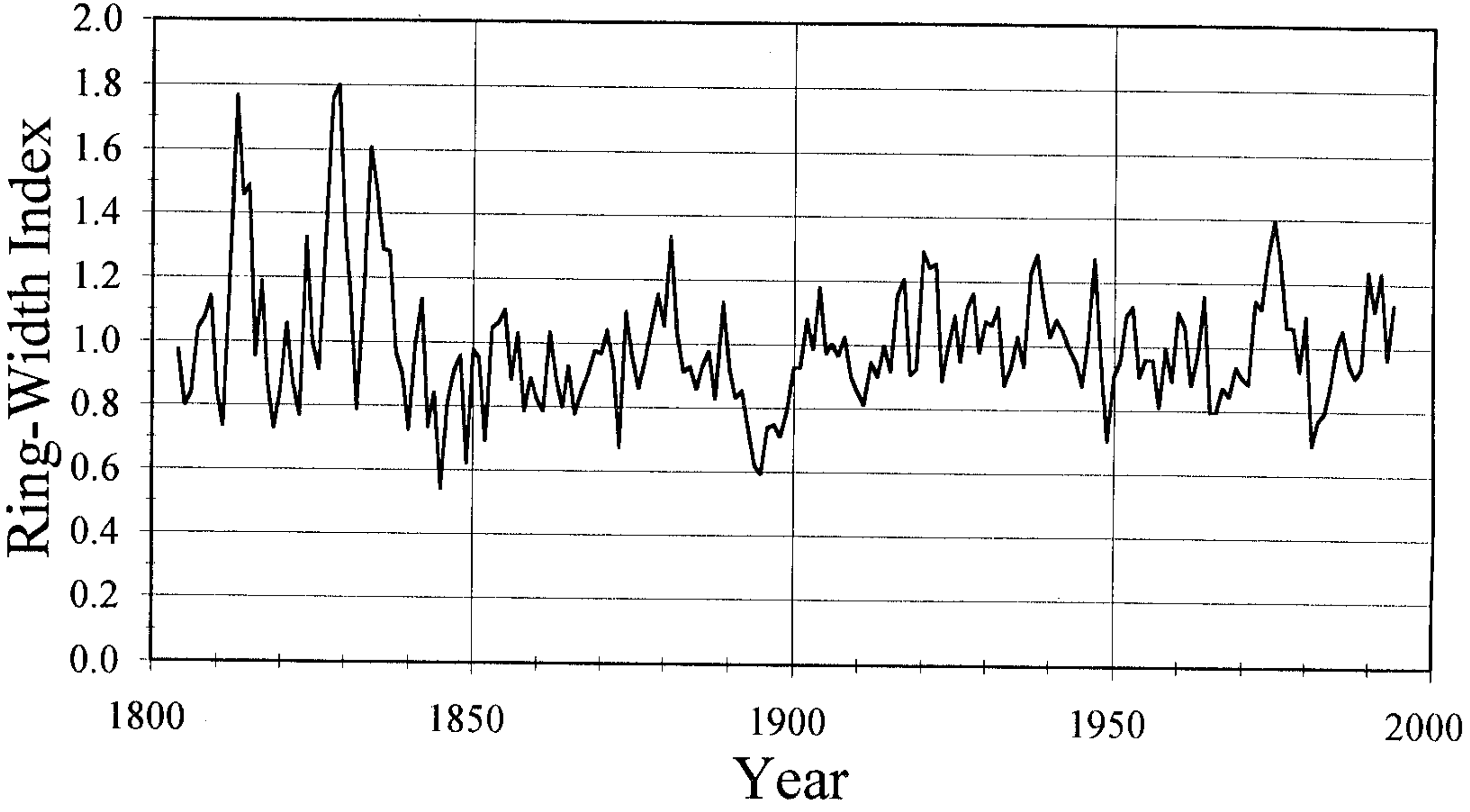
ARTHUR'S BROOK
PDSI, 1908-1990
FOR MAY - SEP, N: 83
SIG SIMPLE R: .220

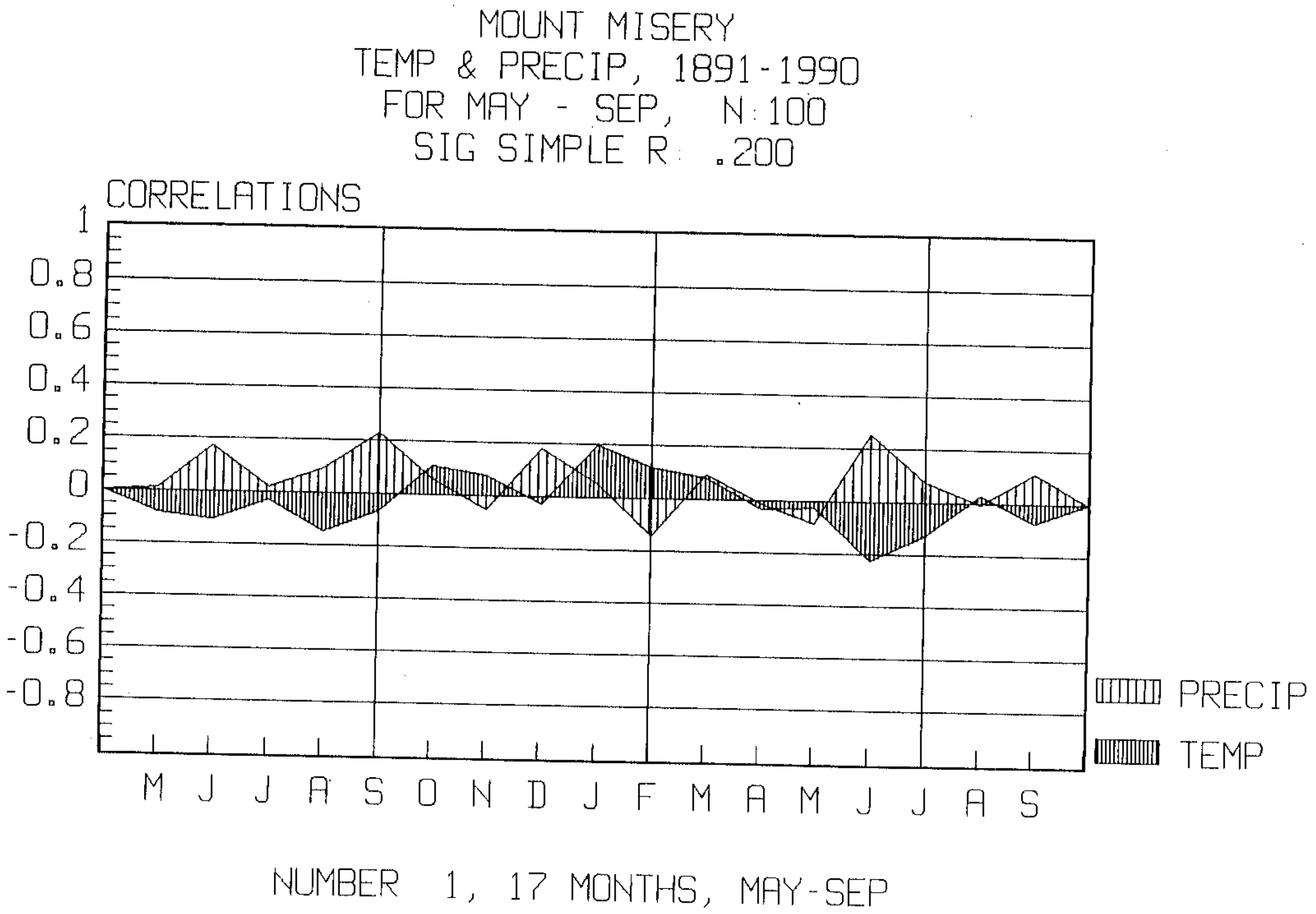


A.ii. Mount Misery

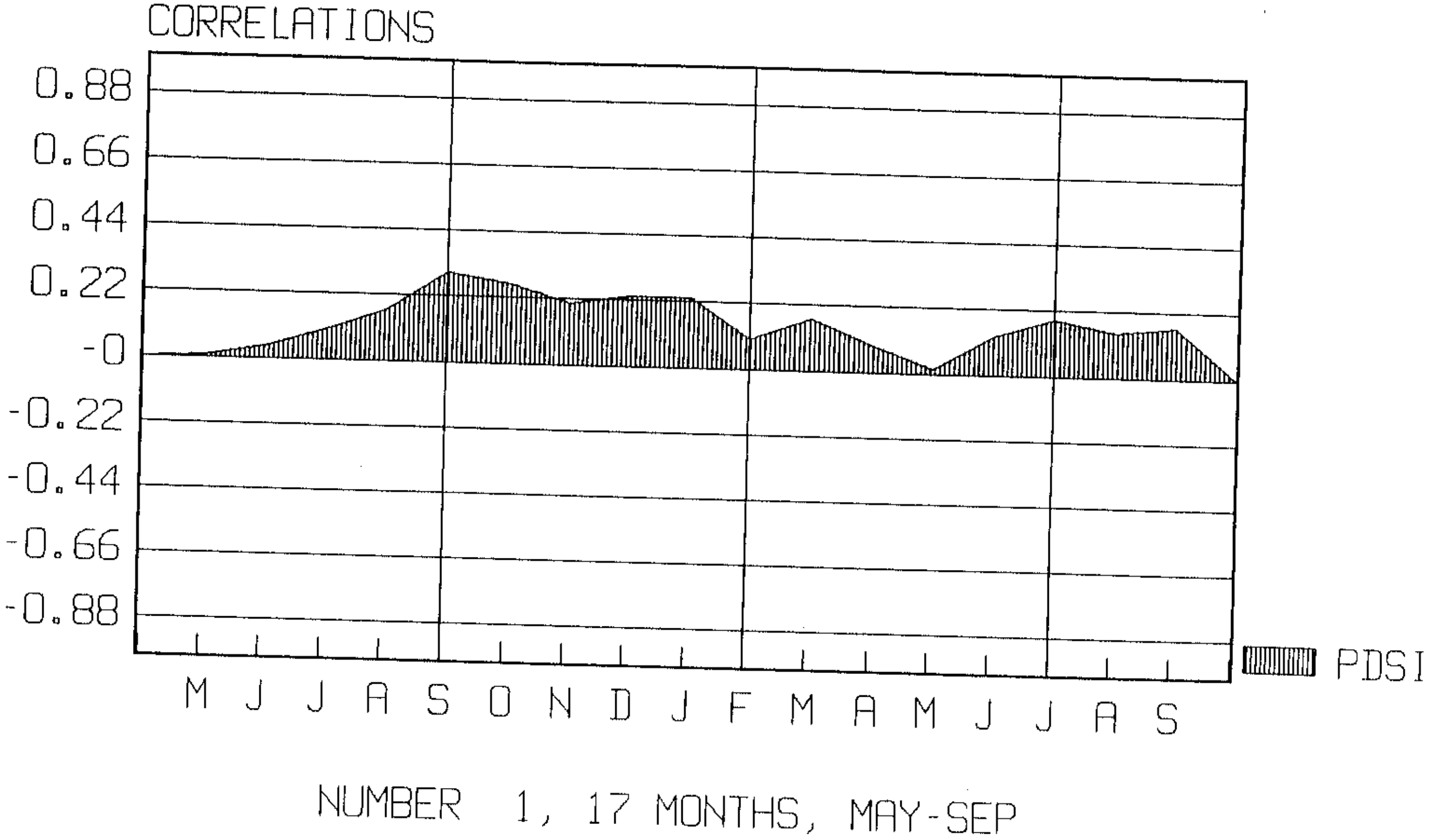
The Mount Misery plot, 5A4, had the oldest trees cored. The long term plot sits at the base of Mount Misery. Sampling headed up the east side of Mount Misery and culminated with samples taken at the top along the rockier, steeper edges of the site. There were 43 samples taken with a series intercorrelation of .633. The oldest dated ring was 1806. From the Artstan master chronology (Figure 10) the largest ring was laid in 1828 and measured at 1.651. The narrowest ring was in 1845 at 0.638. The correlations between ring-width and climatic data are from 1892-1990 and have a correlation coefficient of 0.2. Figure 11, illustrates the relationship between temperature and precipitation and the ring width. Similar to the results from Arthur's Brook, there is a significant positive correlation with September precipitation and the following June precipitation, and a negative correlation for temperature in the following June and a small negative correlation for January. For PDSI,(Figure 12) the significant correlation coefficient is 0.220. Again we see the high correlation for the September before the growth season, as well as, correlations greater than 0.220 for December and January.

Mount Misery -- Quercus prinus
ARSTAN Chronology




MOUNT MISERY
TEMP & PRECIP, 1891-1990
FOR MAY - SEP, N:100
SIG SIMPLE R: .200
CORRELATIONS
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A
S
PRECIP
TEMP
NUMBER 1, 17 MONTHS, MAY-SEP

MOUNT MISERY
PDSI, 1908-1990
FOR MAY - SEP, N: 83
SIG SIMPLE R .220

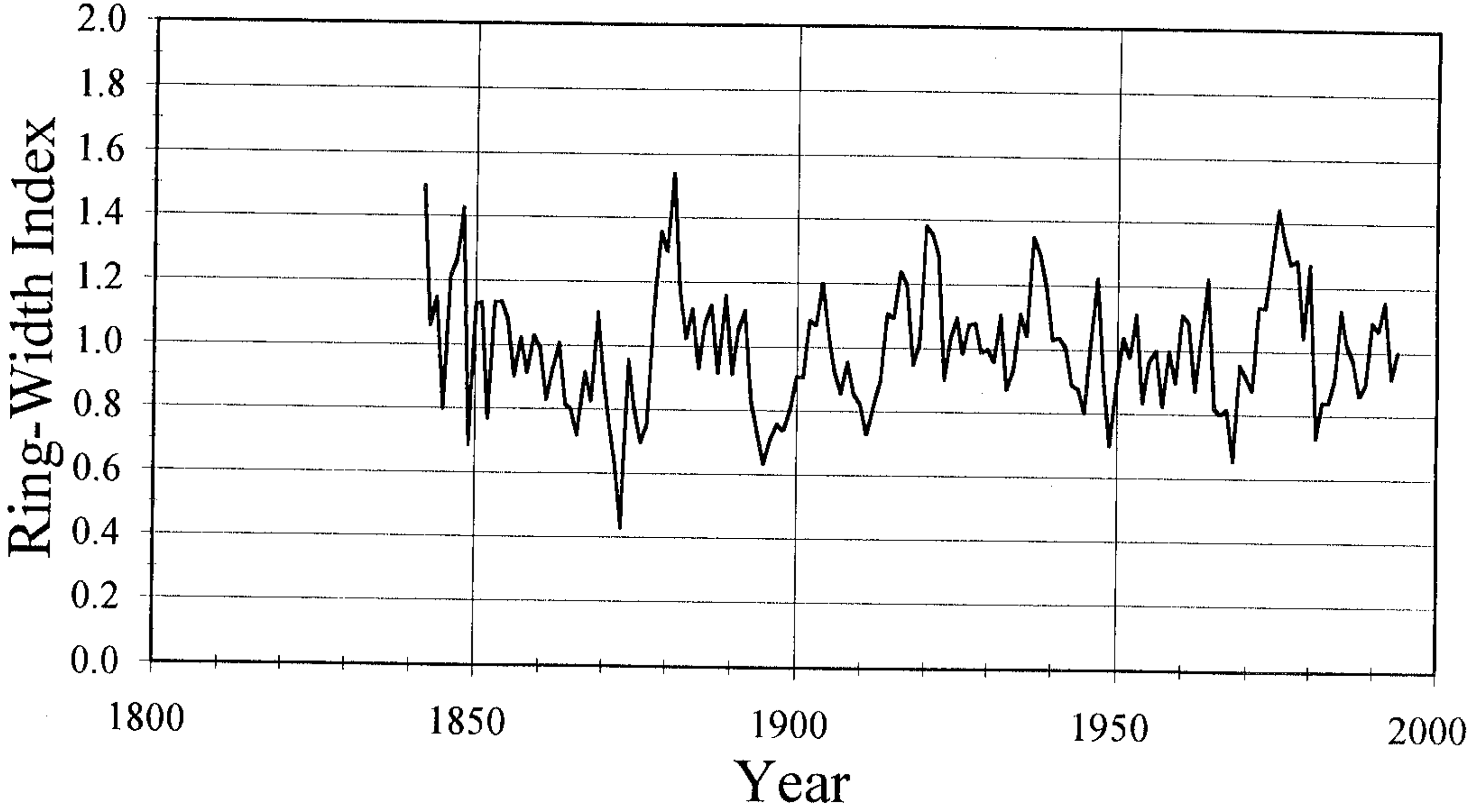


A.iii. Bog Spring

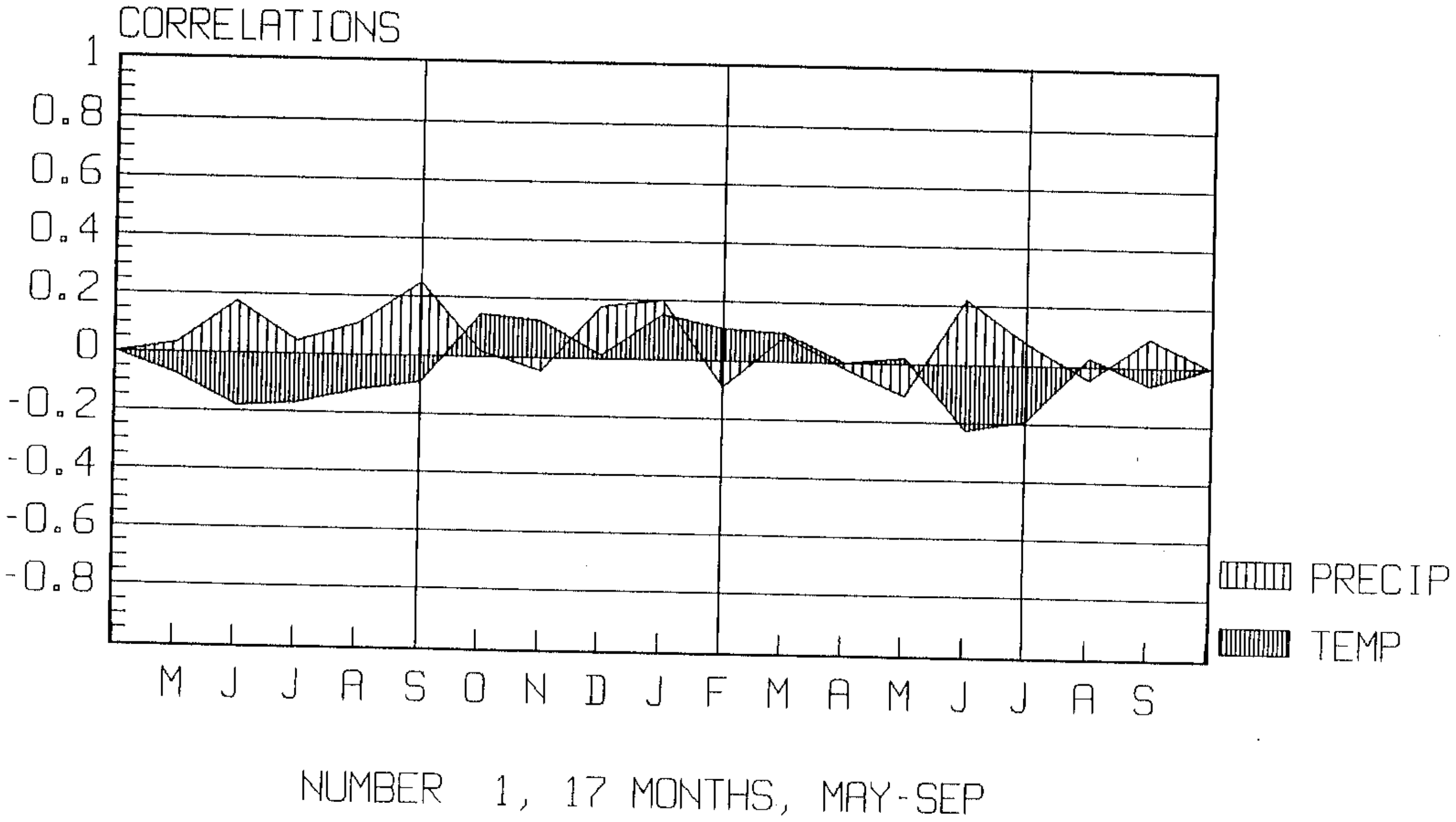
Bog Spring is located on a rise across from the Hill of Pines. There is a moderate incline going up from the road. From the topography it looks as if an old logging road at one time ran near to the plots. There were 46 cores analyzed from site 9A2. Figure 13, depicts the Artstan chronology. The master chronology is from 1841 to 1994; 154 years. Between each core there is a series intercorrelation of 0.612. The largest ring is in 1881 at 1.408, while the narrowest ring would be in the preceding decade in 1873 at 0.593.

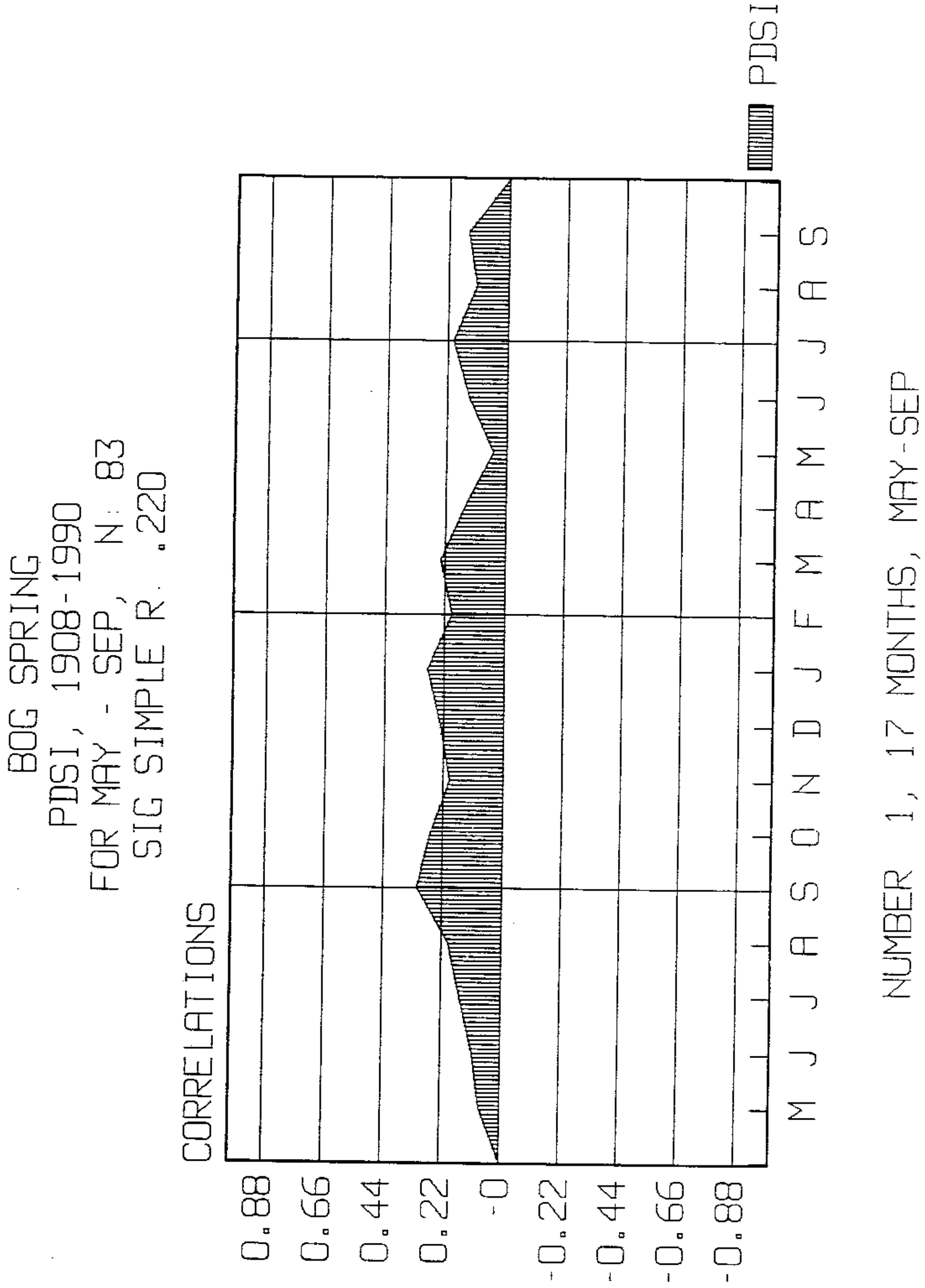
Figure 14, shows the correlation between West Point temperature and precipitation with Bog Spring ring widths. Note the correlations are based on data for the years 1891-1990. As with the past two sites, the cut-off for significant correlation is 0.200. There is a high positive correlation for precipitation in the previous September and the current June, while there is a high negative correlation for temperature in that same June. The PDSI correlations are in Figure 15. Again there is a high correlation, over 0.220, for the previous September, as well as January, and the current March.

Bog Spring -- Quercus prinus
ARSTAN Chronology



BOG SPRING
TEMP & PRECIP, 1891-1990
FOR MAY - SEP, N:100
SIG SIMPLE R: .200




BOG SPRING
PDSI, 1908-1990
FOR MAY - SEP, N: 83
SIG SIMPLE R: .220
CORRELATIONS
0.88
0.66
0.44
0.22
-0
-0.22
-0.44
-0.66
-0.88
M
J
J
A
S
O
N
D
J
F
M
A
M
J
J
A
S
NUMBER 1, 17 MONTHS, MAY-SEP
PDSI

B. Model Results

Table 4, contains the actual transpiration and potential transpiration data resulting from the simulations. (All simulation output files are in Appendix B). A stress index of 1 would indicate that the tree is meeting the potential demand and is not growing in a stressed environment. However, note that even in our non-stressed sites the ratio never meets one. The trees in both sites are consistently operating at half their potential.

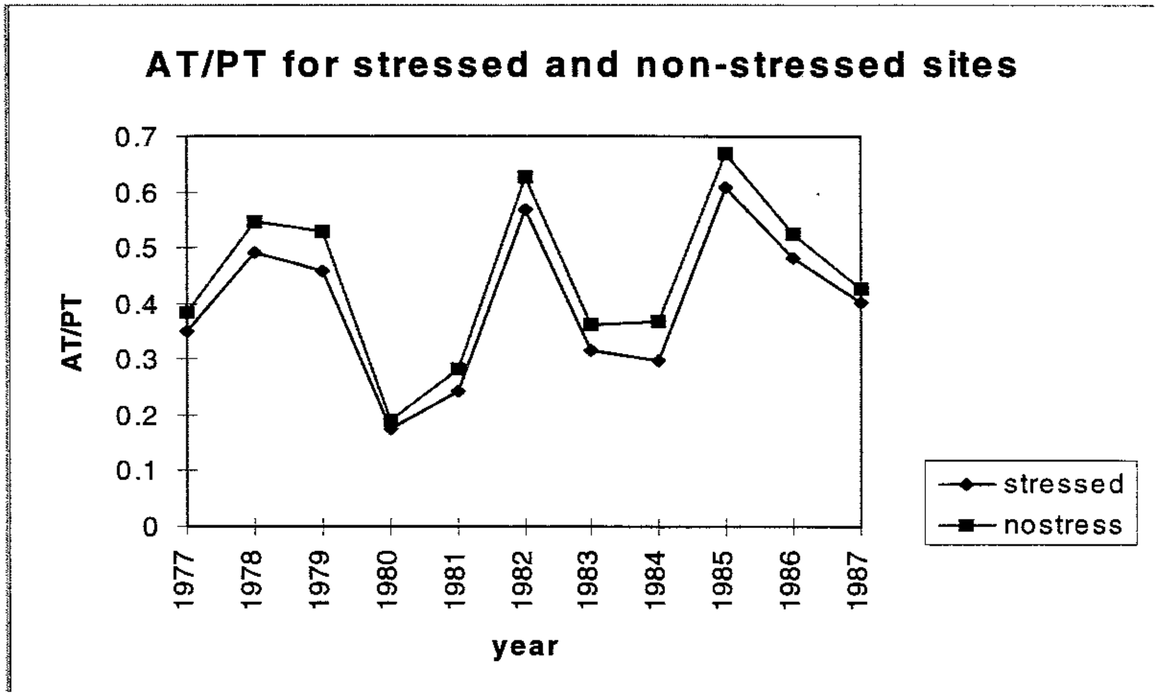
Table 4--Actual transpiration(AT) and Potential Transpiration(PT) in Stressed and Non-stressed Sites

Stressed--5A4 **Non-Stressed--4A2C**

Year	AT (mm)	PT (mm)	AT/PT		AT(mm)	PT(mm)	AT/PT
1977	143	408	0.34		156	498	0.38
1978	198	400	0.49		218	414	0.55
1979	189	414	0.46		218	414	0.53
1980	77	441	0.17		44	441	0.19
1981	103	425	0.24		120	425	0.28
1982	223	392	0.57		246	392	0.63
1983	129	409	0.31		148	409	0.36
1984	122	409	0.30		151	409	0.37
1985	248	408	0.61		273	408	0.67
1986	204	424	0.48		222	424	0.53
1987	164	407	0.40		174	407	0.43

Figure 16 shows the ratio of actual over potential transpiration. Although soil profiles were different for each site, the stress index appears very close. My results do not fall over a wide range. However, such a stressed environment is accurate for BRF considering that the majority of the forest soils are rocky and very porous.

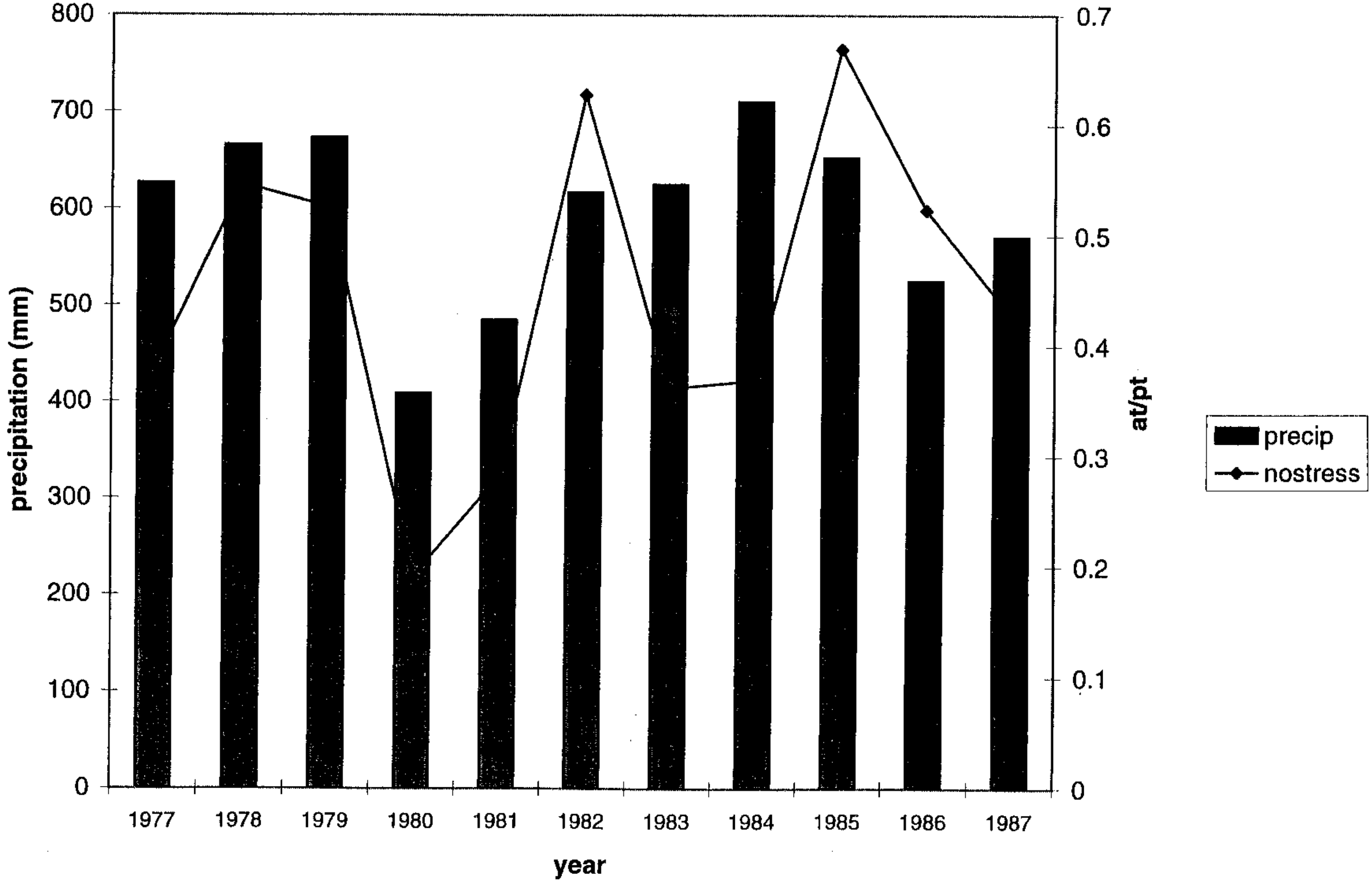
Figure 16

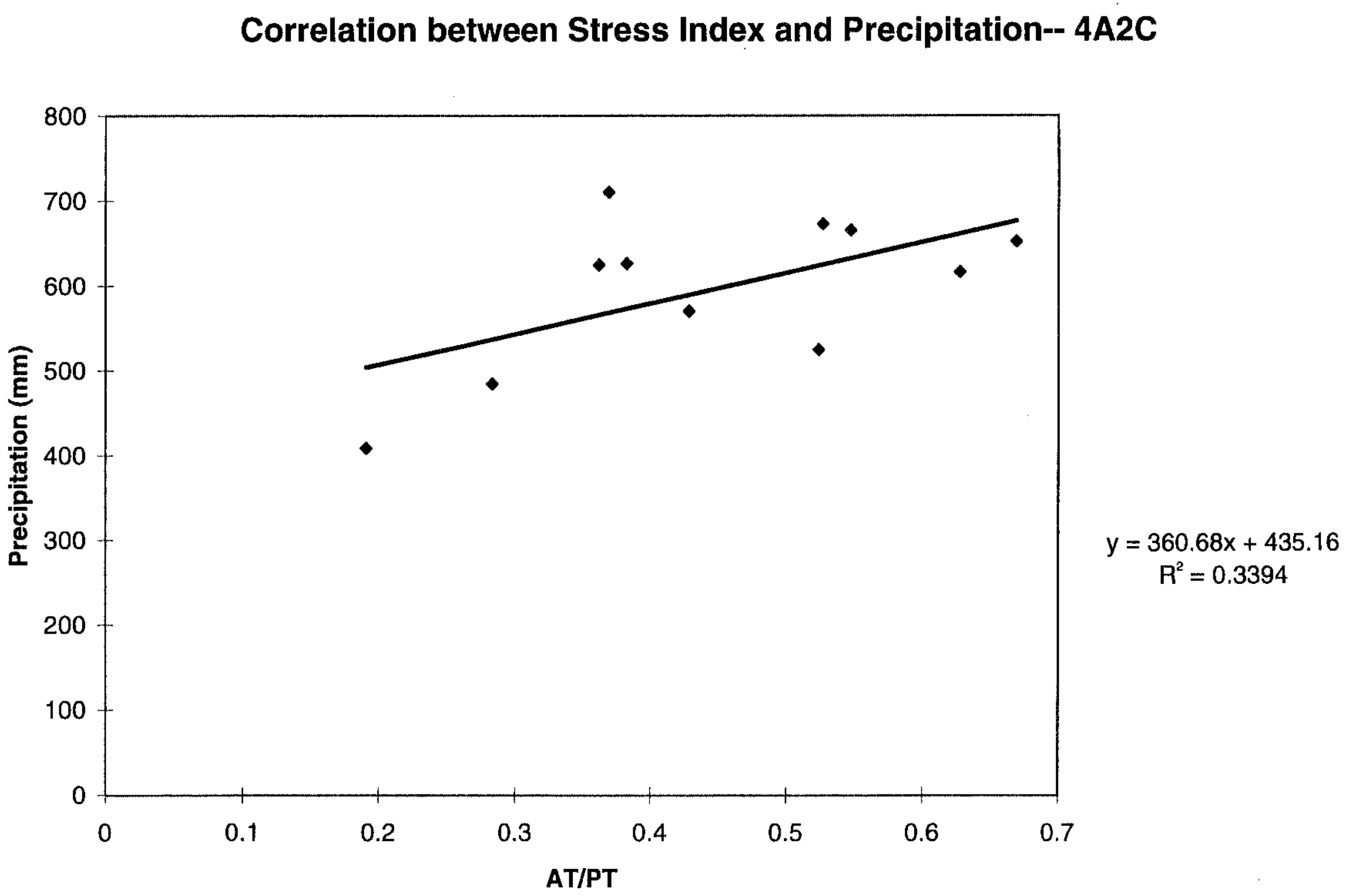


B.i.Stress Correlation and Precipitation

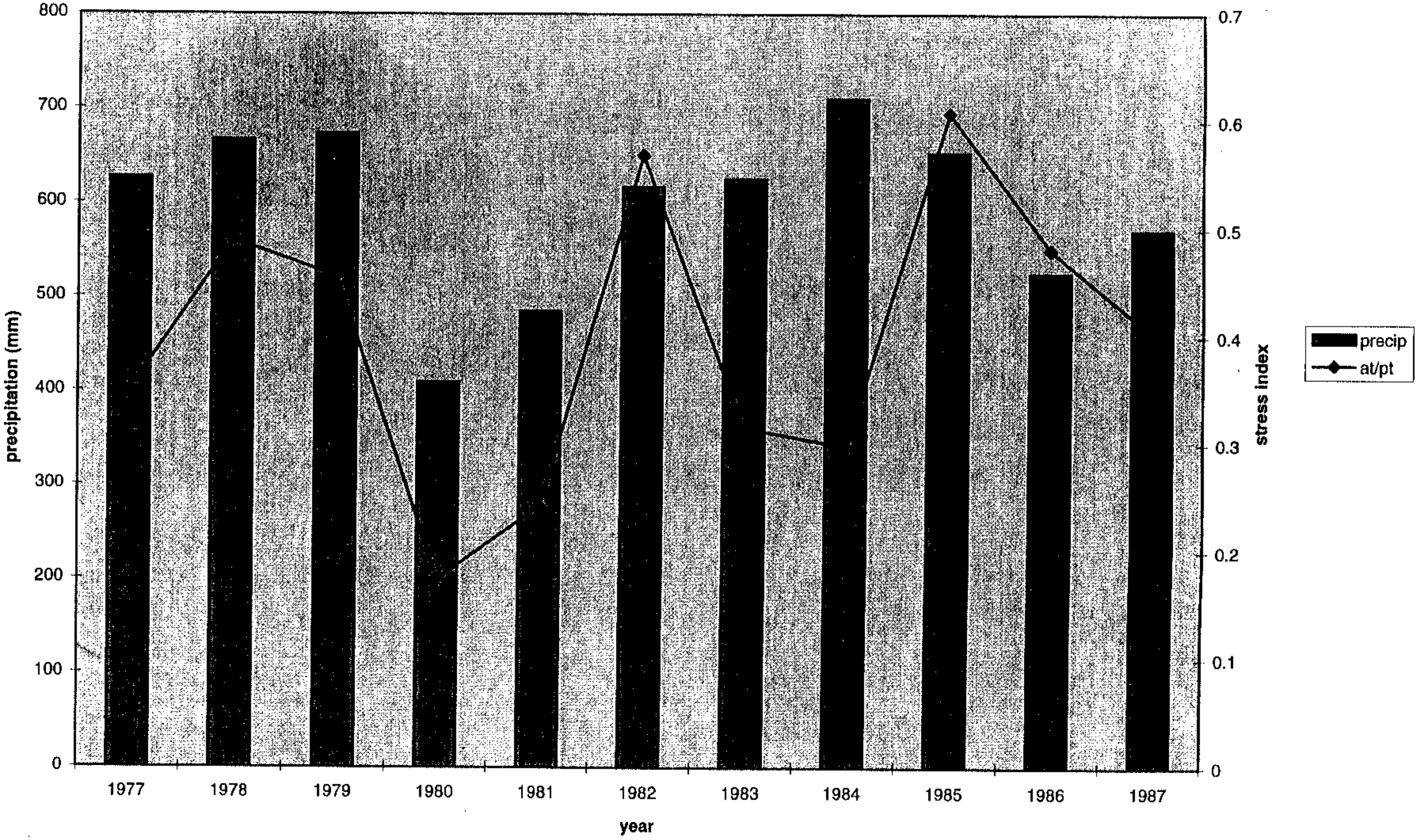
As with the tree-ring analysis, each site's stress level was analyzed individually in comparison to precipitation. As stated previously, this is important because the stress index should be proportional to the soil type and precipitation levels. Figure 17 and Figure 19 shows this association between AT/PT vs. precipitation for 4A2C, the non-stressed plot, and 5A4, the stressed site. Observe the corresponding trends between the amount of rain and the stress ratio. The marker year of 1980 is well noted in each site. In general, because 1980 was such a hot dry summer it is easily detected in all the comparisons. The rain levels and the stress index are in synch in 4A2C from 1977-1978, 1979-1982, 1983-1984, and 1985-1986. Graph 18 calculates the correlation, for 4A2C, between the two factors and plots the best fit line to establish a linear relationship. The correlation coefficient is 0.3394. Figure 19, shows the AT/PT and precipitation for 5A4. Note there are similar trends to the 4A2C sites, although the years 1983-1984 show the reverse relationship to the precipitation. Figure 20, graphs the statistical significance between the two. The R_2= 0.2703. Again this number is relatively small for a correlation. This low

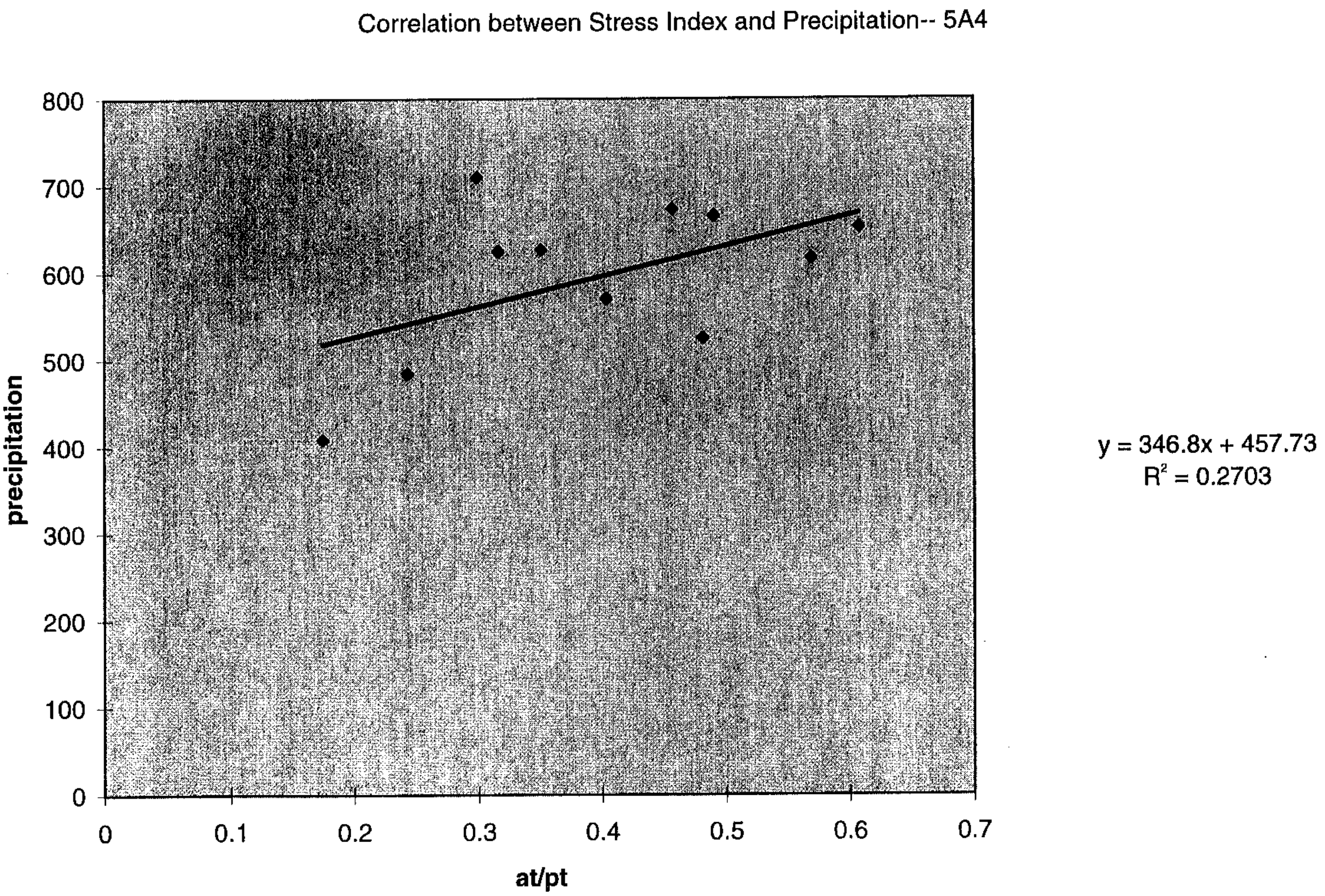
Precipitation and Stress Index--4A2C




Correlation between Stress Index and Precipitation-- 4A2C
Precipitation (mm)
800
700
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
AT/PT
y = 360.68x + 435.16
R² = 0.3394

Precipitation and Stress Index--5A4C



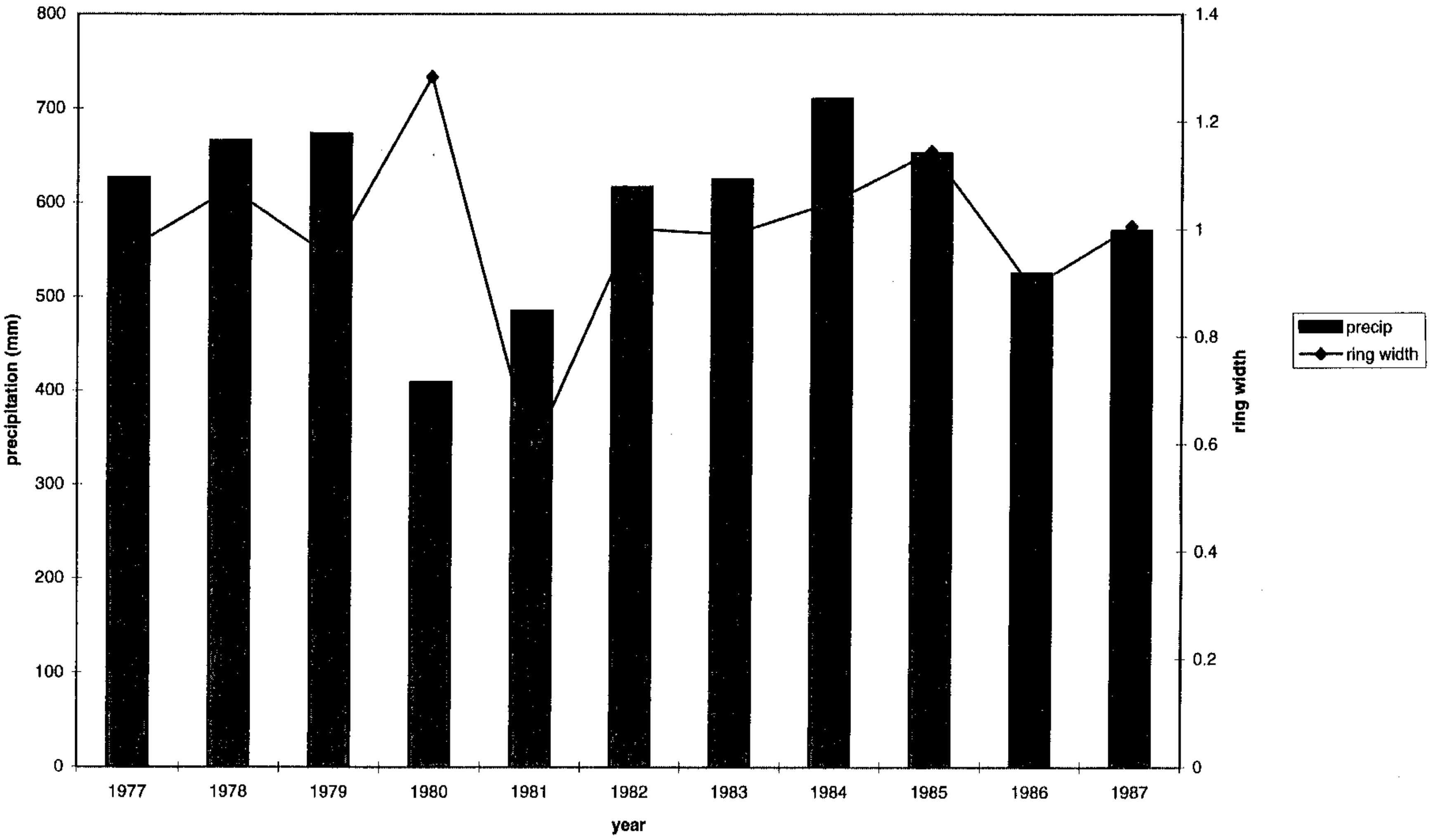


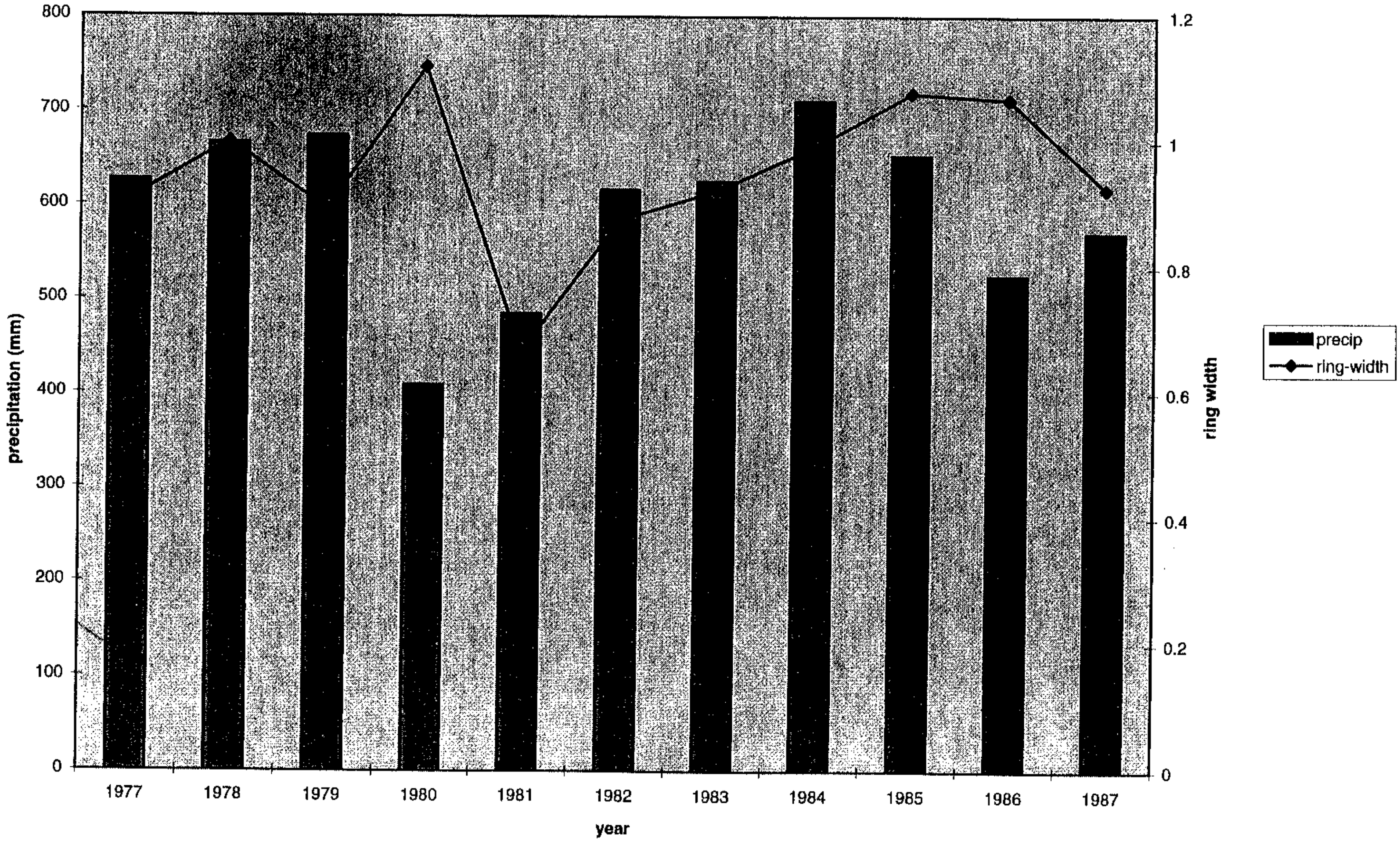
Correlation between Stress Index and Precipitation-- 5A4 number indicates that seasonal patterns of rainfall may influence the seasonal cumulative stress experienced by the trees.

B.ii. Stress, Precipitation and Ring Width Correlation

Precipitation, ring width and stress index numbers each show similar trends through out the decade analyzed. It is beneficial to first observe the relationship between ring width and precipitation and then build on from there. Figure 21 and Figure 22 exemplify the relationship between rainfall and tree growth. Present in both charts is a annual regressive element. As stated previously, 1980 was an extremely hot, dry summer which reached it's pinnacle between August and September. Monthly average precipitation values were 3.66 mm and 3.58 mm respectively. Both of these low numbers were observed in the stress index. However, tree-rings did not record this stressy growth environment until the following year. Because of the correlation between ring width and previous August to September rainfall and current June levels, a late summer drought like the one experienced in 1980, would not be observed in ring width measurements until the following season.

Ring Width and Precipitation--4A2C



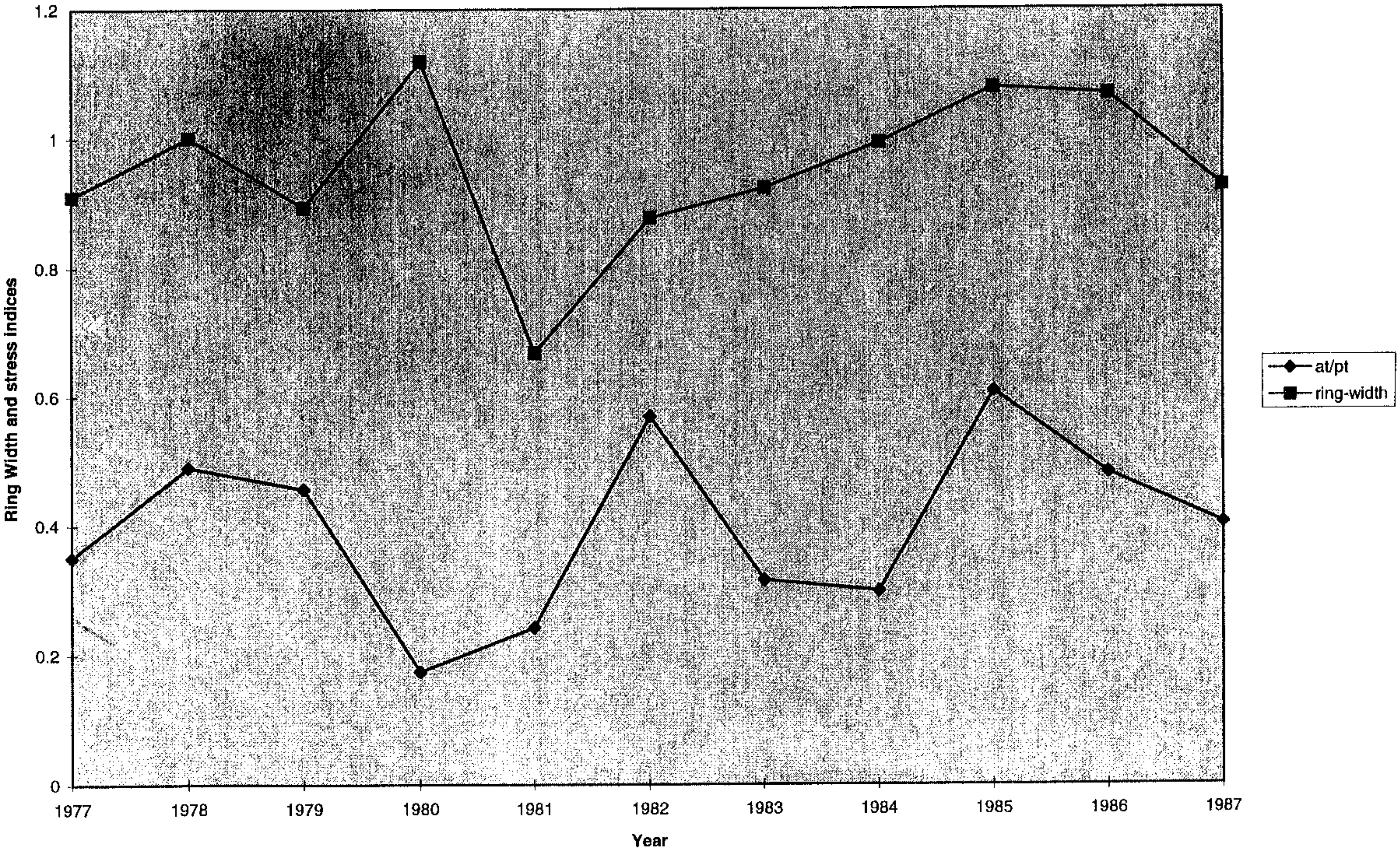


Ring Width and Precipitation-- 5A4

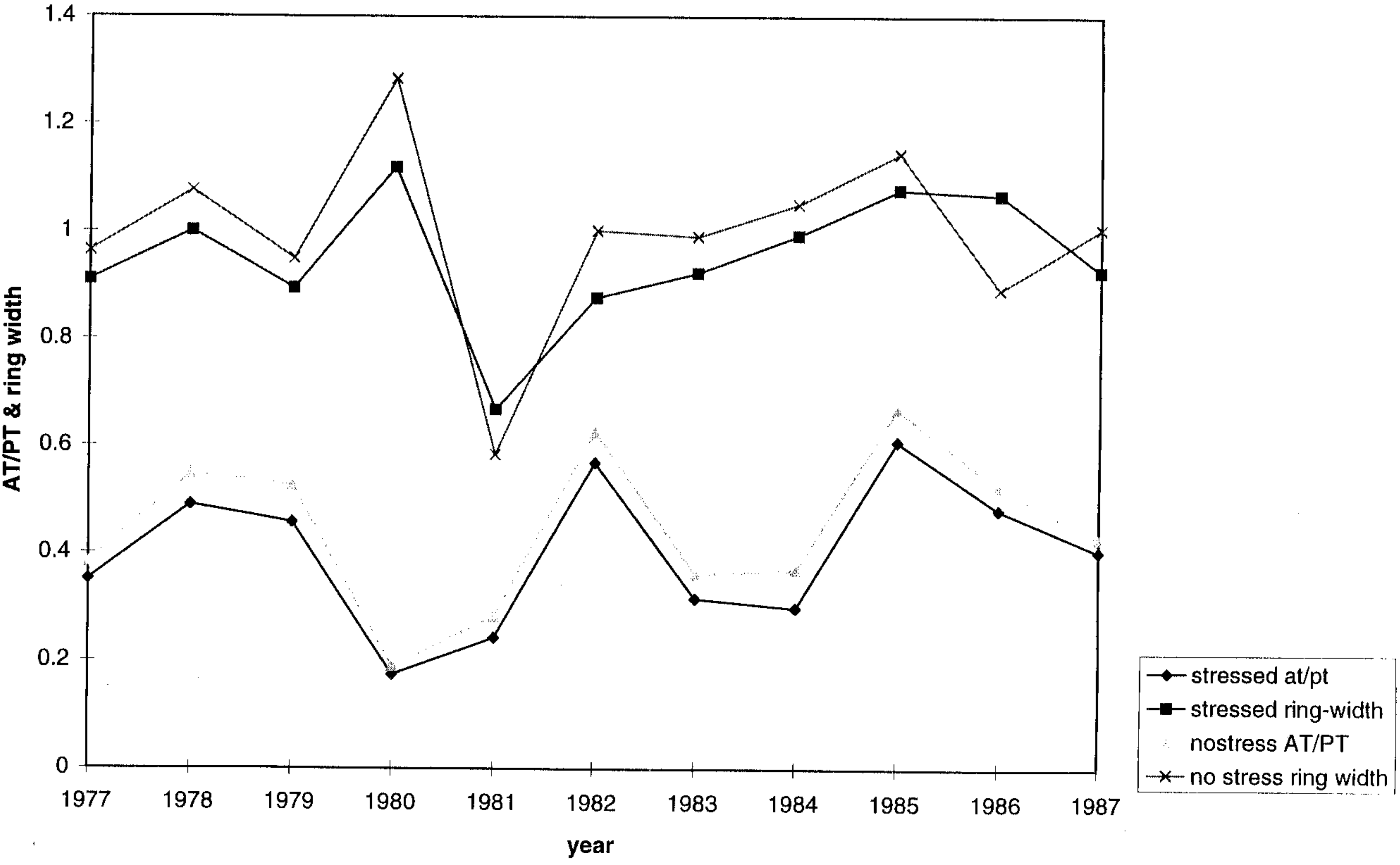
After establishing the above correlations, we can go on to developing the relationship between the AT/PT and the tree-ring widths. Figure 23 and Figure 24 shows the relationship between AT/PT and ring width for sites 4A2C and 5A4. Here again we see the yearly regressive element between ring width and AT/PT. Graph 25, compiles each site information into one graph. Although there is a difference between 4A2C and 5A4 once again we can observe that BRF growing conditions are stressed even in what would be considered a complacent site (refer back to Figure 4). Lastly, all three variables are combined into Figures 26 and 27 for each site.


Stress Index and Ring Width-- 4A2C
ring width and stress indices
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
Year
AT/PT
ring width

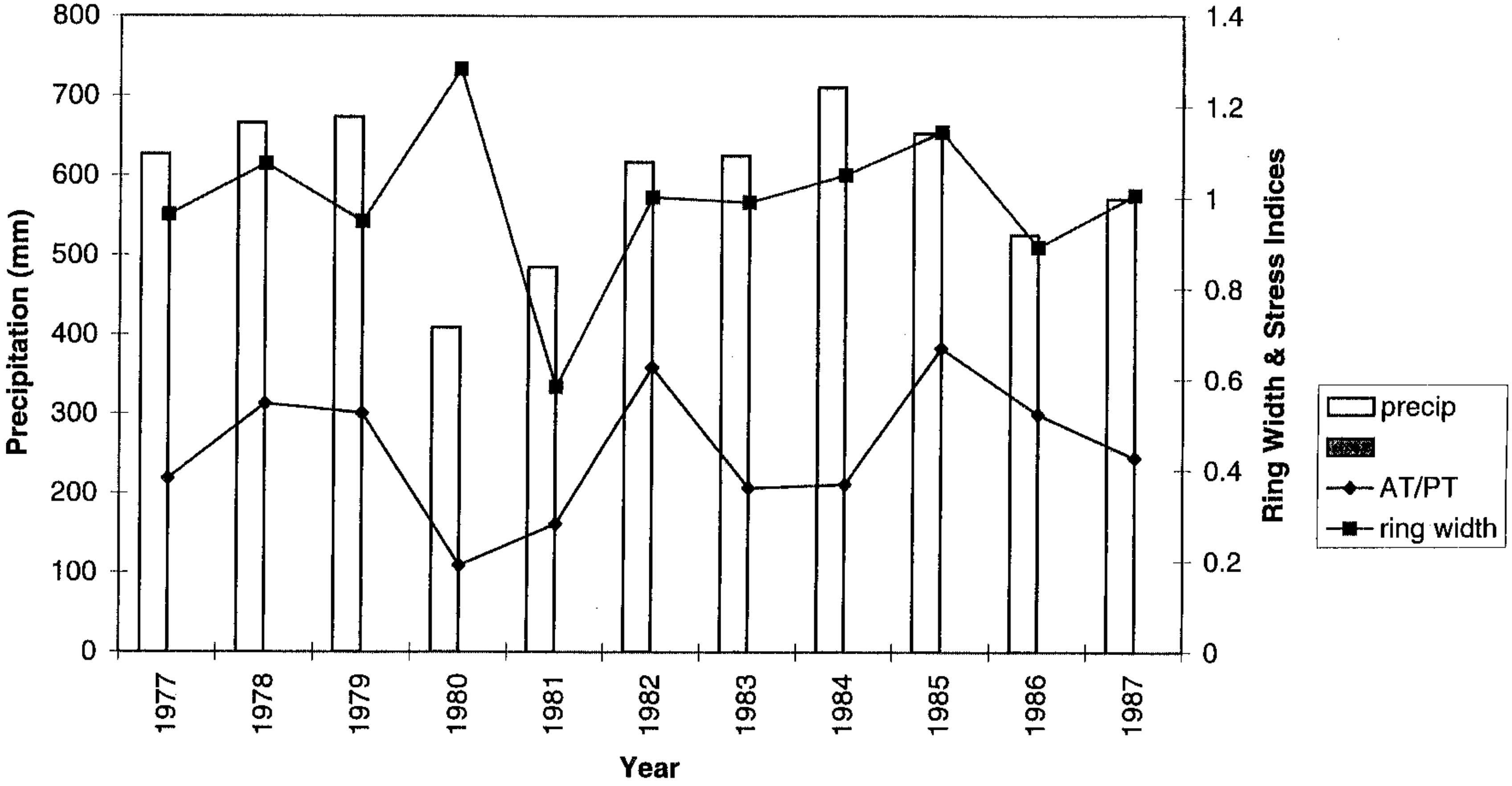
Stress Index and Ring Width-- 5A4

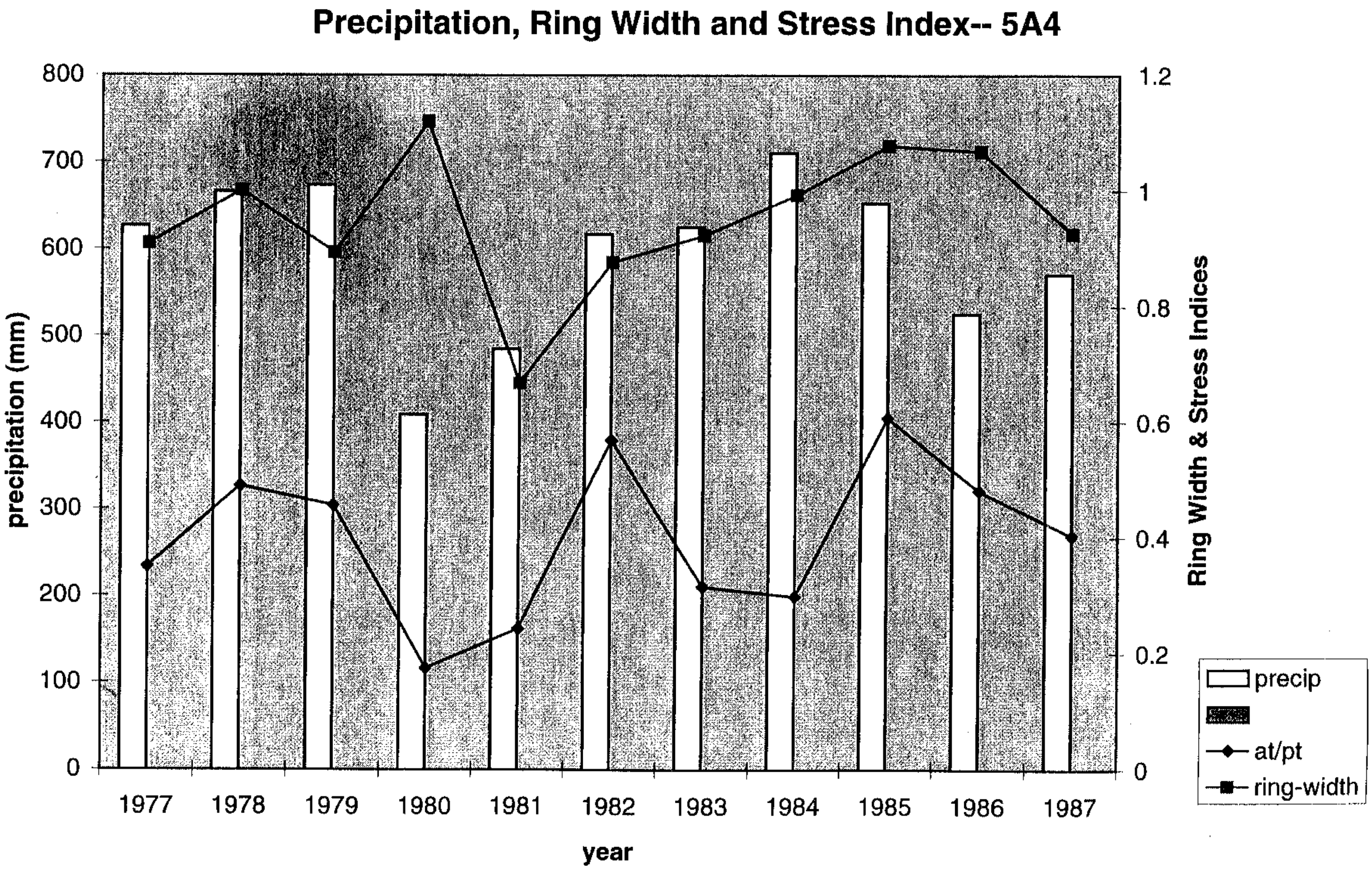


Stressed and Non-stressed Sites Compared



Precipitation, Ring Width and Stress Index--4A2C

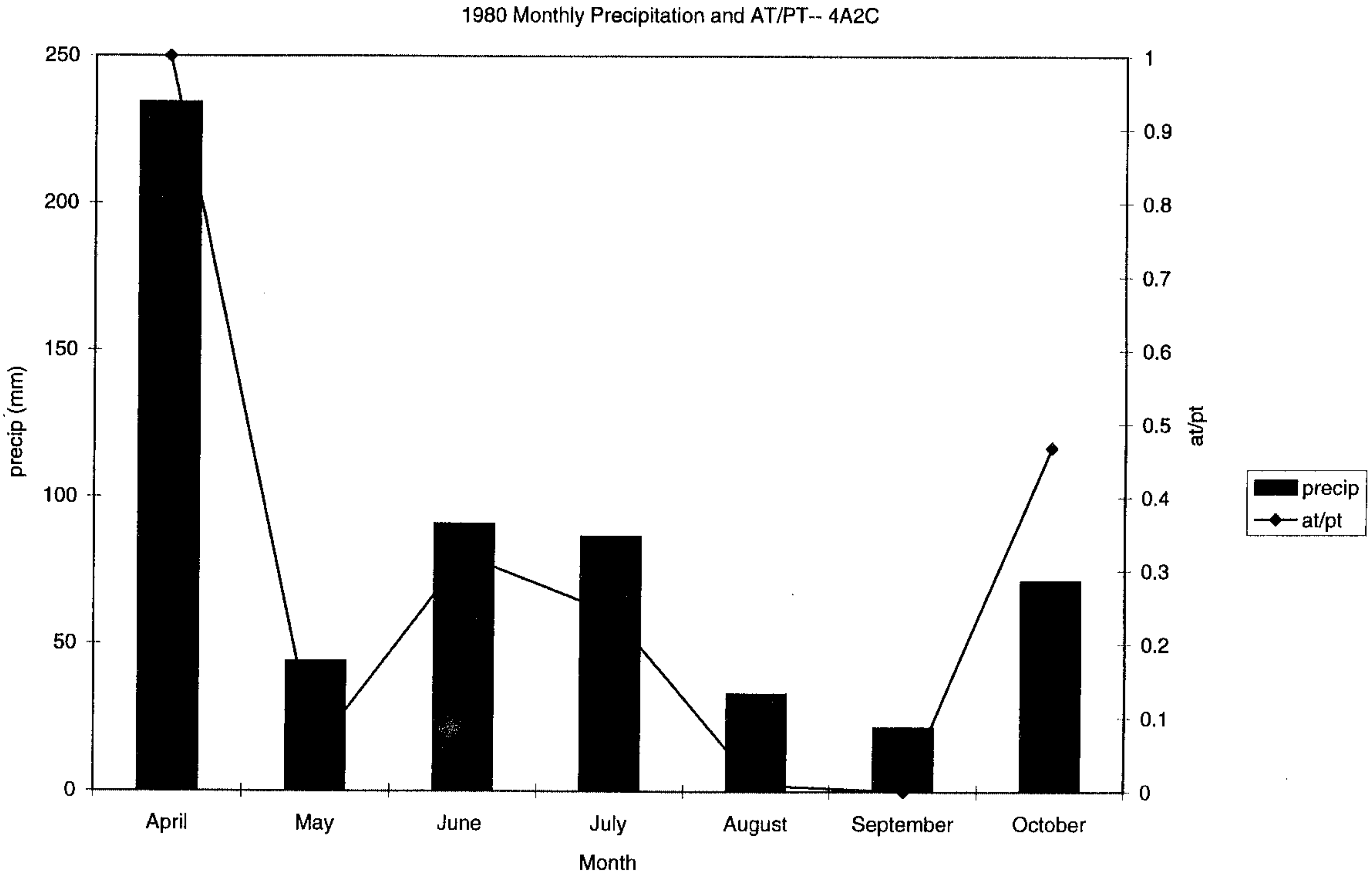



Precipitation, Ring Width and Stress Index-- 5A4
precipitation (mm)
800
700
600
500
400
300
200
100
0
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
year
Ring Width & Stress Indices
1.2
1
0.8
0.6
0.4
0.2
0
precip
at/pt
ring-width

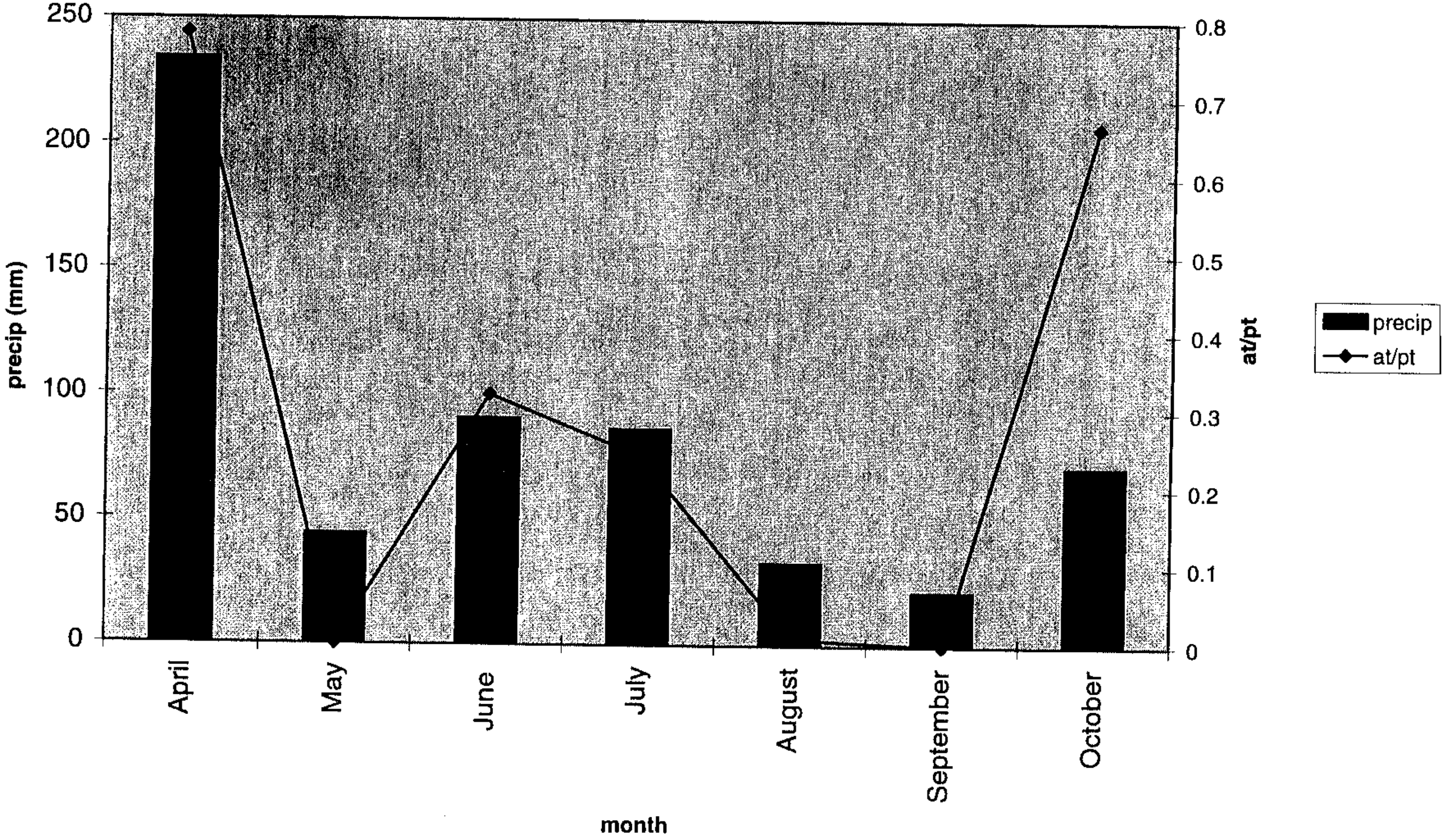
B.iii. Explaining anomalies

To account for the most anomalous points; points where there is a drastic inverse relationship between stress and the ring-width and precipitation data, mainly 1982-1983 and 1984-1985, we can analyze the monthly precipitation values from West Point. If we consider the tree-ring growth correlations correct, then growth in the chestnut oak should be affected by prior August to September and current June to July precipitation values. Thus, monthly precipitation values for the years 1982-1984 should give us some insight to the seemingly contrasting results. However, before we so this, we can test the hypothesis of the tree growth correlation.

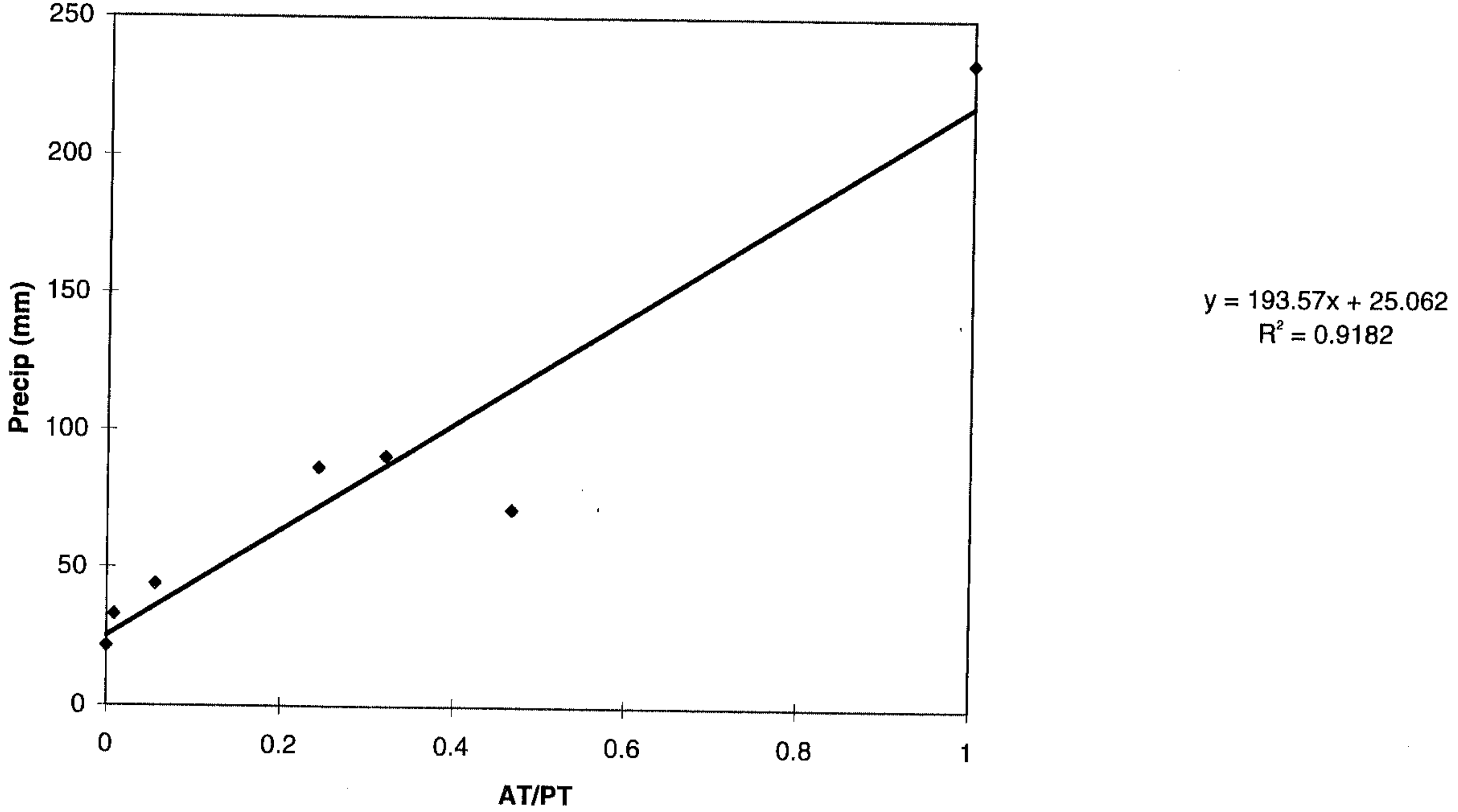
It is easiest to look at the monthly precipitation values for 1980. This is not only a marker year in all of our analyses, but there is a drastic year lag between the stress index and the tree-ring width. Temperature correlations could be used for this analysis. However, from previously presented data, it was determined chestnut oak has a stronger precipitation signal. Figures 28 and 29 illustrates the relationship between the monthly stress and precipitation numbers. One can immediately observe the strong correlation between the two sets of data. The correlations are much higher when stress is compared to monthly figures. Figures 30 and 31 show the significance for the relationship of 1980 monthly precipitation values and the stress index level. For 5A4, the monthly correlation coefficient is now 0.6578. While for the non-stressed, 4A2C site, the correlation is now 0.9182. The lowest ratio of AT/PT corresponds with the lowest precipitation numbers in the month of September. The stress index for September of 1980, is 0. The tree could not meet any of the water demand from the atmosphere. This of course corresponds to the hypothesis that chestnut oaks have a high growth correlation to the previous September precipitation values. June and July rain fall numbers are also moderately low in the following 1981 growing season (appendix C) which corresponds with the strong correlation between current June and July precipitation and ring-width.


1980 Monthly Precipitation and AT/PT-- 4A2C
precip (mm)
250
200
150
100
50
0
at/pt
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
April
May
June
July
August
September
October
Month
precip
at/pt

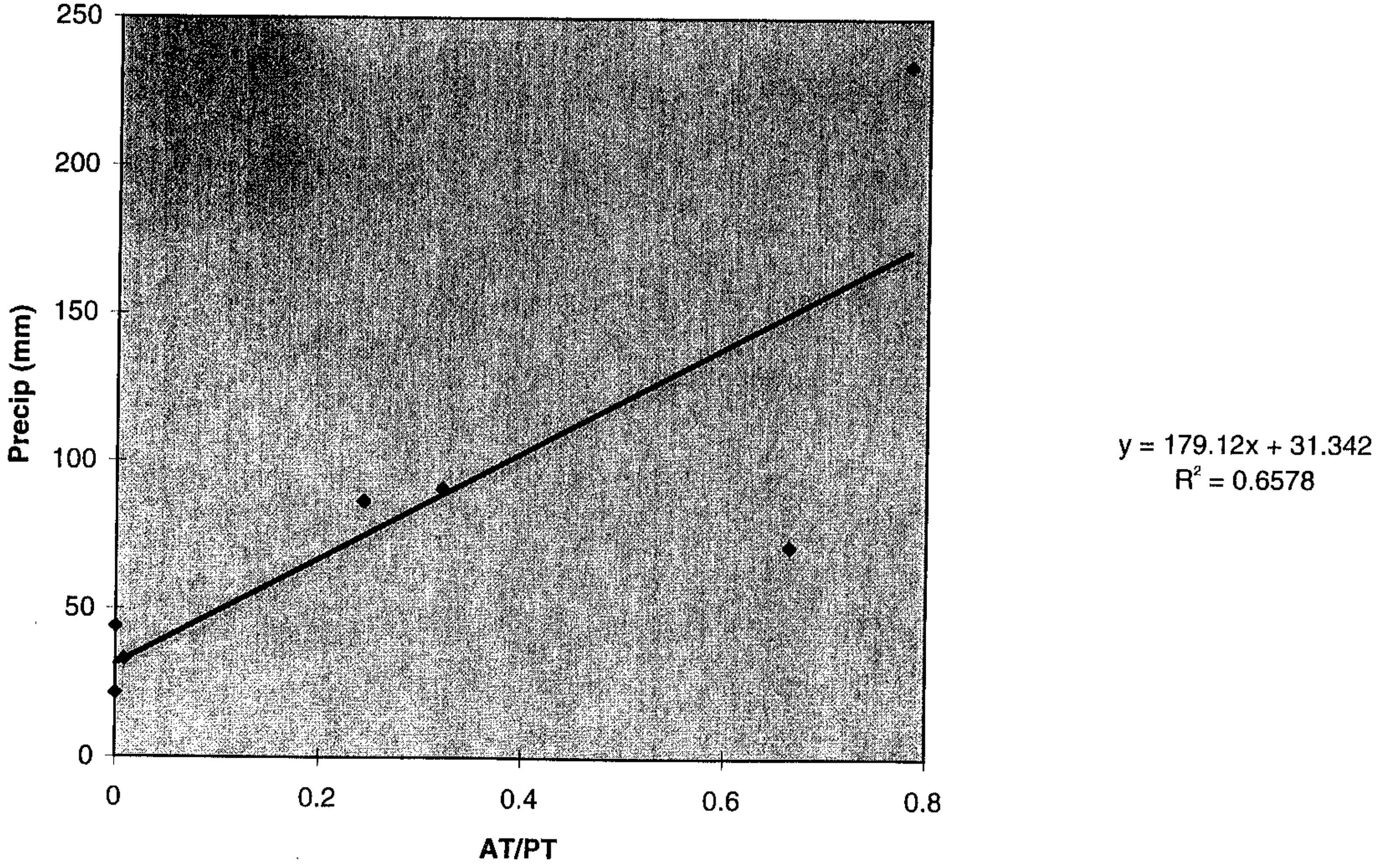
1980 Monthly Precipitation and AT/PT-- 5A4



Correlation of monthly Precipitation and AT/PT--4A2C



Correlation of Monthly Precipitation and AT/PT--5A4



Once this relationship has been established, by the tree-rings, and tested, by the model, we can try to explain the anomalous points. Table 5 summarizes the monthly data for the growing season 1979-1985. A full year's data was not used because the model does not simulate winter metabolic processes. Appendix C has the total monthly precipitation records.

Table 5-- Monthly Total Precipitation Values for the Growing Season 1979-1985

Month	1979	1980	1981	1982	1983	1984	1985
April	132.1	234.12	127.08	127.08	309.72	50.28	50.28
May	141.28	43.89	155.65	155.65	143.66	312.4	177.43
June	45.2	90.64	76.64	160.57	51.04	66.88	102.8
July	42.4	86.4	97.5	80.73	83.1	219.7	150.1
August	154.9	32.94	27.63	118.44	107.91	42.48	101.97
Sept	148.1	21.48	34.44	37.8	44.94	30.96	79.38
Oct	172.2	71.36	79.68	20.72	130.08	33.36	39.6

Briefly, if we examine the data for 1979-1980 again, we see again, that September 1979, was an extremely wet month and that June of 1980 was a moderate to highly moderate wet month. This explains why a drought hitting the Hudson Valley late summer would not be seen in the tree-rings until the following growing season. The inverse relationship between stress and rain fall in both sites for the years 1982-1983 and 1984-1985 can also be explained. 1983, in total precipitation was a slightly higher than that of 1982, however the model results indicate that stress increased in 1983. This may be accountable because of the low September to October precipitation values the following year and the low precipitation values for that current June and July. This also explains the decrease in stress level between the years of 1984, a high stress year, to 1985, a low stress year, while the precipitation for the area decreased. From the table, we see that precipitation values were high in that current June and July probably relieving much of the stress on the tree and that rainfall was distributed nicely all season.

V. DISCUSSION

A. Tree-Ring Correlations

The master chronologies obtained from each site (Figures 13, 10, and 7), depict the similarity of chestnut oak growth across differing site parameters. In each chronology there is some similar trends. From 1965-1968, a period of low precipitation in the Hudson Valley, there are narrow rings at each site. This is also true for sites in Mohonk, New York (D'Arrigo, 1992) which show the same narrow ring trend. Another common marker year is 1981. At all three sites, this is an extremely narrow ring, ranging from 0.584-0.689. This is in synch with the dry and exceptionally hot August and September summer of 1980. There is a regressive component to the slowing of tree growth. Although 1980 had a hot dry summer it is not seen in the tree ring's until the following growth season, when because of the stressed environment the year before, coupled with secondary low precipitation values for 1981 and 1982 the tree finally was affected by the surrounding climate. It also should be noted that during the summer of 1980 B.F. was also plagued by a gypsy moth outbreak that should not be discounted when considering the tree-ring growth (Lawrence, 1995).

The overall nature of the correlations for each site give us some insight to the growth habits of the chestnut oak. Each correlation shows a strong positive relation between the previous September and the current June precipitation and growth. This exemplifies the strong connection between growth and precipitation in the chestnut oak. A strong August-September precipitation signal allows for some release growth in the late wood, as well as, permitting some retention of carbohydrates and nutrients for the following growth season (Kozlowski, et al. 1992). The PDSI data for each sight also confirms the strong positive correlation for previous September growth.

June-July Precipitation is another high positive correlation in the ring series. Each site has this positive relationship as well as a negative correlation for temperature in the same month. The high summer temperatures will limit the tree's growth, thus any high precipitation values during this same period will positively affect growth. This again is in support of the importance of drought stress in this species. Chestnut oak's ability to live in well-drained soils makes their growth highly dependent on the moisture supply (LeBlanc, 1992).

B. Correlation of Simulations, Soil, and Precipitation

The simulation model of the stress index, actual transpiration over potential transpiration, illustrated the strong relationship of precipitation and soil type on the stress of a tree. We can deduce the importance of soil composition and mechanics, by observing these stress index numbers to tree-ring widths. For example, again we can look at 1980. The yearly AT/PT for 1980 at the 5A4 stressed site was 0.1746. When GAPS is manipulated to simulate a more productive soil, possible a silty loam capable of high organic yield, with the same precipitation conditions, the stress number increases, relieving stress. For one such run where the soil conditions were altered in our 1980 scenario file, the new stress index number was 0.236. This is still relatively low, but much higher considering the climatic conditions late in that year's growing season.

Monthly correlations for 1980, illustrated the strong relationship of monthly stress levels in a tree to monthly precipitation levels. When the stress level was compared to annual precipitation we saw a low correlation number. However, the significance of our correlation increased dramatically when monthly ratios were calculated.

C. Correlations of Tree Ring and Simulations

When analyzed, a noticeable regressive relationship between the stress level ratio and the tree-ring widths were observed. In 1980, despite the below average precipitation in August and September, the ring width increased from the previous year instead of decreasing. This relationship was tested under the premise of a high previous September and June precipitation correlation with ring width. As noted previously, September of 1979 had high rainfall, with a low stress index, this coupled with the above average precipitation in June contributed to the wide ring width. The trees did not experience any stress in 1980 until late into their growth season during the months of August and September. It was this late season water deficit that contributed to the observed narrow ring in 1981. However, in total annual precipitation 1980 was not low. It is only when we observe the monthly rain distribution throughout the growing season that the stress level can be extrapolated.

Having the previous September and current June correlations from ring widths coupled with the strong relationship of monthly rainfall and stress index values for 1980, seemingly anomalous years such as 1982-1983 were able to be analyzed and understood. Annual precipitation and tree-ring widths from 1982 to 1983 slightly increased while the stress index of the simulated tree dropped significantly. This would seem to be the exact opposite of what we would expect considering the strong relationship of precipitation to stress levels. However, when monthly distribution of rain was analyzed we saw a high August to September precipitation in 1982 and a moderately high July precipitation level for 1983. This can explain the differences in results for the two indices.

Here it is also important to note the role of solar radiation and the demand of potential evapotranspiration during the growth season. Potential evapotranspiration (PET), the demand for water from the atmosphere, roughly follows the levels of solar radiation throughout the year (Campbell, 1992). Solar radiation peaks during the beginning of summer, June to early July, which, not surprisingly corresponds with the relationship between tree-ring growth and June precipitation and temperature. Thus, trees are surviving in this tentative balance of supply and demand of water during the summer. PET is highest during months when rainfall is at it's lowest. This confirms the dependency of growth on water supply and uptake during these months.

VI. Conclusion

From the dendrochronology analysis and the outputs from GAPS it is obvious that a relationship not only exists between tree growth and soil composition and mechanics, but that the addition of a simulator can further our understanding of the correlations between ring width, soil stress, and monthly precipitation levels. This research was undertaken to examine chestnut oak growth at Black Rock Forest through the study of tree-rings and on a broader scale to bring some new insight to the role of soil in dendrochronology and the range of climatic patterns .

The results obtained from the dendrochronology analysis in each site correlates previous September and current June precipitation with the tree growth. This September correlation is also reaffirmed by the high PDSI correlations with the ring width indices for each site.

The stress index level obtained for sites 4A2C and 5A4 showed the correlation between the ratio of actual transpiration over potential transpiration to precipitation and ring width. From my results, years that are plagued by extreme conditions late in the growing season, namely 1980, showed highly correlated results between AT/PT and precipitation for that year and ring width for the following year.

These three correlations: precipitation to ring width, stress index to precipitation and ring width to stress index have a stronger relationship when considered on a monthly time scale versus an annual one. This analysis has established the importance of considering water stress and soil dynamics when examining tree growth. We have seen the role of soil and how it can affect what the stress is on a tree. In the long run, it might be less accurate to establish a paleo-climatic record from tree-ring studies with out also considering the interactions between tree, soil and water on a micro-level.

VI. Recommendations

This research was able to further understanding of the importance of soil water balance in a tree. However, if further research was undertaken it would be worth while to set up GAPS to model photosynthesis with a fluctuating canopy which occurs in nature. For our model there was a constant LAI which did not account for budding or a slow defoliation process in the fall. The importance of rainfall redistribution falling on a canopy could not be calculated (Landsberg, 1986).

It also would be important to understand what metabolic processes were occurring in the tree during the winter when photosynthesis has stopped. It is assumed that there is a stored amount of carbon, water and nutrients which allows the tree to bud the following spring, this was not modeled. It would take further model development to actually calculate ring width rather than a stress index. In the long run, this would make the proven relationships of previous September stress with following year growth more explicit.

Lastly, if there was more time it would be interesting and useful to have the leisure to model many different variabilities within climate and soil to see the results. These manipulations were only tried briefly with this thesis.

VII. Acknowledgments

I would like to deeply thank my advisors Dr. Jennifer Phillips and Dr. Peter Bower for their research and academic guidance. I would also like to thank Dr. William Schuster, John Brady and Aaron Kimple at Black Rock Forest for their assistance with research during the summers, as well as, the BRF consortium for financial support for summer research. I wish to acknowledge Dr. Roseanne D'Arrigo and David Lawrence of Lamont Doherty Earth Observatory for assistance with the dendrochronology aspect of the thesis. Lastly, I want to thank the Goddard institute for Space Studies and the Northeast Institute for Global Environmental Change for their financial support of this research.

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Appendix A

BLACK ROCK FOREST NORMALIZED TREE-RING WIDTHS FOR THE CHESTNUT OAK										
ARTHUR'S BROOK										
ABQ										
ABQRES1856	9990	9990	9990	9990	9990	0	823	869	1056	1293
ABQRES1860	962	847	1011	970	704	1062	899	1084	962	1054
ABQRES1870	1006	984	789	670	1394	1034	828	1062	1101	1152
ABQRES1880	1025	1239	850	904	886	880	1012	1106	943	1215
ABQRES1890	912	725	698	787	762	920	1055	922	859	1062
ABQRES1900	1096	963	1019	1025	1161	917	974	955	1023	873
ABQRES1910	947	967	954	935	1243	894	1292	1167	786	1048
ABQRES1920	1426	1171	1060	833	1025	1112	892	1118	963	926
ABQRES1930	940	919	1332	896	1068	1111	967	1361	1147	1110
ABQRES1940	904	1036	915	985	937	873	1208	1316	755	817
ABQRES1950	1123	1007	1178	1124	803	1000	1031	847	1011	894
ABQRES1960	1169	1000	788	1082	1110	686	867	874	791	1067
ABQRES1970	959	874	1125	1016	1115	1148	1195	964	1076	949
ABQRES1980	1283	584	1002	991	1051	1145	892	1006	989	1027
ABQRES1990	1168	1009	1198	886	1101	9990	9990	9990	9990	9990

```
------------------------------------------------------------------------------------------------------------------------------

 QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

 Title of run:           Arthur's Brook -- Quercus prinus

 File of DATED series:   ABQUPR.RWL

 CONTENTS:

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

 RUN CONTROL OPTIONS SELECTED                             VALUE

         1  Cubic smoothing spline 50% wavelength cutoff for filtering
                                                           32 years
         2  Segments examined are                          50 years lagged successively by  25 years
         3  Autoregressive model applied                    A  Residuals are used in master dating series and testing
         4  Series transformed to logarithms                Y  Each series log-transformed for master dating series and testing
         5  Critical correlation, 99% confidence level   .3281
         6  Master dating series saved                      N
         7  Listing of ring measurements in Part 6          N
         8  Parts printed                             1234567
         9  Absent rings included in master series          N

 Time span of Master dating series is  1854 to  1994   141 years
 Continuous time span is               1854 to  1994   141 years
 Portion with two or more series is    1854 to  1994   141 years


                                         ******************************************
                                         *C* Number of dated series        44 *C*
                                         *O* Master series 1854 1994  141 yrs *O*
                                         *F* Total rings in all series   5192 *F*
                                         *E* Total dated rings checked   5192 *E*
                                         *C* Series intercorrelation     .633 *C*
                                         *H* Average mean sensitivity    .214 *H*
                                         *A* Segments, possible problems    1 *A*
                                         ******************************************

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

             No ring measurements of zero value
```

```
1[]  DENDROCHRONOLOGY PROGRAM LIBRARY                                           Run ABQ  Program COF  15:11  Thu 24 AUG 1995  Page   2
 []
 []  PART 2:  TIME PLOT OF TREE-RING SERIES: Arthur's Brook -- Quercus prinus                                  Version  1.24P    22152
------------------------------------------------------------------------------------------------------------------------------------------
1000      1100      1200      1300      1400      1500      1600      1700      1800      1900      2000           Beg  End
                                                                                                      Ident    Seq year year  Yrs
:    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==========>. ABQ904SE   1 1888 1994  107
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. ABQ920W    2 1877 1994  118
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.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <=============>. ABQ905NW   5 1854 1994  141
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.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. ABQ911SE   7 1877 1994  118
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. ABQ908SE   8 1860 1994  135
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.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. ABQ901E   11 1918 1994   77
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.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. ABQ902    18 1920 1994   75
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.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==========>. ABQ901N   24 1889 1994  106
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.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. ABQ908NW  40 1860 1994  135
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.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. ABQ912E   44 1920 1994   75

:    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1000      1100      1200      1300      1400      1500      1600      1700      1800      1900      2000
```

```
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   1.042   40    1950    .315   43
                                                                                    1901    .459   40    1951   -.065   43
                                                                                    1902    .595   41    1952   1.035   43
                                                                                    1903    .622   41    1953   1.353   43
                                                               1854   1.470    3    1904   1.651   41    1954   -.620   43
                                                               1855    .831    4    1905    .292   41    1955    .068   43
                                                               1856    .170    5    1906    .179   41    1956    .344   43
                                                               1857   -.757    5    1907   -.050   41    1957   -.848   43
                                                               1858   -.304    7    1908    .330   41    1958    .072   43
                                                               1859   1.514    8    1909   -.836   41    1959   -.716   43

                                                               1860    .738   12    1910   -.799   41    1960   1.165   43
                                                               1861    .260   13    1911   -.770   41    1961    .640   43
                                                               1862    .284   15    1912   -.958   41    1962   -.839   43
                                                               1863    .370   16    1913  -1.277   41    1963    .612   43
                                                               1864  -1.955   16    1914    .881   40    1964   1.332   43
                                                               1865   -.110   18    1915   -.761   40    1965  -1.421   43
                                                               1866   -.643   19    1916   1.258   40    1966  -1.004   43
                                                               1867    .222   19    1917   1.236   40    1967  -1.107   43
                                                               1868   -.320   19    1918  -1.061   41    1968  -2.122   43
                                                               1869    .127   19    1919   -.195   41    1969   -.237   43

                                                               1870    .108   20    1920   2.064   43    1970   -.407   43
                                                               1871    .063   20    1921   1.643   43    1971   -.926   43
                                                               1872  -1.394   20    1922    .934   43    1972    .490   43
                                                               1873  -3.413   20    1923   -.793   43    1973    .097   43
                                                               1874   1.119   21    1924   -.213   43    1974    .722   43
                                                               1875    .714   24    1925    .447   43    1975   1.109   43
                                                               1876   -.635   26    1926   -.854   43    1976   1.695   43
                                                               1877    .317   29    1927    .405   43    1977    .803   43
                                                               1878    .374   30    1928   -.427   43    1978    .921   43
                                                               1879   1.031   32    1929   -.993   43    1979    .072   43

                                                               1880    .466   32    1930  -1.435   43    1980   1.639   42
                                                               1881   1.777   32    1931  -1.775   43    1981  -2.287   42
                                                               1882    .288   32    1932   1.212   43    1982   -.823   42
                                                               1883   -.014   32    1933   -.864   43    1983   -.750   42
                                                               1884   -.592   33    1934    .077   43    1984   -.320   42
                                                               1885   -.693   34    1935    .327   43    1985    .671   42
                                                               1886   -.033   34    1936   -.324   43    1986   -.595   42
                                                               1887    .772   34    1937   1.829   43    1987   -.288   42
                                                               1888    .404   36    1938   1.430   43    1988   -.624   42
                                                               1889   1.489   37    1939   1.304   43    1989   -.314   42

                                                               1890    .772   38    1940    .069   43    1990    .759   42
                                                               1891   -.613   38    1941    .141   43    1991    .104   42
                                                               1892  -1.597   39    1942   -.768   43    1992   1.367   42
                                                               1893  -1.800   39    1943   -.627   43    1993   -.680   42
                                                               1894  -2.256   39    1944   -.956   43    1994    .257   42
                                                               1895  -1.207   39    1945  -1.618   43
                                                               1896    .073   40    1946    .662   43
                                                               1897   -.180   40    1947   2.032   43
                                                               1898   -.770   40    1948   -.641   43
                                                               1899    .256   40    1949  -1.501   43
---------------------------------------------------------------------------------------------------------------------------
```

```
1 PART 4:  Master Bar Plot: Arthur's Brook -- Quercus prinus                                              15:11  Thu 24 AUG 1995  Page   4
---------------------------------------------------------------------------------------------------------------------------------------------
    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------A
                                                                                                                      1901-------B       1951----@
                                                                                                                      1902-------B       1952---------D
                                                                                                                      1903--------B      1953---------E
                                                                                                   1854----------F    1904----------G    1954---b
                                                                                                   1855--------C      1905------A        1955-----@
                                                                                                   1856-----A         1906------A        1956------A
                                                                                                   1857--c            1907-----@         1957--c
                                                                                                   1858----a          1908------A        1958-----@
                                                                                                   1859----------F    1909--c            1959--c
+   ____               ____               ____               ____               ____               ____               ____               ____
                                                                                                   1860--------C      1910--c            1960---------E
                                                                                                   1861------A        1911--c            1961--------C
                                                                                                   1862------A        1912-d             1962--c
                                                                                                   1863------A        1913-e             1963-------B
                                                                                                   1864h              1914--------D      1964---------E
                                                                                                   1865----@          1915--c            1965f
                                                                                                   1866---c           1916---------E     1966-d
                                                                                                   1867------A        1917---------E     1967-d
                                                                                                   1868----a          1918-d             1968h
                                                                                                   1869-----A         1919----a          1969----a
+   ____               ____               ____               ____               ____               ____               ____               ____
                                                                                                   1870-----@         1920----------H    1970---b
                                                                                                   1871-----@         1921----------G    1971-d
                                                                                                   1872f              1922--------D      1972-------B
                                                                                                   1873n              1923--c            1973-----@
                                                                                                   1874---------D     1924----a          1974--------C
                                                                                                   1875--------C      1925-------B       1975---------D
                                                                                                   1876---c           1926--c            1976----------G
                                                                                                   1877------A        1927-------B       1977--------C
                                                                                                   1878-------A       1928---b           1978--------D
                                                                                                   1879---------D     1929-d             1979-----@
+   ____               ____               ____               ____               ____               ____               ____               ____
                                                                                                   1880-------B       1930f              1980----------G
                                                                                                   1881----------G    1931g              1981i
                                                                                                   1882------A        1932---------E     1982--c
                                                                                                   1883-----@         1933-c             1983--c
                                                                                                   1884---b           1934-----@         1984----a
                                                                                                   1885--c            1935------A        1985--------C
                                                                                                   1886-----@         1936----a          1986---b
                                                                                                   1887--------C      1937----------G    1987----a
                                                                                                   1888-------B       1938---------F     1988---b
                                                                                                   1889----------F    1939---------E     1989----a
+   ____               ____               ____               ____               ____               ____               ____               ____
                                                                                                   1890--------C      1940-----@         1990--------C
                                                                                                   1891---b           1941-----A         1991-----@
                                                                                                   1892f              1942--c            1992---------E
                                                                                                   1893g              1943---c           1993---c
                                                                                                   1894i              1944-d             1994------A
                                                                                                   1895-e             1945f
                                                                                                   1896-----@         1946--------C
                                                                                                   1897----a          1947----------H
                                                                                                   1898--c            1948---c
                                                                                                   1899------A        1949f
+   ____               ____               ____               ____               ____               ____               ____               ____
---------------------------------------------------------------------------------------------------------------------------------------------
    141 values in series
```

```
1  PART 5:  CORRELATION BY SEGMENTS OF SERIES: Arthur's Brook -- Quercus prinus          15:11  Thu 24 AUG 1995  Page   5
-----------------------------------------------------------------------------------------------------------------------
 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   Interval   1850 1875 1900 1925 1950
                         1899 1924 1949 1974 1999
   1 ABQ904SE 1888 1994    -   .62  .79  .79  .78   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   2 ABQ920W  1877 1994    -   .72  .81  .72  .71   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   3 ABQ915NW 1874 1994   .56  .56  .59  .53  .58   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   4 ABQ915SE 1875 1994    -   .63  .63  .54  .34   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   5 ABQ905NW 1854 1994   .60  .66  .54  .41  .55   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   6 ABQ907SE 1863 1994   .49  .67  .80  .75  .81   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   7 ABQ911SE 1877 1994    -   .66  .61  .72  .85   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   8 ABQ908SE 1860 1994   .75  .67  .70  .69  .74   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
   9 ABQ909NW 1875 1994    -   .24  .60  .77  .80   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
+                             ___B
  10 ABQ913E  1862 1994   .72  .71  .64  .57  .65   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  11 ABQ901E  1918 1994    -    -   .66  .63  .69   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  12 ABQ913W  1866 1994   .59  .60  .53  .49  .52   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  13 ABQ906SE 1860 1994   .65  .72  .69  .52  .66   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  14 ABQ916SE 1884 1994    -   .45  .51  .58  .67   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  15 ABQ914SE 1856 1994   .42  .56  .60  .57  .51   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  16 ABQ913   1855 1994   .61  .67  .61  .59  .65   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  17 ABQ902NW 1892 1979    -   .54  .58  .57  .58   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  18 ABQ902   1920 1994    -    -   .72  .67  .45   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  19 ABQ910SE 1858 1994   .76  .54  .43  .45  .54   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  20 ABQ918S  1878 1994    -   .59  .68  .73  .77   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  21 ABQ905SE 1877 1994    -   .54  .66  .62  .62   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  22 ABQ902SE 1896 1994    -   .60  .64  .58  .48   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  23 ABQ917SE 1876 1994    -   .82  .75  .73  .82   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  24 ABQ901N  1889 1994    -   .64  .65  .71  .76   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  25 ABQ911NW 1865 1994   .70  .65  .68  .77  .77   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  26 ABQ919   1870 1994   .71  .65  .71  .71  .75   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  27 ABQ920E  1876 1994    -   .57  .70  .73  .77   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  28 ABQ914NW 1854 1994   .56  .56  .62  .56  .55   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  29 ABQ918N  1879 1994    -   .62  .63  .57  .76   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  30 ABQ912W  1860 1994   .81  .64  .60  .39  .35   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  31 ABQ904NW 1888 1994    -   .67  .72  .76  .78   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  32 ABQ911NW 1865 1994   .71  .76  .78  .79  .84   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  33 ABQ917NW 1875 1994    -   .67  .76  .61  .66   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  34 ABQ910NW 1859 1994   .71  .60  .53  .58  .39   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  35 ABQ919NE 1879 1994    -   .41  .49  .61  .66   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  36 ABQ919SE 1862 1994   .63  .57  .69  .77  .74   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  37 ABQ909SE 1861 1994   .57  .55  .64  .75  .80   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  38 ABQ901S  1902 1994    -    -   .62  .70  .59   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  39 ABQ906NW 1858 1994   .65  .66  .69  .62  .52   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  40 ABQ908NW 1860 1994   .72  .68  .77  .75  .67   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  41 ABQ903NW 1890 1994    -   .75  .79  .74  .46   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  42 ABQ916NW 1885 1994    -   .66  .64  .68  .74   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  43 ABQ912E  1854 1913   .50  .59   -    -    -    -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
  44 ABQ912E  1920 1994    -    -   .64  .62  .54   -  -  -  -  -  -  -  -  -  -  -  -  -  -  -
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 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

 [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
=======================================================================================================================

 ABQ904SE  1888 to  1994     107 years
                                                                                                         Series   1
 [B] Entire series, effect on correlation (  .716) is:
      Lower   1889  -.038   1891  -.019   1968  -.009   1986  -.009  Higher   1981   .044   1894   .008   1965   .007   1937   .007

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

 ABQ920W   1877 to  1994     118 years
                                                                                                         Series   2
 [B] Entire series, effect on correlation (  .730) is:
      Lower   1878  -.017   1952  -.016   1953  -.013   1945  -.011  Higher   1981   .030   1894   .008   1937   .007   1892   .007

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

 ABQ915NW  1874 to  1994     121 years
                                                                                                         Series   3
 [B] Entire series, effect on correlation (  .546) is:
      Lower   1988  -.031   1879  -.020   1930  -.014   1931  -.012  Higher   1965   .016   1947   .016   1920   .015   1968   .013

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

 ABQ915SE  1875 to  1994     120 years
                                                                                                         Series   4
 [B] Entire series, effect on correlation (  .488) is:
      Lower   1981  -.027   1956  -.021   1986  -.016   1980  -.015  Higher   1968   .019   1920   .017   1894   .014   1947   .013

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

 ABQ905NW  1854 to  1994     141 years
                                                                                                         Series   5
 [B] Entire series, effect on correlation (  .573) is:
      Lower   1962  -.023   1858  -.022   1940  -.021   1947  -.012  Higher   1981   .042   1873   .032   1968   .013   1976   .008

 [E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
      1940 +3.7 SD;    1962 +3.1 SD
=======================================================================================================================

 ABQ907SE  1863 to  1994     132 years
                                                                                                         Series   6
 [B] Entire series, effect on correlation (  .700) is:
      Lower   1864  -.028   1873  -.013   1919  -.010   1944  -.009  Higher   1981   .028   1968   .010   1920   .008   1947   .006

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1864 +3.1 SD
=======================================================================================================================

 ABQ911SE  1877 to  1994     118 years
                                                                                                         Series   7
 [B] Entire series, effect on correlation (  .714) is:
      Lower   1930  -.021   1931  -.015   1918  -.013   1905  -.012  Higher   1981   .014   1965   .012   1920   .009   1968   .007

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

 ABQ908SE  1860 to  1994     135 years
                                                                                                         Series   8
 [B] Entire series, effect on correlation (  .724) is:
      Lower   1974  -.013   1932  -.012   1914  -.008   1933  -.007  Higher   1873   .029   1981   .012   1864   .011   1968   .009

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ABQ909NW  1875 to  1994     120 years
                                                                                                    Series   9
[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           -.18 -.38 -.15 -.17  .01  .14 -.05  .11 -.16  .19  .24  .06  .14  .27  .00 -.03  .06  .13  .00 -.21 -.20
+               3                                                       ___            <___>

[B] Entire series, effect on correlation (  .608) is:
     Lower   1916  -.037   1895  -.018   1918  -.017   1882  -.011  Higher   1981   .030   1965   .019   1947   .011   1937   .011
    1875 to 1924 segment:
     Lower   1916  -.087   1895  -.040   1918  -.034   1913  -.025  Higher   1920   .057   1915   .047   1892   .043   1893   .024

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
     1895 +3.3 SD;    1916 -4.6 SD
==============================================================================================================================
ABQ913E    1862 to  1994     133 years
                                                                                                    Series  10
[B] Entire series, effect on correlation (  .660) is:
     Lower   1967  -.025   1922  -.015   1865  -.013   1948  -.012  Higher   1873   .036   1981   .021   1965   .009   1937   .009

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1967 +3.6 SD
==============================================================================================================================
ABQ901E    1918 to  1994      77 years
                                                                                                    Series  11
[B] Entire series, effect on correlation (  .631) is:
     Lower   1931  -.044   1948  -.025   1933  -.022   1942  -.012  Higher   1968   .020   1918   .012   1949   .011   1920   .009

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1931 +3.8 SD
==============================================================================================================================
ABQ913W    1866 to  1994     129 years
                                                                                                    Series  12
[B] Entire series, effect on correlation (  .529) is:
     Lower   1987  -.023   1872  -.017   1985  -.015   1875  -.013  Higher   1981   .047   1873   .024   1920   .016   1937   .014
==============================================================================================================================
ABQ906SE   1860 to  1994     135 years
                                                                                                    Series  13
[B] Entire series, effect on correlation (  .645) is:
     Lower   1952  -.045   1873  -.010   1990  -.009   1940  -.009  Higher   1981   .036   1864   .011   1918   .007   1947   .006

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1952 -4.8 SD
==============================================================================================================================
ABQ916SE   1884 to  1994     111 years
                                                                                                    Series  14
[B] Entire series, effect on correlation (  .571) is:
     Lower   1955  -.030   1919  -.019   1912  -.015   1889  -.014  Higher   1981   .027   1968   .017   1918   .014   1920   .011
==============================================================================================================================
ABQ914SE   1856 to  1994     139 years
                                                                                                    Series  15
[B] Entire series, effect on correlation (  .495) is:
     Lower   1993  -.019   1857  -.019   1994  -.018   1949  -.016  Higher   1981   .042   1918   .012   1965   .011   1980   .010
==============================================================================================================================
ABQ913     1855 to  1994     140 years
                                                                                                    Series  16
[B] Entire series, effect on correlation (  .614) is:
     Lower   1867  -.020   1861  -.018   1925  -.009   1986  -.009  Higher   1981   .027   1873   .017   1965   .014   1968   .012
==============================================================================================================================
ABQ902NW   1892 to  1979      88 years
                                                                                                    Series  17
[B] Entire series, effect on correlation (  .540) is:
     Lower   1915  -.023   1892  -.018   1930  -.018   1968  -.017  Higher   1920   .017   1932   .016   1965   .014   1948   .013
==============================================================================================================================
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ABQ902     1920 to  1994     75 years                                                                   Series  18

[B] Entire series, effect on correlation (  .539) is:
     Lower   1990  -.089   1975  -.014   1973  -.011   1984  -.010  Higher   1937   .020   1945   .016   1932   .015   1948   .015
==================================================================================================================================
ABQ910SE   1858 to  1994    137 years                                                                   Series  19

[B] Entire series, effect on correlation (  .559) is:
     Lower   1981  -.023   1935  -.023   1930  -.014   1923  -.014  Higher   1873   .039   1864   .013   1920   .013   1968   .009
==================================================================================================================================
ABQ918S    1878 to  1994    117 years                                                                   Series  20

[B] Entire series, effect on correlation (  .703) is:
     Lower   1880  -.015   1948  -.015   1945  -.013   1911  -.011  Higher   1981   .022   1965   .010   1947   .009   1893   .005
==================================================================================================================================
ABQ905SE   1877 to  1994    118 years                                                                   Series  21

[B] Entire series, effect on correlation (  .612) is:
     Lower   1952  -.025   1965  -.014   1991  -.013   1993  -.013  Higher   1981   .057   1968   .014   1920   .013   1980   .010
==================================================================================================================================
ABQ902SE   1896 to  1994     99 years                                                                   Series  22

[B] Entire series, effect on correlation (  .523) is:
     Lower   1952  -.018   1972  -.017   1992  -.013   1984  -.012  Higher   1948   .013   1931   .012   1920   .012   1937   .011
==================================================================================================================================
ABQ917SE   1876 to  1994    119 years                                                                   Series  23

[B] Entire series, effect on correlation (  .791) is:
     Lower   1933  -.017   1963  -.012   1941  -.008   1930  -.007  Higher   1981   .029   1894   .005   1920   .005   1892   .005
==================================================================================================================================
ABQ901N    1889 to  1994    106 years                                                                   Series  24

[B] Entire series, effect on correlation (  .697) is:
     Lower   1936  -.018   1931  -.014   1920  -.010   1988  -.010  Higher   1981   .023   1968   .013   1918   .009   1932   .008
==================================================================================================================================
ABQ911NW   1865 to  1994    130 years                                                                   Series  25

[B] Entire series, effect on correlation (  .727) is:
     Lower   1931  -.020   1905  -.017   1981  -.016   1866  -.011  Higher   1873   .018   1965   .006   1874   .006   1932   .006
==================================================================================================================================
ABQ919     1870 to  1994    125 years                                                                   Series  26

[B] Entire series, effect on correlation (  .719) is:
     Lower   1892  -.020   1945  -.014   1955  -.013   1887  -.008  Higher   1873   .012   1981   .009   1965   .009   1947   .008
==================================================================================================================================
ABQ920E    1876 to  1994    119 years                                                                   Series  27

[B] Entire series, effect on correlation (  .707) is:
     Lower   1952  -.026   1902  -.021   1879  -.013   1878  -.010  Higher   1981   .041   1892   .007   1894   .007   1881   .007
==================================================================================================================================
ABQ914NW   1854 to  1994    141 years                                                                   Series  28

[B] Entire series, effect on correlation (  .571) is:
     Lower   1968  -.017   1884  -.013   1915  -.011   1961  -.007  Higher   1864   .010   1980   .010   1965   .009   1872   .008
==================================================================================================================================
ABQ918N    1879 to  1994    116 years                                                                   Series  29

[B] Entire series, effect on correlation (  .665) is:
     Lower   1951  -.024   1943  -.022   1880  -.016   1915  -.015  Higher   1981   .040   1965   .011   1947   .009   1894   .009
==================================================================================================================================
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ABQ912W   1860 to  1994     135 years
                                                                                       Series  30
[B] Entire series, effect on correlation (  .567) is:
     Lower   1975  -.016   1973  -.014   1922  -.013   1986  -.012  Higher   1873   .038   1981   .028   1864   .015   1872   .008
=================================================================================================================================

ABQ904NW  1888 to  1994     107 years
                                                                                       Series  31
[B] Entire series, effect on correlation (  .730) is:
     Lower   1986  -.016   1915  -.014   1931  -.013   1889  -.012  Higher   1981   .025   1965   .009   1918   .008   1892   .006
=================================================================================================================================

ABQ911NW  1865 to  1994     130 years
                                                                                       Series  32
[B] Entire series, effect on correlation (  .787) is:
     Lower   1866  -.024   1956  -.011   1904  -.007   1931  -.006  Higher   1981   .020   1873   .017   1965   .008   1968   .005

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1866 +3.7 SD
=================================================================================================================================

ABQ917NW  1875 to  1994     120 years
                                                                                       Series  33
[B] Entire series, effect on correlation (  .655) is:
     Lower   1884  -.028   1878  -.011   1931  -.010   1891  -.009  Higher   1981   .015   1920   .011   1965   .009   1892   .009
=================================================================================================================================

ABQ910NW  1859 to  1994     136 years
                                                                                       Series  34
[B] Entire series, effect on correlation (  .545) is:
     Lower   1981  -.041   1993  -.012   1935  -.012   1992  -.010  Higher   1873   .048   1968   .012   1894   .011   1920   .010
=================================================================================================================================

ABQ919NE  1879 to  1994     116 years
                                                                                       Series  35
[B] Entire series, effect on correlation (  .509) is:
     Lower   1892  -.041   1994  -.027   1931  -.024   1937  -.021  Higher   1981   .051   1965   .022   1918   .016   1920   .013

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
     1892 +4.3 SD;    1931 +3.1 SD
=================================================================================================================================

ABQ919SE  1862 to  1994     133 years
                                                                                       Series  36
[B] Entire series, effect on correlation (  .697) is:
     Lower   1901  -.009   1983  -.009   1964  -.007   1968  -.007  Higher   1981   .015   1965   .011   1864   .011   1947   .009
=================================================================================================================================

ABQ909SE  1861 to  1994     134 years
                                                                                       Series  37
[B] Entire series, effect on correlation (  .669) is:
     Lower   1918  -.019   1875  -.013   1933  -.012   1889  -.011  Higher   1981   .032   1873   .012   1965   .010   1881   .008
=================================================================================================================================

ABQ901S   1902 to  1994      93 years
                                                                                       Series  38
[B] Entire series, effect on correlation (  .576) is:
     Lower   1984  -.042   1981  -.029   1942  -.015   1989  -.015  Higher   1968   .023   1945   .013   1947   .011   1933   .009
=================================================================================================================================

ABQ906NW  1858 to  1994     137 years
                                                                                       Series  39
[B] Entire series, effect on correlation (  .607) is:
     Lower   1994  -.044   1952  -.035   1993  -.018   1922  -.009  Higher   1981   .038   1864   .016   1937   .009   1968   .008

[C] Year-to-year changes diverging by over 4.0 std deviations:
     1993 1994  -4.0 SD

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

ABQ908NW  1860 to  1994     135 years
                                                                                       Series  40
[B] Entire series, effect on correlation (  .708) is:
     Lower   1993  -.015   1984  -.012   1903  -.008   1981  -.008  Higher   1873   .025   1864   .010   1920   .007   1947   .006
=================================================================================================================================
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ABQ903NW  1890 to  1994      105 years                                                                                   Series  41

[B] Entire series, effect on correlation (  .587) is:
     Lower   1990  -.077   1992  -.031   1993  -.027   1970  -.007  Higher   1981   .021   1976   .010   1918   .009   1932   .009

================================================================================================================================
ABQ916NW  1885 to  1994      110 years                                                                                   Series  42

[B] Entire series, effect on correlation (  .709) is:
     Lower   1951  -.019   1930  -.013   1912  -.010   1975  -.009  Higher   1981   .036   1968   .011   1918   .008   1894   .008

================================================================================================================================
ABQ912E   1854 to  1913       60 years                                                                                   Series  43

[B] Entire series, effect on correlation (  .496) is:
     Lower   1857  -.058   1858  -.028   1909  -.016   1890  -.013  Higher   1892   .028   1874   .023   1889   .023   1859   .022

================================================================================================================================
ABQ912E   1920 to  1994       75 years                                                                                   Series  44

[B] Entire series, effect on correlation (  .609) is:
     Lower   1969  -.017   1982  -.014   1949  -.013   1948  -.012  Higher   1947   .014   1937   .014   1920   .011   1976   .010

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                                               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 ABQ904SE 1888 1994    107      4      0    .716  1.28   2.15   .414   .765   .175   1.84   .323  -.007    1
  2 ABQ920W  1877 1994    118      4      0    .730  1.74   2.94   .528   .583   .231   1.99   .402  -.044    1
  3 ABQ915NW 1874 1994    121      5      0    .546  1.03   4.76   .595   .788   .187   2.06   .325  -.008    1
  4 ABQ915SE 1875 1994    120      4      0    .488  1.06   4.47   .689   .877   .190   2.25   .437  -.037    1
  5 ABQ905NW 1854 1994    141      5      0    .573   .72   2.65   .487   .831   .264   2.25   .365  -.029    1
  6 ABQ907SE 1863 1994    132      5      0    .700   .89   1.86   .313   .607   .224   2.11   .409  -.044    1
  7 ABQ911SE 1877 1994    118      4      0    .714  1.25   2.08   .359   .710   .177   2.18   .502   .027    1
  8 ABQ908SE 1860 1994    135      5      0    .724   .82   1.72   .323   .724   .229   2.03   .327   .017    2
  9 ABQ909NW 1875 1994    120      4      1    .608  1.02   2.22   .462   .701   .256   1.96   .360   .036    1
 10 ABQ913E  1862 1994    133      5      0    .660  1.35   2.54   .426   .592   .200   1.98   .328   .042    2
 11 ABQ901E  1918 1994     77      3      0    .631  1.99   3.94   .726   .641   .290   1.82   .334  -.076    1
 12 ABQ913W  1866 1994    129      5      0    .529  1.02   2.44   .446   .754   .195   2.14   .397   .005    1
 13 ABQ906SE 1860 1994    135      5      0    .645   .69   1.49   .302   .801   .211   1.92   .358  -.014    2
 14 ABQ916SE 1884 1994    111      4      0    .571   .95   1.63   .250   .534   .201   2.04   .433   .024    1
 15 ABQ914SE 1856 1994    139      5      0    .495   .69   4.59   .523   .766   .197   1.95   .361  -.088    1
 16 ABQ913   1855 1994    140      5      0    .614  1.21   3.34   .588   .781   .214   2.11   .349  -.026    1
 17 ABQ902NW 1892 1979     88      4      0    .540  1.01   2.30   .450   .764   .244   1.90   .290  -.015    1
 18 ABQ902   1920 1994     75      3      0    .539  1.06   2.95   .650   .796   .268   2.05   .398  -.031    1
 19 ABQ910SE 1858 1994    137      5      0    .559   .88   3.96   .636   .930   .180   2.08   .397   .015    1
 20 ABQ918S  1878 1994    117      4      0    .703  1.24   2.54   .369   .615   .194   1.92   .318  -.013    1
 21 ABQ905SE 1877 1994    118      4      0    .612   .70   3.19   .441   .743   .240   2.03   .318  -.064    1
 22 ABQ902SE 1896 1994     99      4      0    .523  1.12   2.47   .562   .853   .220   1.98   .339   .025    1
 23 ABQ917SE 1876 1994    119      4      0    .791  1.09   3.45   .496   .764   .222   1.93   .342  -.023    2
 24 ABQ901N  1889 1994    106      4      0    .697  1.59   2.79   .394   .533   .186   2.18   .460  -.024    1
 25 ABQ911NW 1865 1994    130      5      0    .727  1.38   2.52   .423   .756   .170   1.97   .394  -.024    2
 26 ABQ919   1870 1994    125      5      0    .719  1.02   2.27   .342   .565   .239   2.22   .470  -.002    1
 27 ABQ920E  1876 1994    119      4      0    .707  1.10   2.18   .321   .439   .242   1.89   .335  -.021    1
 28 ABQ914NW 1854 1994    141      5      0    .571   .90   3.75   .499   .843   .193   2.07   .322  -.048    1
 29 ABQ918N  1879 1994    116      4      0    .665  1.34   2.59   .428   .618   .213   1.96   .390  -.053    1
 30 ABQ912W  1860 1994    135      5      0    .567  1.07   3.75   .694   .904   .205   2.01   .349  -.021    1
 31 ABQ904NW 1888 1994    107      4      0    .730  1.59   3.21   .454   .699   .183   2.07   .451  -.034    1
 32 ABQ911NW 1865 1994    130      5      0    .787  1.52   3.21   .520   .707   .202   2.09   .408   .011    2
 33 ABQ917NW 1875 1994    120      4      0    .655  1.17   3.18   .484   .784   .208   1.97   .352  -.090    1
 34 ABQ910NW 1859 1994    136      5      0    .545   .96   2.83   .457   .829   .202   1.90   .337  -.061    1
 35 ABQ919NE 1879 1994    116      4      0    .509   .89   1.83   .224   .456   .199   1.95   .345   .016    1
 36 ABQ919SE 1862 1994    133      5      0    .697  1.08   2.21   .328   .497   .221   2.27   .388  -.016    1
 37 ABQ909SE 1861 1994    134      5      0    .669   .96   2.08   .407   .725   .261   2.14   .396  -.031    1
 38 ABQ901S  1902 1994     93      3      0    .576  2.11   4.76   .827   .742   .211   1.97   .386  -.001    1
 39 ABQ906NW 1858 1994    137      5      0    .607   .71   2.46   .373   .793   .264   2.02   .369  -.011    2
 40 ABQ908NW 1860 1994    135      5      0    .708   .96   5.38   .642   .794   .257   1.89   .309  -.005    2
 41 ABQ903NW 1890 1994    105      4      0    .587  1.57   5.45   .959   .868   .227   2.03   .370  -.044    1
 42 ABQ916NW 1885 1994    110      4      0    .709  1.14   1.83   .278   .452   .202   1.93   .395  -.005    1
 43 ABQ912E  1854 1913     60      2      0    .496  1.40   2.97   .531   .765   .174   2.04   .382   .031    1
 44 ABQ912E  1920 1994     75      3      0    .609   .77   1.45   .321   .907   .149   2.00   .415   .014    1
--- -------- ---------  -----  -----  -----  ------ -----  -----  -----  -----  -----  -----  -----  -----   --
Total or mean:           5192    190      1    .633  1.11   5.45   .471   .719   .214   2.27   .373  -.018

                                   - = [ COFECHA ABQCOF ] = -
```

BLACK ROCK FOREST NORMALIZED TREE-RING WIDTHS FOR THE CHESTNUT OAK										
MOUNT MISERY										
MMQ										
MMQRES1806	9990	9990	9990	9990	9990	9990	919	1129	1081	1109
MMQRES1810	774	777	1327	1723	1138	1212	704	1141	803	756
MMQRES1820	967	1531	867	813	1432	904	871	1346	1651	1467
MMQRES1830	949	895	690	1211	1578	1220	1028	1108	821	876
MMQRES1840	768	1113	1173	684	926	638	1012	1045	1018	649
MMQRES1850	1129	1009	716	1172	1087	1072	837	1060	793	968
MMQRES1860	895	872	1139	905	838	1021	834	950	995	1033
MMQRES1870	990	1059	927	693	1232	969	864	1005	1090	1145
MMQRES1880	991	1293	902	855	959	900	994	1024	848	1199
MMQRES1890	897	845	931	816	743	774	945	905	844	938
MMQRES1900	1046	986	1120	964	1174	907	991	969	1038	899
MMQRES1910	887	883	1038	949	1044	932	1190	1159	807	934
MMQRES1920	1336	1141	1124	757	1011	1108	914	1126	1126	901
MMQRES1930	1066	1038	1086	822	967	1072	935	1248	1211	1001
MMQRES1940	935	1054	1013	962	952	894	1077	1282	841	687
MMQRES1950	1029	1028	1127	1096	846	980	986	832	1078	921
MMQRES1960	1149	1038	841	1009	1188	738	856	979	922	1015
MMQRES1970	950	929	1204	1078	1217	1274	1080	910	1001	894
MMQRES1980	1119	668	877	923	993	1078	1068	926	920	984
MMQRES1990	1275	1033	1160	859	1118	9990	9990	9990	9990	9990

```
[] DENDROCHRONOLOGY PROGRAM LIBRARY                    Run MMQ  Program COF  23:42  Wed 23 AUG 1995  Page   1
[]
[] P R O G R A M     C O F E C H A                                                  Version   1.24P    22151
------------------------------------------------------------------------------------------------------------------

QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

Title of run:           Mount Misery -- Quercus prinus

File of DATED series:   MMQUPR.RWL

CONTENTS:

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

RUN CONTROL OPTIONS SELECTED                             VALUE

        1  Cubic smoothing spline 50% wavelength cutoff for filtering
                                                          32 years
        2  Segments examined are                          50 years lagged successively by  25 years
        3  Autoregressive model applied                    A  Residuals are used in master dating series and testing
        4  Series transformed to logarithms                Y  Each series log-transformed for master dating series and testing
        5  Critical correlation, 99% confidence level  .3281
        6  Master dating series saved                      N
        7  Listing of ring measurements in Part 6          N
        8  Parts printed                             1234567
        9  Absent rings included in master series          N

Time span of Master dating series is  1803 to  1994   192 years
Continuous time span is               1803 to  1994   192 years
Portion with two or more series is    1805 to  1994   190 years


                                        *******************************************
                                        *C* Number of dated series        43 *C*
                                        *O* Master series 1803 1994  192 yrs *O*
                                        *F* Total rings in all series   4921 *F*
                                        *E* Total dated rings checked   4919 *E*
                                        *C* Series intercorrelation     .604 *C*
                                        *H* Average mean sensitivity    .206 *H*
                                        *A* Segments, possible problems    1 *A*
                                        *******************************************

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

            No ring measurements of zero value
```

```
1[] DENDROCHRONOLOGY PROGRAM LIBRARY                          Run MMQ  Program COF  23:42  Wed 23 AUG 1995  Page   2
 []
 [] PART 2:  TIME PLOT OF TREE-RING SERIES: Mount Misery -- Quercus prinus                     Version  1.24P   22151
------------------------------------------------------------------------------------------------------------------------------
1000      1100      1200      1300      1400      1500      1600      1700      1800      1900      2000            Beg  End
                                                                                                      Ident     Seq year year  Yrs
:    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : --------  --- ---- ---- ----
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. MMQ960W     1 1923 1994   72
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <=========>. MMQ941E     2 1899 1994   96
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ947E     3 1878 1994  117
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. MMQ943      4 1901 1994   94
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. MMQ953      5 1913 1994   82
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. MMQ942W     6 1918 1994   77
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ959W     7 1873 1994  122
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ943W     8 1877 1994  118
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=================>. MMQ955N     9 1814 1994  181
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<===========> . MMQ945W    10 1868 1989  122
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ943E    11 1875 1994  120
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==========>. MMQ949W    12 1884 1994  111
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ947W    13 1870 1994  125
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. MMQ952N    14 1865 1994  130
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. MMQ941W    15 1919 1994   76
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ959E    16 1871 1994  124
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <===============>. MMQ950W    17 1838 1994  157
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ945E    18 1873 1994  122
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. MMQ959     19 1867 1994  128
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. MMQ950E    20 1861 1994  134
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ946W    21 1870 1994  125
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ951     22 1870 1994  125
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <====>.    . MMQ958E    23 1899 1944   46
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==>. MMQ958E    24 1960 1994   35
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. MMQ941     25 1903 1994   92
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. MMQ940E    26 1920 1994   75
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==================>. MMQ955N    27 1803 1994  192
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <==================>. MMQ955S    28 1805 1994  190
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>. MMQ956S    29 1844 1994  151
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. MMQ940W    30 1923 1994   72
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. MMQ952S    31 1868 1994  127
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ953S    32 1876 1994  119
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <====>.    . MMQ958W    33 1891 1948   58
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<==>. MMQ958W    34 1960 1994   35
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ947     35 1872 1994  123
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ956N    36 1870 1994  125
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ953N    37 1871 1994  124
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>. MMQ948W    38 1843 1994  152
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <=============>. MMQ948     39 1858 1994  137
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. MMQ951N    40 1864 1994  131
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. MMQ951S    41 1865 1994  130
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. MMQ954S    42 1873 1994  122
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. MMQ946E    43 1868 1994  127

:    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1000      1100      1200      1300      1400      1500      1600      1700      1800      1900      2000
```

```
1  PART 3:  Master Dating Series: Mount Misery -- Quercus prinus                  23:42  Wed 23 AUG 1995  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
 ------------------   ------------------   ------------------   ------------------   ------------------   ------------------
                                                                1850    .866     6   1900    .357    33   1950   -.422    39
                                                                1851    .307     6   1901    .169    34   1951   -.206    39
                                                                1852  -1.043     6   1902   1.198    34   1952    .832    39
                                           1803  -1.800     1   1853   1.671     6   1903    .360    35   1953   1.092    39
                                           1804   1.136     1   1854   1.405     6   1904   1.542    35   1954   -.566    39
                                           1805  -1.144     2   1855   1.700     6   1905    .090    35   1955    .140    39
                                           1806   -.743     2   1856   -.144     6   1906    .413    35   1956    .056    39
                                           1807    .574     2   1857    .394     6   1907    .315    35   1957  -1.208    39
                                           1808    .485     2   1858  -1.589     7   1908    .412    35   1958    .455    39
                                           1809    .757     2   1859    .243     7   1909   -.253    35   1959   -.477    39

                                           1810  -1.318     2   1860   -.509     7   1910   -.663    35   1960   1.144    41
                                           1811  -1.746     2   1861   -.654     8   1911   -.930    35   1961    .771    41
                                           1812    .881     2   1862   1.127     8   1912    .198    35   1962   -.626    41
                                           1813   2.838     2   1863   -.020     8   1913   -.630    36   1963    .177    41
                                           1814   1.224     3   1864   -.700     9   1914   -.027    36   1964   1.334    41
                                           1815   1.637     3   1865    .707    11   1915   -.764    36   1965  -1.344    41
                                           1816   -.773     3   1866  -1.089    11   1916    .751    36   1966  -1.051    41
                                           1817    .922     3   1867   -.126    12   1917    .859    36   1967   -.509    41
                                           1818  -1.043     3   1868    .113    15   1918   -.982    37   1968   -.788    41
                                           1819  -1.728     3   1869    .608    15   1919   -.655    38   1969   -.370    41

                                           1820   -.873     3   1870    .399    19   1920   1.211    39   1970   -.606    41
                                           1821   -.042     3   1871    .717    21   1921    .761    39   1971   -.747    41
                                           1822  -1.375     3   1872    .126    22   1922   1.058    39   1972    .636    41
                                           1823  -1.641     3   1873  -2.215    25   1923  -1.545    41   1973    .382    41
                                           1824   1.101     3   1874    .881    25   1924   -.241    41   1974   1.354    41
                                           1825   -.484     3   1875   -.471    26   1925    .268    41   1975   1.822    41
                                           1826   -.750     3   1876   -.959    27   1926   -.839    41   1976   1.318    41
                                           1827    .928     3   1877   -.188    28   1927    .558    41   1977    .340    41
                                           1828   2.240     3   1878    .289    29   1928    .709    41   1978    .550    41
                                           1829   1.634     3   1879    .822    29   1929   -.789    41   1979   -.246    41

                                           1830    .627     3   1880    .263    29   1930    .234    41   1980    .739    41
                                           1831   -.104     3   1881   1.869    29   1931    .219    41   1981  -2.149    41
                                           1832  -1.931     3   1882    .215    29   1932    .595    41   1982  -1.239    41
                                           1833    .203     3   1883   -.351    29   1933  -1.467    41   1983  -1.408    41
                                           1834   1.987     3   1884    .077    30   1934   -.734    41   1984   -.614    41
                                           1835   1.223     3   1885   -.381    30   1935   -.124    41   1985    .153    41
                                           1836    .717     3   1886    .052    30   1936   -.961    41   1986    .380    41
                                           1837   1.227     3   1887    .416    30   1937   1.292    41   1987   -.337    41
                                           1838  -1.112     4   1888   -.487    30   1938   1.611    41   1988   -.663    41
                                           1839   -.688     4   1889   1.540    30   1939    .760    41   1989   -.494    41

                                           1840  -1.956     4   1890    .163    30   1940    .084    41   1990   1.469    40
                                           1841    .429     4   1891   -.148    31   1941    .566    41   1991    .372    40
                                           1842   1.372     4   1892    .070    31   1942    .272    41   1992   1.309    40
                                           1843  -1.386     5   1893   -.752    31   1943   -.173    41   1993   -.837    40
                                           1844    .358     6   1894  -1.547    31   1944   -.402    41   1994    .777    40
                                           1845  -1.920     6   1895  -1.897    31   1945  -1.196    40
                                           1846   -.219     6   1896   -.678    31   1946    .243    40
                                           1847    .014     6   1897   -.519    31   1947   1.840    40
                                           1848    .165     6   1898   -.981    31   1948   -.535    40
                                           1849  -2.218     6   1899   -.525    33   1949  -2.482    39
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1  PART 4:  Master Bar Plot: Mount Misery -- Quercus prinus                                      23:42  Wed 23 AUG 1995  Page   4
----------------------------------------------------------------------------------------------------------------------------------
   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--------C   1900------A     1950---b
                                                                                   1851------A     1901-----A      1951----a
                                                                                   1852-d          1902---------E  1952--------C
                                                                   1803g           1853----------G 1903------A     1953---------D
                                                                   1804---------E  1854---------F  1904----------F 1954---b
                                                                   1805-e          1855----------G 1905-----@      1955-----A
                                                                   1806--c         1856----a       1906-------B    1956-----@
                                                                   1807-------B    1857-------B    1907------A     1957-e
                                                                   1808-------B    1858f           1908-------B    1958-------B
                                                                   1809--------C   1859------A     1909----a       1959---b
+  ____            ____            ____            ____            ____            ____            ____            ____
                                                                   1810-e          1860---b        1910--c         1960---------E
                                                                   1811g           1861--c         1911-d          1961--------C
                                                                   1812--------D   1862---------E  1912------A     1962---c
                                                                   1813----------K 1863-----@      1913---c        1963-----A
                                                                   1814---------E  1864--c         1914-----@      1964---------E
                                                                   1815----------G 1865--------C   1915--c         1965-e
                                                                   1816--c         1866-d          1916--------C   1966-d
                                                                   1817--------D   1867----a       1917--------C   1967---b
                                                                   1818-d          1868-----@      1918-d          1968--c
                                                                   1819g           1869--------B   1919--c         1969---a
+  ____            ____            ____            ____            ____            ____            ____            ____
                                                                   1820--c         1870-------B    1920---------E  1970---b
                                                                   1821-----@      1871--------C   1921--------C   1971--c
                                                                   1822-f          1872-----A      1922---------D  1972--------C
                                                                   1823g           1873i           1923f           1973-------B
                                                                   1824---------D  1874--------D   1924----a       1974---------E
                                                                   1825---b        1875---b        1925------A     1975----------G
                                                                   1826--c         1876-d          1926--c         1976---------E
                                                                   1827--------D   1877----a       1927-------B    1977------A
                                                                   1828----------I 1878------A     1928--------C   1978-------B
                                                                   1829----------G 1879--------C   1929--c         1979----a
+  ____            ____            ____            ____            ____            ____            ____            ____
                                                                   1830--------C   1880------A     1930------A     1980--------C
                                                                   1831----@       1881----------G 1931------A     1981i
                                                                   1832h           1882------A     1932-------B    1982-e
                                                                   1833------A     1883----a       1933f           1983-f
                                                                   1834----------H 1884-----@      1934--c         1984---b
                                                                   1835---------E  1885---b        1935----@       1985-----A
                                                                   1836--------C   1886-----@      1936-d          1986-------B
                                                                   1837---------E  1887-------B    1937---------E  1987----a
                                                                   1838-d          1888---b        1938----------F 1988--c
                                                                   1839--c         1889----------F 1939--------C   1989---b
+  ____            ____            ____            ____            ____            ____            ____            ____
                                                                   1840h           1890-----A      1940-----@      1990----------F
                                                                   1841-------B    1891----a       1941-------B    1991-------A
                                                                   1842---------E  1892-----@      1942------A     1992---------E
                                                                   1843-f          1893--c         1943----a       1993--c
                                                                   1844------A     1894f           1944---b        1994--------C
                                                                   1845h           1895h           1945-e
                                                                   1846----a       1896--c         1946------A
                                                                   1847-----@      1897---b        1947----------G
                                                                   1848-----A      1898-d          1948---b
                                                                   1849i           1899---b        1949j
+  ____            ____            ____            ____            ____            ____            ____            ____
----------------------------------------------------------------------------------------------------------------------------------
    192 values in series
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 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   Interval   1800 1825 1850 1875 1900 1925 1950
                         1849 1874 1899 1924 1949 1974 1999
   1 MMQ960W  1923 1994    -    -    -    -  .69  .65  .65    -    -    -    -    -    -    -    -    -    -    -    -    -
   2 MMQ941E  1899 1994    -    -    -  .58  .62  .63  .53    -    -    -    -    -    -    -    -    -    -    -    -    -
   3 MMQ947E  1878 1994    -    -    -  .50  .59  .73  .79    -    -    -    -    -    -    -    -    -    -    -    -    -
   4 MMQ943   1901 1994    -    -    -    -  .65  .74  .77    -    -    -    -    -    -    -    -    -    -    -    -    -
   5 MMQ953   1913 1994    -    -    -    -  .65  .61  .73    -    -    -    -    -    -    -    -    -    -    -    -    -
   6 MMQ942W  1918 1994    -    -    -    -  .63  .64  .79    -    -    -    -    -    -    -    -    -    -    -    -    -
   7 MMQ959W  1873 1994    -    -  .60  .46  .63  .74  .76    -    -    -    -    -    -    -    -    -    -    -    -    -
   8 MMQ943W  1877 1994    -    -    -  .55  .74  .80  .83    -    -    -    -    -    -    -    -    -    -    -    -    -
   9 MMQ955N  1814 1994  .75  .63  .51  .61  .68  .75  .82    -    -    -    -    -    -    -    -    -    -    -    -    -
  10 MMQ945W  1868 1989    -    -  .35  .38  .48  .45  .48    -    -    -    -    -    -    -    -    -    -    -    -    -
  11 MMQ943E  1875 1994    -    -    -  .43  .68  .56  .68    -    -    -    -    -    -    -    -    -    -    -    -    -
  12 MMQ949W  1884 1994    -    -    -  .46  .57  .55  .51    -    -    -    -    -    -    -    -    -    -    -    -    -
  13 MMQ947W  1870 1994    -    -  .65  .62  .68  .73  .74    -    -    -    -    -    -    -    -    -    -    -    -    -
  14 MMQ952N  1865 1994    -    -  .63  .60  .47  .44  .44    -    -    -    -    -    -    -    -    -    -    -    -    -
  15 MMQ941W  1919 1994    -    -    -    -  .63  .51  .55    -    -    -    -    -    -    -    -    -    -    -    -    -
  16 MMQ959E  1871 1994    -    -  .53  .62  .64  .47  .57    -    -    -    -    -    -    -    -    -    -    -    -    -
  17 MMQ950W  1838 1994    -  .60  .58  .71  .64  .65  .78    -    -    -    -    -    -    -    -    -    -    -    -    -
  18 MMQ945E  1873 1994    -    -  .63  .53  .50  .53  .54    -    -    -    -    -    -    -    -    -    -    -    -    -
  19 MMQ959   1867 1994    -    -  .49  .54  .66  .51  .57    -    -    -    -    -    -    -    -    -    -    -    -    -
  20 MMQ950E  1861 1994    -    -  .66  .74  .76  .70  .75    -    -    -    -    -    -    -    -    -    -    -    -    -
  21 MMQ946W  1870 1994    -    -  .48  .54  .50  .57  .65    -    -    -    -    -    -    -    -    -    -    -    -    -
  22 MMQ951   1870 1994    -    -  .30  .40  .53  .67  .70    -    -    -    -    -    -    -    -    -    -    -    -    -
+                               ___A
  23 MMQ958E  1899 1944    -    -    -  .56    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  24 MMQ958E  1960 1994    -    -    -  .54    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  25 MMQ941   1903 1994    -    -    -    -  .74  .63  .49    -    -    -    -    -    -    -    -    -    -    -    -    -
  26 MMQ940E  1920 1994    -    -    -    -  .50  .53  .49    -    -    -    -    -    -    -    -    -    -    -    -    -
  27 MMQ955N  1803 1994  .86  .66  .41  .40  .66  .76  .81    -    -    -    -    -    -    -    -    -    -    -    -    -
  28 MMQ955S  1805 1994  .78  .67  .48  .34  .40  .39  .48    -    -    -    -    -    -    -    -    -    -    -    -    -
  29 MMQ956S  1844 1994    -  .59  .53  .46  .57  .61  .66    -    -    -    -    -    -    -    -    -    -    -    -    -
  30 MMQ940W  1923 1994    -    -    -    -  .72  .70  .71    -    -    -    -    -    -    -    -    -    -    -    -    -
  31 MMQ952S  1868 1994    -    -  .39  .49  .51  .48  .64    -    -    -    -    -    -    -    -    -    -    -    -    -
  32 MMQ953S  1876 1994    -    -    -  .40  .60  .64  .67    -    -    -    -    -    -    -    -    -    -    -    -    -
  33 MMQ958W  1891 1948    -    -    -  .36  .44    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  34 MMQ958W  1960 1994    -    -    -    -  .72    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  35 MMQ947   1872 1994    -    -  .75  .69  .79  .78  .80    -    -    -    -    -    -    -    -    -    -    -    -    -
  36 MMQ956N  1870 1994    -    -  .52  .38  .60  .64  .73    -    -    -    -    -    -    -    -    -    -    -    -    -
  37 MMQ953N  1871 1994    -    -  .67  .59  .61  .61  .63    -    -    -    -    -    -    -    -    -    -    -    -    -
  38 MMQ948W  1843 1994    -  .64  .65  .67  .66  .61  .34    -    -    -    -    -    -    -    -    -    -    -    -    -
  39 MMQ948   1858 1994    -    -  .75  .63  .54  .47  .51    -    -    -    -    -    -    -    -    -    -    -    -    -
  40 MMQ951N  1864 1994    -    -  .44  .45  .50  .59  .60    -    -    -    -    -    -    -    -    -    -    -    -    -
  41 MMQ951S  1865 1994    -    -  .57  .67  .60  .53  .50    -    -    -    -    -    -    -    -    -    -    -    -    -
  42 MMQ954S  1873 1994    -    -  .62  .58  .56  .61  .71    -    -    -    -    -    -    -    -    -    -    -    -    -
  43 MMQ946E  1868 1994    -    -  .63  .71  .79  .75  .75    -    -    -    -    -    -    -    -    -    -    -    -    -
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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

[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
==============================================================================================================================

MMQ960W   1923 to  1994     72 years                                                                                Series   1

[B] Entire series, effect on correlation (  .652) is:
     Lower   1993  -.023   1932  -.022   1949  -.012   1934  -.012  Higher   1923   .029   1981   .014   1933   .013   1938   .010

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

MMQ941E   1899 to  1994     96 years                                                                                Series   2

[B] Entire series, effect on correlation (  .510) is:
     Lower   1972  -.030   1911  -.021   1966  -.020   1974  -.019  Higher   1933   .024   1990   .017   1965   .017   1947   .016

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
     1899 +3.2 SD;    1966 +3.2 SD
==============================================================================================================================

MMQ947E   1878 to  1994    117 years                                                                                Series   3

[B] Entire series, effect on correlation (  .650) is:
     Lower   1913  -.028   1918  -.016   1936  -.012   1921  -.008  Higher   1949   .025   1933   .010   1889   .009   1937   .009

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

MMQ943    1901 to  1994     94 years                                                                                Series   4

[B] Entire series, effect on correlation (  .705) is:
     Lower   1934  -.012   1914  -.012   1915  -.012   1907  -.010  Higher   1981   .020   1923   .019   1937   .009   1990   .008

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

MMQ953    1913 to  1994     82 years                                                                                Series   5

[B] Entire series, effect on correlation (  .671) is:
     Lower   1968  -.031   1925  -.014   1933  -.013   1978  -.013  Higher   1981   .042   1949   .019   1923   .016   1965   .015

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1968 +4.2 SD
==============================================================================================================================

MMQ942W   1918 to  1994     77 years                                                                                Series   6

[B] Entire series, effect on correlation (  .682) is:
     Lower   1935  -.046   1922  -.016   1919  -.012   1918  -.012  Higher   1923   .026   1981   .025   1933   .017   1965   .012

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

MMQ959W   1873 to  1994    122 years                                                                                Series   7

[B] Entire series, effect on correlation (  .658) is:
     Lower   1923  -.028   1953  -.017   1930  -.011   1980  -.011  Higher   1949   .021   1965   .015   1873   .012   1981   .009

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1887 +3.5 SD
==============================================================================================================================

MMQ943W   1877 to  1994    118 years                                                                                Series   8

[B] Entire series, effect on correlation (  .726) is:
     Lower   1898  -.014   1897  -.010   1899  -.009   1912  -.006  Higher   1981   .027   1923   .016   1933   .007   1960   .005

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1917 +3.0 SD
==============================================================================================================================
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MMQ955N   1814 to  1994     181 years                                                                   Series   9

 [B] Entire series, effect on correlation (  .687) is:
      Lower   1873  -.020   1914  -.011   1921  -.009   1847  -.009  Higher   1949   .016   1923   .009   1845   .007   1881   .006

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1931 +3.5 SD
====================================================================================================================================
MMQ945W   1868 to  1989     122 years                                                                   Series  10

 [B] Entire series, effect on correlation (  .442) is:
      Lower   1972  -.021   1875  -.014   1892  -.013   1929  -.012  Higher   1981   .037   1964   .013   1923   .013   1975   .012

====================================================================================================================================
MMQ943E   1875 to  1994     120 years                                                                   Series  11

 [B] Entire series, effect on correlation (  .577) is:
      Lower   1965  -.043   1875  -.018   1876  -.015   1963  -.015  Higher   1981   .046   1949   .033   1923   .027   1937   .009

====================================================================================================================================
MMQ949W   1884 to  1994     111 years                                                                   Series  12

 [B] Entire series, effect on correlation (  .507) is:
      Lower   1920  -.055   1946  -.023   1957  -.019   1960  -.015  Higher   1949   .059   1923   .017   1981   .017   1933   .014

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1920 -4.5 SD
====================================================================================================================================
MMQ947W   1870 to  1994     125 years                                                                   Series  13

 [B] Entire series, effect on correlation (  .718) is:
      Lower   1892  -.015   1949  -.013   1975  -.010   1946  -.009  Higher   1873   .022   1965   .012   1981   .010   1923   .008

====================================================================================================================================
MMQ952N   1865 to  1994     130 years                                                                   Series  14

 [B] Entire series, effect on correlation (  .506) is:
      Lower   1950  -.024   1953  -.017   1866  -.016   1930  -.011  Higher   1873   .034   1965   .012   1881   .011   1889   .011

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1912 +4.1 SD
====================================================================================================================================
MMQ941W   1919 to  1994      76 years                                                                   Series  15

 [B] Entire series, effect on correlation (  .574) is:
      Lower   1973  -.021   1974  -.019   1993  -.019   1965  -.017  Higher   1981   .050   1923   .016   1949   .013   1920   .012

====================================================================================================================================
MMQ959E   1871 to  1994     124 years                                                                   Series  16

 [B] Entire series, effect on correlation (  .564) is:
      Lower   1948  -.021   1950  -.017   1990  -.011   1875  -.011  Higher   1949   .031   1923   .027   1981   .015   1965   .011

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1892 +3.0 SD
====================================================================================================================================
MMQ950W   1838 to  1994     157 years                                                                   Series  17

 [B] Entire series, effect on correlation (  .658) is:
      Lower   1940  -.019   1840  -.018   1865  -.013   1944  -.010  Higher   1981   .020   1949   .015   1849   .013   1965   .010

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1934 +3.2 SD
====================================================================================================================================
MMQ945E   1873 to  1994     122 years                                                                   Series  18

 [B] Entire series, effect on correlation (  .548) is:
      Lower   1986  -.035   1949  -.024   1938  -.018   1992  -.012  Higher   1873   .034   1981   .031   1965   .019   1881   .010

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MMQ959     1867 to  1994     128 years                                                                     Series  19

[B] Entire series, effect on correlation ( .536) is:
     Lower   1965  -.033   1869  -.028   1990  -.028   1875  -.013  Higher   1949   .032   1981   .030   1873   .013   1937   .012

[E] Outliers      2   3.0 SD above or -4.5 SD below mean for year
     1875 +3.3 SD;    1892 +3.3 SD
=================================================================================================================================
MMQ950E    1861 to  1994     134 years                                                                     Series  20

[B] Entire series, effect on correlation ( .720) is:
     Lower   1962  -.013   1868  -.010   1968  -.009   1865  -.008  Higher   1981   .023   1965   .013   1949   .012   1923   .011

=================================================================================================================================
MMQ946W    1870 to  1994     125 years                                                                     Series  21

[B] Entire series, effect on correlation ( .604) is:
     Lower   1911  -.025   1912  -.022   1949  -.017   1874  -.014  Higher   1981   .030   1923   .016   1873   .015   1933   .011

[E] Outliers      1   3.0 SD above or -4.5 SD below mean for year
     1911 +3.6 SD
=================================================================================================================================
MMQ951     1870 to  1994     125 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
    ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
    1870 1919          .14  .19  .13  .19 -.15 -.15 -.15  .04 -.12  .10  .30  .06 -.22  .14  .04 -.01 -.08 -.02  .03 -.15  .14
+               0                                                      <__>

[B] Entire series, effect on correlation ( .569) is:
     Lower   1902  -.015   1915  -.014   1904  -.014   1954  -.012  Higher   1981   .030   1923   .014   1933   .014   1947   .013
   1870 to 1919 segment:
     Lower   1902  -.035   1915  -.032   1904  -.031   1909  -.022  Higher   1895   .096   1881   .031   1918   .028   1889   .021

=================================================================================================================================
MMQ958E    1899 to  1944      46 years                                                                     Series  23

[B] Entire series, effect on correlation ( .558) is:
     Lower   1935  -.049   1931  -.036   1937  -.033   1929  -.020  Higher   1923   .060   1918   .036   1904   .033   1920   .030

=================================================================================================================================
MMQ958E    1960 to  1994      35 years                                                                     Series  24

[B] Entire series, effect on correlation ( .537) is:
     Lower   1988  -.060   1970  -.022   1978  -.021   1983  -.019  Higher   1965   .069   1992   .027   1990   .026   1993   .022

=================================================================================================================================
MMQ941     1903 to  1994      92 years                                                                     Series  25

[B] Entire series, effect on correlation ( .554) is:
     Lower   1992  -.042   1972  -.024   1981  -.020   1966  -.016  Higher   1949   .040   1933   .019   1918   .013   1990   .012

=================================================================================================================================
MMQ940E    1920 to  1994      75 years                                                                     Series  26

[B] Entire series, effect on correlation ( .434) is:
     Lower   1993  -.051   1934  -.042   1920  -.026   1994  -.022  Higher   1949   .059   1923   .037   1981   .021   1960   .013

[C] Year-to-year changes diverging by over 4.0 std deviations:
     1933 1934   -4.1 SD

[E] Outliers      1   3.0 SD above or -4.5 SD below mean for year
     1993 +3.8 SD
=================================================================================================================================
MMQ955N    1803 to  1994     192 years                                                                     Series  27

[*] Early part of series cannot be checked from 1803 to 1804 -- not matched by another series

[B] Entire series, effect on correlation ( .655) is:
     Lower   1887  -.038   1873  -.011   1948  -.009   1857  -.009  Higher   1949   .015   1845   .007   1813   .007   1947   .006

[E] Outliers      1   3.0 SD above or -4.5 SD below mean for year
     1887 -5.1 SD
=================================================================================================================================
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MMQ955S   1805 to  1994     190 years                                                                      Series  28

[B] Entire series, effect on correlation (  .531) is:
     Lower   1958  -.019   1980  -.012   1891  -.009   1878  -.008  Higher   1873   .011   1849   .011   1813   .010   1923   .009

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
     1887 +4.1 SD;    1907 +3.0 SD;    1909 +3.1 SD
========================================================================================================================

MMQ956S   1844 to  1994     151 years                                                                      Series  29

[B] Entire series, effect on correlation (  .598) is:
     Lower   1923  -.017   1891  -.016   1938  -.009   1948  -.009  Higher   1849   .020   1981   .012   1933   .012   1947   .010

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

MMQ940W   1923 to  1994      72 years                                                                      Series  30

[B] Entire series, effect on correlation (  .692) is:
     Lower   1993  -.032   1945  -.022   1929  -.018   1959  -.016  Higher   1949   .042   1923   .025   1981   .014   1933   .012

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MMQ952S   1868 to  1994     127 years                                                                      Series  31

[B] Entire series, effect on correlation (  .514) is:
     Lower   1871  -.030   1899  -.017   1931  -.016   1948  -.013  Higher   1981   .019   1965   .015   1889   .013   1895   .012

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MMQ953S   1876 to  1994     119 years                                                                      Series  32

[B] Entire series, effect on correlation (  .599) is:
     Lower   1948  -.017   1963  -.011   1912  -.010   1894  -.009  Higher   1981   .027   1949   .026   1933   .018   1975   .009

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1912 +4.1 SD
========================================================================================================================

MMQ958W   1891 to  1948      58 years                                                                      Series  33

[B] Entire series, effect on correlation (  .427) is:
     Lower   1902  -.029   1910  -.027   1891  -.020   1900  -.019  Higher   1894   .031   1947   .027   1918   .024   1904   .019

[E] Outliers     2   3.0 SD above or -4.5 SD below mean for year
     1910 +3.5 SD;    1924 +3.3 SD
========================================================================================================================

MMQ958W   1960 to  1994      35 years                                                                      Series  34

[B] Entire series, effect on correlation (  .722) is:
     Lower   1961  -.022   1980  -.020   1967  -.012   1981  -.010  Higher   1965   .040   1993   .019   1964   .016   1992   .015

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MMQ947    1872 to  1994     123 years                                                                      Series  35

[B] Entire series, effect on correlation (  .772) is:
     Lower   1964  -.011   1876  -.010   1892  -.009   1918  -.007  Higher   1981   .014   1947   .006   1937   .005   1923   .005

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MMQ956N   1870 to  1994     125 years                                                                      Series  36

[B] Entire series, effect on correlation (  .598) is:
     Lower   1952  -.035   1899  -.026   1919  -.025   1923  -.014  Higher   1949   .028   1873   .025   1981   .017   1933   .013

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MMQ953N   1871 to  1994     124 years                                                                      Series  37

[B] Entire series, effect on correlation (  .632) is:
     Lower   1968  -.021   1983  -.013   1959  -.010   1885  -.010  Higher   1873   .022   1965   .018   1990   .009   1949   .009

[E] Outliers     3   3.0 SD above or -4.5 SD below mean for year
     1886 +3.4 SD;    1912 +3.6 SD;    1968 +4.0 SD
========================================================================================================================
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MMQ948W   1843 to  1994    152 years                                                                                    Series  38

[B] Entire series, effect on correlation (  .538) is:
      Lower   1856  -.041   1980  -.033   1994  -.014   1981  -.013  Higher   1949   .023   1873   .021   1965   .010   1881   .010

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1984 +4.0 SD
=====================================================================================================================================
MMQ948    1858 to  1994    137 years                                                                                    Series  39

[B] Entire series, effect on correlation (  .600) is:
      Lower   1960  -.016   1948  -.014   1947  -.012   1915  -.011  Higher   1873   .023   1981   .018   1949   .017   1881   .010

=====================================================================================================================================
MMQ951N   1864 to  1994    131 years                                                                                    Series  40

[B] Entire series, effect on correlation (  .537) is:
      Lower   1875  -.018   1922  -.012   1901  -.011   1993  -.010  Higher   1965   .018   1889   .011   1990   .010   1895   .010

=====================================================================================================================================
MMQ951S   1865 to  1994    130 years                                                                                    Series  41

[B] Entire series, effect on correlation (  .566) is:
      Lower   1951  -.018   1965  -.014   1945  -.013   1949  -.011  Higher   1933   .017   1947   .014   1895   .012   1918   .009

=====================================================================================================================================
MMQ954S   1873 to  1994    122 years                                                                                    Series  42

[B] Entire series, effect on correlation (  .626) is:
      Lower   1930  -.028   1917  -.015   1952  -.014   1945  -.011  Higher   1949   .027   1965   .018   1881   .011   1933   .008

=====================================================================================================================================
MMQ946E   1868 to  1994    127 years                                                                                    Series  43

[B] Entire series, effect on correlation (  .731) is:
      Lower   1957  -.022   1874  -.020   1911  -.009   1964  -.007  Higher   1981   .011   1873   .011   1965   .010   1947   .007

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                                                   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 MMQ960W  1923 1994           72      3      0   .652  2.04   4.66   .768   .801   .181   2.01   .475  -.075   1
  2 MMQ941E  1899 1994           96      4      0   .510  1.28   3.12   .697   .864   .207   2.07   .331   .045   1
  3 MMQ947E  1878 1994          117      4      0   .650   .88   1.77   .335   .744   .228   2.02   .353  -.024   1
  4 MMQ943   1901 1994           94      3      0   .705  1.55   3.78   .771   .806   .246   2.05   .346   .006   1
  5 MMQ953   1913 1994           82      3      0   .671  1.40   6.49  1.091   .859   .192   2.03   .389   .006   1
  6 MMQ942W  1918 1994           77      3      0   .682  1.53   3.46   .630   .794   .220   1.90   .421  -.018   2
  7 MMQ959W  1873 1994          122      5      0   .658  1.03   2.99   .499   .713   .244   2.15   .351  -.034   3
  8 MMQ943W  1877 1994          118      4      0   .726  1.26   3.06   .587   .863   .198   2.12   .370  -.035   1
  9 MMQ955N  1814 1994          181      7      0   .687  1.10   3.05   .542   .779   .217   2.04   .330  -.024   1
 10 MMQ945W  1868 1989          122      5      0   .442  1.13   3.77   .637   .738   .238   2.06   .369   .004   1
 11 MMQ943E  1875 1994          120      4      0   .577  1.41   3.50   .675   .859   .215   1.96   .322   .047   2
 12 MMQ949W  1884 1994          111      4      0   .507   .64   1.27   .215   .728   .185   1.90   .293  -.058   1
 13 MMQ947W  1870 1994          125      5      0   .718  1.10   2.55   .377   .730   .182   2.08   .356   .000   1
 14 MMQ952N  1865 1994          130      5      0   .506   .97   3.52   .507   .895   .164   2.25   .428  -.003   2
 15 MMQ941W  1919 1994           76      3      0   .574  1.12   5.38   .792   .791   .240   2.04   .449   .058   2
 16 MMQ959E  1871 1994          124      5      0   .564  1.18   4.17   .590   .682   .229   2.14   .362  -.065   1
 17 MMQ950W  1838 1994          157      6      0   .658  1.29   3.14   .421   .613   .203   2.15   .424  -.014   1
 18 MMQ945E  1873 1994          122      5      0   .548   .96   3.16   .603   .840   .212   2.04   .419  -.106   1
 19 MMQ959   1867 1994          128      5      0   .536  1.32   4.09   .671   .754   .247   2.29   .456  -.058   1
 20 MMQ950E  1861 1994          134      5      0   .720  1.26   2.11   .288   .548   .172   1.99   .389   .010   1
 21 MMQ946W  1870 1994          125      5      0   .604  1.30   2.43   .387   .673   .182   1.93   .312   .012   1
 22 MMQ951   1870 1994          125      5      1   .569  1.06   4.46   .617   .868   .175   1.88   .284   .006   1
 23 MMQ958E  1899 1944           46      1      0   .558   .92   1.97   .393   .751   .181   2.47   .547  -.007   3
 24 MMQ958E  1960 1994           35      1      0   .537  1.28   3.09   .704   .803   .249   2.00   .395  -.007   1
 25 MMQ941   1903 1994           92      3      0   .554  1.28   3.72   .837   .876   .221   2.02   .422   .020   1
 26 MMQ940E  1920 1994           75      3      0   .434  1.49   3.11   .924   .902   .219   1.90   .337   .026   2
 27 MMQ955N  1803 1994          192      7      0   .655   .99   2.67   .508   .855   .205   1.97   .305  -.030   1
 28 MMQ955S  1805 1994          190      7      0   .531   .75   2.16   .265   .744   .181   2.17   .354  -.027   1
 29 MMQ956S  1844 1994          151      6      0   .598   .50   1.26   .185   .627   .231   2.09   .413  -.064   1
 30 MMQ940W  1923 1994           72      3      0   .692  1.52   3.80   .969   .893   .249   1.81   .334  -.053   1
 31 MMQ952S  1868 1994          127      5      0   .514   .93   2.06   .284   .643   .194   2.11   .414  -.039   1
 32 MMQ953S  1876 1994          119      4      0   .599  1.01   3.31   .396   .588   .184   2.26   .377  -.071   1
 33 MMQ958W  1891 1948           58      2      0   .427   .74   1.89   .305   .547   .276   2.06   .388  -.064   2
 34 MMQ958W  1960 1994           35      1      0   .722   .90   1.57   .328   .702   .235   1.99   .378  -.093   1
 35 MMQ947   1872 1994          123      5      0   .772  1.15   1.98   .349   .699   .181   1.84   .263  -.029   1
 36 MMQ956N  1870 1994          125      5      0   .598  1.33   2.24   .386   .676   .188   1.94   .367  -.003   1
 37 MMQ953N  1871 1994          124      5      0   .632  1.45   4.23   .660   .633   .221   2.08   .338   .002   1
 38 MMQ948W  1843 1994          152      6      0   .538   .97   2.48   .417   .795   .208   2.03   .336  -.027   1
 39 MMQ948   1858 1994          137      5      0   .600   .94   1.97   .335   .695   .213   2.06   .418  -.050   1
 40 MMQ951N  1864 1994          131      5      0   .537  1.13   4.62   .652   .862   .176   1.95   .343  -.022   1
 41 MMQ951S  1865 1994          130      5      0   .566  1.12   3.26   .509   .786   .194   2.16   .382   .017   1
 42 MMQ954S  1873 1994          122      5      0   .626   .91   2.45   .415   .765   .247   1.95   .326  -.077   1
 43 MMQ946E  1868 1994          127      5      0   .731  1.16   4.59   .485   .832   .163   1.90   .302  -.020   1
--- -------- ---------        -----  -----  -----  ------ -----  -----  -----  -----  -----  -----  -----  -----  --
Total or mean:                 4921    187      1   .604  1.12   6.49   .510   .755   .206   2.47   .365  -.022

                                          - = [ COFECHA MMQCOF ] = -
```

BLACK ROCK FOREST NORMALIZED TREE-RING WIDTHS FOR THE CHESTNUT OAK										
BOG SPRING										
BSQ										
BSQRES1843	9990	9990	9990	841	1122	732	1303	1172	1312	496
BSQRES1850	1269	1076	712	1236	1078	1020	867	1067	904	1068
BSQRES1860	978	834	1002	1042	814	881	806	1043	863	1182
BSQRES1870	855	806	736	593	1209	819	787	887	1222	1311
BSQRES1880	1140	1408	939	947	1107	880	1100	1099	861	1198
BSQRES1890	844	1091	1090	781	807	754	874	886	845	920
BSQRES1900	997	944	1127	1032	1171	944	913	891	1018	876
BSQRES1910	887	807	945	977	1152	1046	1199	1092	861	1038
BSQRES1920	1379	1188	1134	774	1077	1082	943	1082	1048	954
BSQRES1930	1005	960	1124	827	995	1139	994	1333	143	1064
BSQRES1940	944	1025	993	887	927	856	1113	1212	820	738
BSQRES1950	1024	1088	960	1122	787	1041	1014	827	1076	899
BSQRES1960	1157	1041	833	1098	1207	722	880	906	734	1109
BSQRES1970	940	911	1193	11074	1222	1321	1151	1122	1166	917
BSQRES1980	1253	609	963	911	985	1168	970	961	876	959
BSQRES1990	1137	1028	1129	847	1039	99990	9990	9990	9990	9990

```
QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

Title of run:           Bog Spring -- Quercus prinus

File of DATED series:   BSQUPR.RWL

CONTENTS:

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

RUN CONTROL OPTIONS SELECTED                             VALUE

        1  Cubic smoothing spline 50% wavelength cutoff for filtering
                                                          32 years
        2  Segments examined are                          50 years lagged successively by  25 years
        3  Autoregressive model applied                    A  Residuals are used in master dating series and testing
        4  Series transformed to logarithms                Y  Each series log-transformed for master dating series and testing
        5  Critical correlation, 99% confidence level   .3281
        6  Master dating series saved                      N
        7  Listing of ring measurements in Part 6          N
        8  Parts printed                             1234567
        9  Absent rings included in master series          N

Time span of Master dating series is  1841 to  1994   154 years
Continuous time span is               1841 to  1994   154 years
Portion with two or more series is    1841 to  1994   154 years


                                        ******************************************
                                        *C* Number of dated series        46 *C*
                                        *O* Master series 1841 1994  154 yrs *O*
                                        *F* Total rings in all series   4078 *F*
                                        *E* Total dated rings checked   4078 *E*
                                        *C* Series intercorrelation     .612 *C*
                                        *H* Average mean sensitivity    .226 *H*
                                        *A* Segments, possible problems    1 *A*
                                        ******************************************

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

           No ring measurements of zero value
```

```
1[] DENDROCHRONOLOGY PROGRAM LIBRARY                                        Run BSQ  Program COF  17:41  Wed 23 AUG 1995  Page  2
 []
 [] PART 2:  TIME PLOT OF TREE-RING SERIES: Bog Spring -- Quercus prinus                                      Version   1.24P    22151
---------------------------------------------------------------------------------------------------------------------------------
1000      1100      1200      1300      1400      1500      1600      1700      1800      1900      2000            Beg  End
                                                                                                      Ident    Seq year year  Yrs
:    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    : -------- --- ---- ---- ----
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<============>. BSQ935W    1 1865 1994  130
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. BSQ929E    2 1921 1994   74
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. BSQ938W    3 1876 1994  119
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ928W    4 1903 1994   92
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ925SW   5 1915 1994   80
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <=========> . BSQ937S    6 1885 1980   96
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ931S    7 1915 1994   80
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. CLIFF2     8 1915 1994   80
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ923NW   9 1905 1994   90
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>. BSQ932NE  10 1844 1994  151
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. BSQ921    11 1920 1994   75
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <=========>. BSQ927W   12 1899 1994   96
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ921NW  13 1914 1994   81
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <=========>. BSQ921SE  14 1897 1994   98
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===>   . BSQ934NE  15 1922 1964   43
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ925    16 1912 1994   83
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <========> .    . BSQ936    17 1845 1937   93
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <===>. BSQ936    18 1950 1994   45
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <=====>. BSQ929W   19 1934 1994   61
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. BSQ935    20 1874 1994  121
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ928E   21 1905 1994   90
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ922NW  22 1907 1994   88
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ927E   23 1900 1994   95
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==>   .    . BSQ939W   24 1880 1919   40
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <====>. BSQ939W   25 1946 1994   49
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. BSQ934SW  26 1924 1994   71
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <======>   .    . BSQ933NE  27 1841 1919   79
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <====>. BSQ933NE  28 1942 1994   53
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ922SE  29 1905 1994   90
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ931N   30 1915 1994   80
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. BSQ935E   31 1873 1994  122
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ924SE  32 1918 1994   77
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ930S   33 1900 1994   95
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ926NW  34 1914 1994   81
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>. BSQ936E   35 1841 1994  154
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. BSQ924NW  36 1915 1994   80
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ926SE  37 1908 1994   87
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>. BSQ932SW  38 1845 1993  149
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. BSQ938E   39 1876 1994  119
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <========>. BSQ923SE  40 1904 1994   91
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .<=======>. CLIFF1    41 1918 1994   77
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <===========>. BSQ930N   42 1872 1994  123
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .   <==============>. BSQ936W   43 1843 1994  152
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .  <==>   .    . BSQ939E   44 1886 1919   34
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    <===>. BSQ939E   45 1956 1994   39
.    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    .    . <======>. BSQ925NE  46 1920 1994   75

:    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :    :
1000      1100      1200      1300      1400      1500      1600      1700      1800      1900      2000
```

```
1 PART 3:  Master Dating Series: Bog Spring -- Quercus prinus                                       17:41  Wed 23 AUG 1995  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
 ------------------   ------------------   ------------------   ------------------   ------------------   ------------------
                                                                1850   .842      6   1900   .494     19   1950  -.241     41
                                                                1851   .617      6   1901   .051     19   1951   .518     41
                                                                1852 -1.880      6   1902  1.208     19   1952   .166     41
                                                                1853  1.144      6   1903   .859     20   1953  1.123     41
                                                                1854   .679      6   1904  1.515     21   1954  -.894     41
                                                                1855   .360      6   1905   .359     24   1955   .319     41
                                                                1856  -.905      6   1906  -.175     24   1956   .326     42
                                                                1857   .677      6   1907  -.626     25   1957  -.911     42
                                                                1858  -.752      6   1908   .300     26   1958   .461     42
                                                                1859   .886      6   1909  -.579     26   1959  -.567     42

                                                                1860   .250      6   1910  -.816     26   1960  1.087     42
                                                                1861  -.498      6   1911 -1.588     26   1961   .895     42
                                                                1862   .444      6   1912  -.855     27   1962  -.539     42
                                                                1863  1.039      6   1913  -.722     27   1963   .564     42
                                                                1864  -.904      6   1914   .457     29   1964  1.525     42
                                                                1865  -.445      7   1915   .212     34   1965 -1.291     41
                                                                1866  -.860      7   1916   .991     34   1966 -1.023     41
                                                                1867   .677      7   1917   .612     34   1967  -.989     41
                                                                1868  -.295      7   1918  -.930     36   1968 -2.273     41
                                                                1869  1.808      7   1919  -.313     36   1969  -.024     41

                                                                1870   .045      7   1920  1.803     35   1970  -.585     41
                                                                1871  -.683      7   1921  1.494     36   1971  -.885     41
                                                                1872 -1.044      8   1922  1.308     37   1972   .776     41
                                                                1873 -2.372      9   1923 -1.409     37   1973   .493     41
                                                                1874  1.070     10   1924   .037     38   1974  1.112     41
                                                                1875  -.850     10   1925   .292     38   1975  1.789     41
                                                                1876 -1.263     12   1926  -.530     38   1976  1.263     41
                                                                1877  -.710     12   1927   .127     38   1977   .989     41
                                                                1878   .756     12   1928   .093     38   1978  1.070     41
                                                                1879  1.388     12   1929  -.620     38   1979  -.293     41

                                                                1880   .864     13   1930  -.627     38   1980  1.002     41
                                                                1881  1.970     13   1931  -.681     38   1981 -2.407     40
                                                                1882  -.032     13   1932   .616     38   1982  -.927     40
                                                                1883  -.439     13   1933 -1.647     38   1983 -1.039     40
                                                                1884   .089     13   1934  -.544     39   1984  -.577     40
                                                                1885  -.410     14   1935   .668     39   1985   .767     40
                                                                1886   .501     15   1936   .078     39   1986   .032     40
                                                                1887   .603     15   1937  1.871     39   1987  -.134     40
                                                                1888  -.549     15   1938  1.480     38   1988  -.938     40
                                                                1889   .959     15   1939   .932     38   1989  -.445     40

                                                                1890  -.786     15   1940  -.204     38   1990   .720     40
                                           1841   .463      2   1891   .336     15   1941   .163     38   1991   .663     40
                                           1842  1.449      2   1892  1.151     15   1942  -.076     39   1992  1.099     40
                                           1843  -.772      3   1893 -1.184     15   1943  -.703     39   1993  -.747     40
                                           1844   .814      4   1894 -1.363     15   1944  -.673     39   1994   .270     39
                                           1845 -1.575      6   1895 -1.785     15   1945 -1.313     39
                                           1846  1.050      6   1896  -.822     15   1946   .548     40
                                           1847   .665      6   1897  -.442     16   1947  1.605     40
                                           1848  1.182      6   1898  -.657     16   1948  -.526     40
                                           1849 -3.543      6   1899  -.152     17   1949 -2.116     40
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1  PART 4:  Master Bar Plot: Bog Spring -- Quercus prinus                                         17:41  Wed 23 AUG 1995  Page   4
------------------------------------------------------------------------------------------------------------------------------------
    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--------C      1900-------B       1950----a
                                                                                                   1851-------B       1901-----@         1951-------B
                                                                                                   1852h              1902---------E     1952-----A
                                                                                                   1853---------E     1903--------C      1953---------D
                                                                                                   1854-------C       1904----------F    1954-d
                                                                                                   1855------A        1905------A        1955------A
                                                                                                   1856-d             1906----a          1956------A
                                                                                                   1857-------C       1907---c           1957-d
                                                                                                   1858--c            1908------A        1958------B
                                                                                                   1859--------D      1909---b           1959---b
+   ____               ____               ____               ____               ____
                                                                                                   1860------A        1910--c            1960---------D
                                                                                                   1861---b           1911f              1961--------D
                                                                                                   1862------B        1912-c             1962---b
                                                                                                   1863---------D     1913--c            1963-------B
                                                                                                   1864-d             1914------B        1964----------F
                                                                                                   1865---b           1915-----A         1965e
                                                                                                   1866-c             1916---------D     1966-d
                                                                                                   1867-------C       1917-------B       1967-d
                                                                                                   1868----a          1918-d             1968i
                                                                                                   1869----------G    1919----a          1969-----@
+   ____               ____               ____               ____               ____
                                                                                                   1870-----@         1920----------G    1970---b
                                                                                                   1871--c            1921----------F    1971-d
                                                                                                   1872-d             1922---------E     1972--------C
                                                                                                   1873i              1923f              1973-------B
                                                                                                   1874---------D     1924-----@         1974---------D
                                                                                                   1875-c             1925------A        1975----------G
                                                                                                   1876-e             1926---b           1976---------E
                                                                                                   1877--c            1927-----A         1977---------D
                                                                                                   1878--------C      1928-----@         1978---------D
                                                                                                   1879----------F    1929---b           1979----a
+   ____               ____               ____               ____               ____
                                                                                                   1880--------C      1930---c           1980---------D
                                                                                                   1881----------H    1931--c            1981j
                                                                                                   1882-----@         1932-------B       1982-d
                                                                                                   1883---b           1933g              1983-d
                                                                                                   1884-----@         1934---b           1984---b
                                                                                                   1885----b          1935-------C       1985--------C
                                                                                                   1886-------B       1936-----@         1986-----@
                                                                                                   1887-------B       1937----------G    1987----a
                                                                                                   1888---b           1938----------F    1988-d
                                                                                                   1889--------D      1939--------D      1989---b
+   ____               ____               ____               ____               ____
                                                                                                   1890--c            1940----a          1990-------C
                                                                                1841------B        1891------A        1941-----A         1991-------C
                                                                                1842----------F    1892---------E     1942-----@         1992---------D
                                                                                1843--c            1893-e             1943--c            1993--c
                                                                                1844--------C      1894e              1944--c            1994------A
                                                                                1845f              1895g              1945e
                                                                                1846---------D     1896--c            1946-------B
                                                                                1847-------C       1897---b           1947----------F
                                                                                1848---------E     1898---c           1948---b
                                                                                1849n              1899----a          1949h
+   ____               ____               ____               ____               ____               ____               ____               ____
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     154 values in series
```

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---------------------------------------------------------------------------------------------------------------------------
 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   Interval   1825 1850 1875 1900 1925 1950
                         1874 1899 1924 1949 1974 1999
   1 BSQ935W  1865 1994     -  .56  .60  .59  .69  .64    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   2 BSQ929E  1921 1994     -    -    -  .55  .51  .49    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   3 BSQ938W  1876 1994     -    -  .56  .73  .73  .73    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   4 BSQ928W  1903 1994     -    -    -  .73  .79  .86    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   5 BSQ925SW 1915 1994     -    -    -  .53  .71  .71    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   6 BSQ937S  1885 1980     -    -  .41  .41  .50  .53    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   7 BSQ931S  1915 1994     -    -    -  .50  .65  .75    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   8 CLIFF2   1915 1994     -    -    -  .62  .67  .64    -    -    -    -    -    -    -    -    -    -    -    -    -    -
   9 BSQ923NW 1905 1994     -    -    -  .60  .76  .61    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  10 BSQ932NE 1844 1994   .79  .71  .59  .54  .43  .44    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  11 BSQ921   1920 1994     -    -    -  .65  .61  .71    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  12 BSQ927W  1899 1994     -    -  .42  .44  .61  .62    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  13 BSQ921NW 1914 1994     -    -    -  .64  .59  .65    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  14 BSQ921SE 1897 1994     -    -  .58  .64  .69  .74    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  15 BSQ934NE 1922 1964     -    -    -  .57    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  16 BSQ925   1912 1994     -    -    -  .55  .61  .69    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  17 BSQ936   1845 1937   .81  .73  .64  .57    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  18 BSQ936   1950 1994     -    -    -    -    -  .49    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  19 BSQ929W  1934 1994     -    -    -    -  .51  .59    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  20 BSQ935   1874 1994     -  .68  .68  .66  .64  .60    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  21 BSQ928E  1905 1994     -    -    -  .58  .65  .75    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  22 BSQ922NW 1907 1994     -    -    -  .64  .76  .77    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  23 BSQ927E  1900 1994     -    -    -  .41  .49  .57    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  24 BSQ939W  1880 1919     -    -    -  .36    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
+                                     ___B
  25 BSQ939W  1946 1994     -    -    -    -  .37    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  26 BSQ934SW 1924 1994     -    -    -  .38  .36  .61    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  27 BSQ933NE 1841 1919   .63  .42  .38    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  28 BSQ933NE 1942 1994     -    -    -    -  .55  .57    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  29 BSQ922SE 1905 1994     -    -    -  .57  .61  .62    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  30 BSQ931N  1915 1994     -    -    -  .65  .71  .66    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  31 BSQ935E  1873 1994     -  .41  .41  .50  .56  .68    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  32 BSQ924SE 1918 1994     -    -    -  .71  .70  .77    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  33 BSQ930S  1900 1994     -    -    -  .56  .69  .83    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  34 BSQ926NW 1914 1994     -    -    -  .67  .83  .83    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  35 BSQ936E  1841 1994   .71  .67  .53  .50  .41  .39    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  36 BSQ924NW 1915 1994     -    -    -  .76  .75  .76    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  37 BSQ926SE 1908 1994     -    -    -  .67  .73  .72    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  38 BSQ932SW 1845 1993   .74  .63  .51  .47  .63  .56    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  39 BSQ938E  1876 1994     -    -  .38  .58  .64  .75    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  40 BSQ923SE 1904 1994     -    -    -  .70  .69  .78    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  41 CLIFF1   1918 1994     -    -    -  .65  .63  .53    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  42 BSQ930N  1872 1994     -  .46  .46  .49  .55  .78    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  43 BSQ936W  1843 1994   .68  .69  .68  .64  .55  .53    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  44 BSQ939E  1886 1919     -  .62    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  45 BSQ939E  1956 1994     -  .56    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -    -
  46 BSQ925NE 1920 1994     -    -    -  .78  .76  .79    -    -    -    -    -    -    -    -    -    -    -    -    -    -
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 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

 [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
===================================================================================================================================

 BSQ935W    1865 to  1994     130 years                                                                                    Series   1

 [B] Entire series, effect on correlation (  .605) is:
       Lower   1993 -.022  1872 -.017  1939 -.014  1906 -.010 Higher  1949  .017  1933  .015  1965  .015  1981  .013
===================================================================================================================================

 BSQ929E    1921 to  1994      74 years                                                                                    Series   2

 [B] Entire series, effect on correlation (  .501) is:
       Lower   1992 -.033  1951 -.028  1933 -.021  1983 -.020 Higher  1968  .049  1981  .028  1923  .023  1937  .013
===================================================================================================================================

 BSQ938W    1876 to  1994     119 years                                                                                    Series   3

 [B] Entire series, effect on correlation (  .660) is:
       Lower   1891 -.014  1889 -.013  1948 -.013  1881 -.012 Higher  1933  .016  1949  .012  1965  .011  1920  .011
===================================================================================================================================

 BSQ928W    1903 to  1994      92 years                                                                                    Series   4

 [B] Entire series, effect on correlation (  .812) is:
       Lower   1942 -.010  1929 -.009  1908 -.008  1906 -.007 Higher  1981  .020  1968  .007  1911  .005  1937  .004
===================================================================================================================================

 BSQ925SW  1915 to  1994      80 years                                                                                    Series   5

 [B] Entire series, effect on correlation (  .605) is:
       Lower   1916 -.103  1918 -.014  1991 -.013  1952 -.012 Higher  1981  .056  1968  .027  1937  .013  1947  .013
===================================================================================================================================

 BSQ937S    1885 to  1980      96 years                                                                                    Series   6

 [B] Entire series, effect on correlation (  .499) is:
       Lower   1974 -.045  1920 -.030  1933 -.023  1918 -.017 Higher  1893  .022  1895  .016  1968  .016  1954  .015

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
       1919 +3.1 SD
===================================================================================================================================

 BSQ931S    1915 to  1994      80 years                                                                                    Series   7

 [B] Entire series, effect on correlation (  .630) is:
       Lower   1921 -.029  1916 -.019  1986 -.016  1932 -.014 Higher  1981  .066  1949  .025  1968  .017  1920  .013
===================================================================================================================================

 CLIFF2     1915 to  1994      80 years                                                                                    Series   8

 [B] Entire series, effect on correlation (  .633) is:
       Lower   1922 -.026  1991 -.018  1988 -.017  1930 -.015 Higher  1923  .020  1968  .020  1949  .018  1965  .018
===================================================================================================================================
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BSQ923NW  1905 to  1994     90 years
                                                                                                  Series   9

 [B] Entire series, effect on correlation (  .595) is:
      Lower   1990  -.106   1914  -.048   1905  -.009   1949  -.008  Higher   1981   .038   1965   .017   1937   .015   1923   .013

 [C] Year-to-year changes diverging by over 4.0 std deviations:
      1990 1991    4.2 SD

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1990 -5.5 SD
================================================================================================================================
BSQ932NE  1844 to  1994    151 years
                                                                                                  Series  10

 [B] Entire series, effect on correlation (  .574) is:
      Lower   1976  -.024   1968  -.015   1930  -.011   1972  -.010  Higher   1849   .043   1873   .017   1949   .015   1965   .012
================================================================================================================================
BSQ921    1920 to  1994     75 years
                                                                                                  Series  11

 [B] Entire series, effect on correlation (  .684) is:
      Lower   1949  -.017   1974  -.014   1967  -.012   1952  -.011  Higher   1981   .019   1937   .012   1923   .011   1975   .011
================================================================================================================================
BSQ927W   1899 to  1994     96 years
                                                                                                  Series  12

 [B] Entire series, effect on correlation (  .520) is:
      Lower   1915  -.051   1951  -.025   1992  -.025   1902  -.016  Higher   1981   .030   1968   .020   1933   .019   1937   .017
================================================================================================================================
BSQ921NW  1914 to  1994     81 years
                                                                                                  Series  13

 [B] Entire series, effect on correlation (  .672) is:
      Lower   1958  -.023   1988  -.018   1936  -.018   1952  -.014  Higher   1981   .063   1923   .019   1920   .013   1949   .012
================================================================================================================================
BSQ921SE  1897 to  1994     98 years
                                                                                                  Series  14

 [B] Entire series, effect on correlation (  .652) is:
      Lower   1931  -.040   1992  -.023   1898  -.017   1952  -.012  Higher   1981   .037   1933   .020   1965   .015   1937   .012
================================================================================================================================
BSQ934NE  1922 to  1964     43 years
                                                                                                  Series  15

 [B] Entire series, effect on correlation (  .567) is:
      Lower   1955  -.036   1923  -.029   1957  -.016   1959  -.014  Higher   1949   .056   1954   .027   1937   .027   1964   .015
================================================================================================================================
BSQ925    1912 to  1994     83 years
                                                                                                  Series  16

 [B] Entire series, effect on correlation (  .645) is:
      Lower   1925  -.025   1916  -.017   1950  -.015   1952  -.014  Higher   1981   .033   1968   .028   1933   .022   1975   .009
================================================================================================================================
BSQ936    1845 to  1937     93 years
                                                                                                  Series  17

 [B] Entire series, effect on correlation (  .723) is:
      Lower   1919  -.015   1893  -.011   1937  -.011   1870  -.010  Higher   1849   .038   1873   .019   1881   .009   1920   .008
================================================================================================================================
BSQ936    1950 to  1994     45 years
                                                                                                  Series  18

 [B] Entire series, effect on correlation (  .491) is:
      Lower   1966  -.047   1965  -.040   1981  -.023   1953  -.018  Higher   1964   .021   1954   .016   1968   .014   1985   .012
================================================================================================================================
BSQ929W   1934 to  1994     61 years
                                                                                                  Series  19

 [B] Entire series, effect on correlation (  .526) is:
      Lower   1940  -.039   1951  -.032   1965  -.025   1983  -.025  Higher   1981   .072   1968   .032   1947   .018   1975   .013
================================================================================================================================
```

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BSQ935   1874 to  1994     121 years
                                                                                                    Series  20
 [B] Entire series, effect on correlation (  .604) is:
      Lower   1994  -.020   1993  -.020   1893  -.015   1940  -.012  Higher   1949   .022   1923   .016   1947   .009   1895   .009
==================================================================================================================================
BSQ928E   1905 to  1994      90 years
                                                                                                    Series  21
 [B] Entire series, effect on correlation (  .702) is:
      Lower   1948  -.019   1911  -.017   1931  -.015   1954  -.014  Higher   1937   .011   1981   .011   1968   .010   1949   .010
==================================================================================================================================
BSQ922NW  1907 to  1994      88 years
                                                                                                    Series  22
 [B] Entire series, effect on correlation (  .722) is:
      Lower   1911  -.023   1951  -.015   1992  -.009   1935  -.009  Higher   1981   .031   1968   .017   1949   .014   1937   .009
==================================================================================================================================
BSQ927E   1900 to  1994      95 years
                                                                                                    Series  23
 [B] Entire series, effect on correlation (  .518) is:
      Lower   1942  -.054   1993  -.026   1992  -.025   1949  -.023  Higher   1981   .042   1911   .014   1968   .014   1933   .012

 [E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
      1942 -5.0 SD
==================================================================================================================================
BSQ939W   1880 to  1919      40 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
     ---------  ----   ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---  ---
   1880 1919          -.05 -.08  .02  .12 -.17 -.07 -.01 -.01  .36  .02  .36  .20 -.24 -.16 -.06  .00 -.03 -.52 -.12  .05 -.07
+                -2                                           <___>      ___

 [B] Entire series, effect on correlation (  .359) is:
      Lower   1914  -.089   1884  -.067   1905  -.030   1909  -.024  Higher   1881   .041   1902   .040   1916   .033   1895   .033
    1880 to 1919 segment:
      Lower   1914  -.089   1884  -.067   1905  -.030   1909  -.024  Higher   1881   .041   1902   .040   1916   .033   1895   .033
==================================================================================================================================
BSQ939W   1946 to  1994      49 years
                                                                                                    Series  25
 [B] Entire series, effect on correlation (  .365) is:
      Lower   1949  -.037   1954  -.033   1964  -.031   1970  -.022  Higher   1957   .023   1993   .022   1992   .015   1948   .015
==================================================================================================================================
BSQ934SW  1924 to  1994      71 years
                                                                                                    Series  26
 [B] Entire series, effect on correlation (  .494) is:
      Lower   1946  -.022   1930  -.020   1933  -.018   1927  -.018  Higher   1981   .070   1965   .020   1968   .020   1993   .014
==================================================================================================================================
BSQ933NE  1841 to  1919      79 years
                                                                                                    Series  27
 [B] Entire series, effect on correlation (  .566) is:
      Lower   1850  -.033   1887  -.030   1878  -.022   1875  -.020  Higher   1849   .119   1881   .016   1873   .012   1869   .012
==================================================================================================================================
BSQ933NE  1942 to  1994      53 years
                                                                                                    Series  28
 [B] Entire series, effect on correlation (  .569) is:
      Lower   1966  -.029   1958  -.024   1945  -.022   1952  -.021  Higher   1981   .090   1965   .022   1975   .017   1993   .012
==================================================================================================================================
BSQ922SE  1905 to  1994      90 years
                                                                                                    Series  29
 [B] Entire series, effect on correlation (  .595) is:
      Lower   1951  -.018   1994  -.012   1913  -.011   1960  -.011  Higher   1981   .034   1933   .024   1975   .012   1968   .010
==================================================================================================================================
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BSQ931N-  1915 to  1994     80 years
                                                                                                     Series  30
[B] Entire series, effect on correlation (  .662) is:
     Lower   1948  -.021   1993  -.019   1964  -.015   1920  -.013  Higher   1949   .020   1965   .016   1981   .014   1933   .014
====================================================================================================================
BSQ935E   1873 to  1994    122 years
                                                                                                     Series  31
[B] Entire series, effect on correlation (  .513) is:
     Lower   1886  -.023   1968  -.019   1885  -.017   1927  -.012  Higher   1949   .022   1965   .019   1981   .017   1893   .014

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1885 +3.2 SD
====================================================================================================================
BSQ924SE  1918 to  1994     77 years
                                                                                                     Series  32
[B] Entire series, effect on correlation (  .727) is:
     Lower   1957  -.014   1940  -.014   1932  -.010   1927  -.010  Higher   1965   .014   1937   .012   1968   .011   1920   .011
====================================================================================================================
BSQ930S   1900 to  1994     95 years
                                                                                                     Series  33
[B] Entire series, effect on correlation (  .712) is:
     Lower   1904  -.023   1928  -.023   1943  -.014   1913  -.013  Higher   1981   .049   1968   .013   1933   .013   1965   .011
====================================================================================================================
BSQ926NW  1914 to  1994     81 years
                                                                                                     Series  34
[B] Entire series, effect on correlation (  .722) is:
     Lower   1917  -.098   1985  -.014   1930  -.013   1918  -.009  Higher   1968   .020   1981   .019   1933   .013   1923   .013
====================================================================================================================
BSQ936E   1841 to  1994    154 years
                                                                                                     Series  35
[B] Entire series, effect on correlation (  .526) is:
     Lower   1954  -.023   1968  -.018   1964  -.015   1980  -.010  Higher   1873   .017   1849   .015   1965   .010   1881   .009

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1954 +3.6 SD
====================================================================================================================
BSQ924NW  1915 to  1994     80 years
                                                                                                     Series  36
[B] Entire series, effect on correlation (  .745) is:
     Lower   1993  -.017   1985  -.017   1961  -.013   1942  -.013  Higher   1923   .015   1965   .010   1920   .010   1937   .010
====================================================================================================================
BSQ926SE  1908 to  1994     87 years
                                                                                                     Series  37
[B] Entire series, effect on correlation (  .709) is:
     Lower   1931  -.015   1949  -.014   1940  -.012   1920  -.011  Higher   1968   .018   1933   .015   1923   .014   1975   .008

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1992 +3.0 SD
====================================================================================================================
BSQ932SW  1845 to  1993    149 years
                                                                                                     Series  38
[B] Entire series, effect on correlation (  .571) is:
     Lower   1992  -.027   1988  -.016   1923  -.014   1980  -.012  Higher   1981   .034   1849   .028   1949   .014   1873   .013

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1988 +3.4 SD
====================================================================================================================
BSQ938E   1876 to  1994    119 years
                                                                                                     Series  39
[B] Entire series, effect on correlation (  .555) is:
     Lower   1879  -.031   1895  -.018   1897  -.016   1889  -.013  Higher   1981   .019   1965   .018   1937   .011   1975   .009

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1897 +3.5 SD
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BSQ923SE  1904 to  1994      91 years                                                                    Series  40

[B] Entire series, effect on correlation (  .754) is:
     Lower   1940  -.015   1961  -.013   1974  -.013   1954  -.012  Higher   1981   .036   1965   .012   1933   .009   1937   .008

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

CLIFF1    1918 to  1994      77 years                                                                    Series  41

[B] Entire series, effect on correlation (  .542) is:
     Lower   1930  -.046   1988  -.025   1994  -.024   1948  -.017  Higher   1949   .030   1920   .021   1965   .019   1968   .017

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BSQ930N   1872 to  1994     123 years                                                                    Series  42

[B] Entire series, effect on correlation (  .596) is:
     Lower   1904  -.026   1943  -.020   1951  -.013   1875  -.013  Higher   1981   .050   1949   .018   1968   .017   1893   .011

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1943 +3.3 SD
=====================================================================================================================================

BSQ936W   1843 to  1994     152 years                                                                    Series  43

[B] Entire series, effect on correlation (  .592) is:
     Lower   1981  -.019   1970  -.017   1956  -.012   1968  -.011  Higher   1873   .013   1949   .012   1852   .010   1881   .007

[E] Outliers     1   3.0 SD above or -4.5 SD below mean for year
     1970 +4.3 SD
=====================================================================================================================================

BSQ939E   1886 to  1919      34 years                                                                    Series  44

[B] Entire series, effect on correlation (  .619) is:
     Lower   1905  -.105   1893  -.036   1909  -.019   1914  -.016  Higher   1902   .026   1889   .023   1918   .022   1916   .020

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

BSQ939E   1956 to  1994      39 years                                                                    Series  45

[B] Entire series, effect on correlation (  .563) is:
     Lower   1969  -.067   1963  -.052   1962  -.033   1965  -.031  Higher   1981   .117   1975   .022   1964   .020   1968   .013

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

BSQ925NE  1920 to  1994      75 years                                                                    Series  46

[B] Entire series, effect on correlation (  .784) is:
     Lower   1979  -.019   1965  -.015   1936  -.013   1988  -.012  Higher   1981   .035   1968   .016   1923   .012   1933   .011

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                                                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 BSQ935W  1865 1994    130      5      0     .605   .68   1.50   .250   .498   .256   2.21   .407  -.013   1
  2 BSQ929E  1921 1994     74      3      0     .501  1.51   3.72   .797   .804   .256   2.02   .374   .015   1
  3 BSQ938W  1876 1994    119      4      0     .660  1.55   6.90   .952   .824   .208   2.04   .340  -.035   1
  4 BSQ928W  1903 1994     92      3      0     .812  1.74   4.34   .716   .638   .253   2.07   .467  -.021   1
  5 BSQ925SW 1915 1994     80      3      0     .605  2.04   4.86   .908   .796   .197   2.07   .392  -.038   3
  6 BSQ937S  1885 1980     96      4      0     .499   .98   3.16   .569   .874   .201   2.09   .424  -.002   2
  7 BSQ931S  1915 1994     80      3      0     .630  1.49   2.82   .481   .542   .234   1.96   .361  -.012   1
  8 CLIFF2   1915 1994     80      3      0     .633  1.22   4.33   .619   .692   .251   2.20   .405   .025   1
  9 BSQ923NW 1905 1994     90      3      0     .595  1.40   2.70   .472   .677   .210   1.93   .354  -.052   1
 10 BSQ932NE 1844 1994    151      6      0     .574   .89   2.54   .445   .768   .207   1.96   .384  -.061   1
 11 BSQ921   1920 1994     75      3      0     .684  1.84   5.84  1.398   .887   .335   1.93   .352  -.028   1
 12 BSQ927W  1899 1994     96      4      0     .520  1.43   2.87   .641   .856   .212   2.05   .372   .010   1
 13 BSQ921NW 1914 1994     81      3      0     .672  1.66   4.21   .703   .759   .243   1.94   .327  -.020   1
 14 BSQ921SE 1897 1994     98      4      0     .652  1.40   3.16   .659   .831   .210   1.92   .342  -.004   1
 15 BSQ934NE 1922 1964     43      1      0     .567  1.26   3.15   .624   .648   .307   2.07   .539   .010   1
 16 BSQ925   1912 1994     83      3      0     .645  2.23   5.88  1.091   .828   .230   2.01   .395  -.070   1
 17 BSQ936   1845 1937     93      4      0     .723  1.08   2.23   .307   .266   .243   2.19   .429  -.019   1
 18 BSQ936   1950 1994     45      1      0     .491   .85   1.19   .158   .177   .195   1.87   .375  -.022   1
 19 BSQ929W  1934 1994     61      2      0     .526  1.44   3.47   .600   .705   .240   1.93   .386  -.036   1
 20 BSQ935   1874 1994    121      5      0     .604   .70   1.37   .226   .434   .280   2.03   .389   .005   1
 21 BSQ928E  1905 1994     90      3      0     .702  2.32   5.40   .913   .624   .264   1.88   .314  -.076   2
 22 BSQ922NW 1907 1994     88      3      0     .722  1.97   3.50   .616   .716   .195   1.90   .368  -.022   1
 23 BSQ927E  1900 1994     95      3      0     .518  1.29   4.43   .840   .910   .196   1.88   .332   .019   1
 24 BSQ939W  1880 1919     40      1      1     .359  1.05   2.71   .579   .805   .230   2.34   .550   .116   1
 25 BSQ939W  1946 1994     49      1      0     .365   .47   1.12   .239   .782   .235   2.11   .404  -.053   1
 26 BSQ934SW 1924 1994     71      3      0     .494  1.23   3.03   .523   .616   .272   2.01   .417  -.069   2
 27 BSQ933NE 1841 1919     79      3      0     .566   .75   2.62   .470   .831   .261   1.89   .272   .062   1
 28 BSQ933NE 1942 1994     53      2      0     .569   .50   1.40   .283   .844   .232   2.16   .453  -.073   1
 29 BSQ922SE 1905 1994     90      3      0     .595  1.54   2.91   .467   .533   .231   1.96   .366  -.048   1
 30 BSQ931N  1915 1994     80      3      0     .662  1.34   2.31   .369   .514   .230   1.97   .349  -.057   1
 31 BSQ935E  1873 1994    122      5      0     .513   .72   3.87   .503   .488   .285   2.16   .371   .019   1
 32 BSQ924SE 1918 1994     77      3      0     .727  1.75   3.77   .760   .659   .256   1.98   .337  -.047   1
 33 BSQ930S  1900 1994     95      3      0     .712  1.88   3.53   .631   .706   .212   1.86   .316  -.078   1
 34 BSQ926NW 1914 1994     81      3      0     .722  1.71   3.01   .549   .831   .151   1.87   .360  -.033   1
 35 BSQ936E  1841 1994    154      6      0     .526   .93   2.47   .327   .546   .202   1.95   .341   .030   1
 36 BSQ924NW 1915 1994     80      3      0     .745  2.05   3.88   .811   .662   .234   1.95   .370  -.037   2
 37 BSQ926SE 1908 1994     87      3      0     .709  2.00   3.62   .645   .734   .184   2.20   .402  -.039   1
 38 BSQ932SW 1845 1993    149      6      0     .571   .85   1.95   .304   .695   .197   1.89   .338  -.003   1
 39 BSQ938E  1876 1994    119      4      0     .555  1.34   3.56   .451   .742   .169   1.94   .334  -.050   1
 40 BSQ923SE 1904 1994     91      3      0     .754  1.67   2.96   .520   .650   .208   2.01   .387  -.052   1
 41 CLIFF1   1918 1994     77      3      0     .542   .82   2.24   .297   .521   .245   1.99   .337   .000   1
 42 BSQ930N  1872 1994    123      5      0     .596  1.47   3.14   .642   .774   .250   1.88   .308  -.009   1
 43 BSQ936W  1843 1994    152      6      0     .592  1.02   2.63   .291   .468   .183   2.17   .427   .004   1
 44 BSQ939E  1886 1919     34      1      0     .619  1.26   2.29   .381   .422   .208   1.99   .504  -.070   1
 45 BSQ939E  1956 1994     39      1      0     .563   .60   1.10   .202   .643   .193   2.06   .499   .020   1
 46 BSQ925NE 1920 1994     75      3      0     .784  1.47   2.33   .382   .604   .193   1.93   .416  -.023   1
--- -------- ---------  -----  -----  -----   ------ -----  -----  -----  -----  -----  -----  -----  -----  --
Total or mean:           4078    150      1     .612  1.32   6.90   .552   .669   .226   2.34   .376  -.020

                                  - = [ COFECHA BSQCOF ] = -
```

Appendix B

```
BRF 1977-Nostress Site

***** Input file names ***********************
Site       :  C:\GAPS3\BRF.LOC
Soil       :  C:\GAPS3\BR-NOSTR.SOL
Climate    :  C:\GAPS3\BR1977.CLI
Plant 1    :  C:\GAPS3\BR-OAK.PLT
Save       :  C:\GAPS3\MONTHLY.SAV

***** Output file names **********************
Summary      : C:\GAPS3\1977.SUM
Model        : C:\GAPS3\1977.DET

***** Simulation procedures *****************

Soil temperature      : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff        : not simulated
Soil water flow       : Tipping Bucket (Tipping_Bucket)
Plant water uptake    : Plant-available water (SimpleWaterUptake)
Field hours           : not simulated


***** Beginning simulation year  1 *************

First day                :       1
Last day                 :     365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

*** Constant crop model summary:

****** summary water budget (kg/m2 or mm) *****
Total Precipitation                :   1425
Total Runoff                       :      0
Total Water Input to Surface       :   1170
Total Potential ET                 :    999
Total Potential Transpiration      :    408
Total Actual Transpiration         :    156
Total Potential Evaporation        :    336
Total Actual Soil Evaporation      :    318
Accumulated Deep Drainage          :    699
Initially in profile               :     57
Finally in profile                 :     55
Change in Storage                  :     -2
```

```
BRF 1977- Stress Site
***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1977.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary       : C:\GAPS3\1977S.SUM
Model         : C:\GAPS3\1977S.DET

***** Simulation procedures *****************

Soil temperature      : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff        : not simulated
Soil water flow       : Tipping Bucket (Tipping_Bucket)
Plant water uptake    : Plant-available water (SimpleWaterUptake)
Field hours           : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation               :   1425
Total Runoff                      :      0
Total Water Input to Surface      :   1170
Total Potential ET                :    999
Total Potential Transpiration     :    408
Total Actual Transpiration        :    143
Total Potential Evaporation       :    336
Total Actual Soil Evaporation     :    317
Accumulated Deep Drainage         :    713
Initially in profile              :     37
Finally in profile                :     35
Change in Storage                 :     -2
```

BRF, 1978- Stress Site

```
***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1978.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1978S.SUM
Model        : C:\GAPS3\1978S.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                   :      1
Last day                    :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation              :   1235
Total Runoff                     :      0
Total Water Input to Surface     :    984
Total Potential ET               :    973
Total Potential Transpiration    :    400
Total Actual Transpiration       :    196
Total Potential Evaporation      :    323
Total Actual Soil Evaporation    :    294
Accumulated Deep Drainage        :    498
Initially in profile             :     37
Finally in profile               :     34
Change in Storage                :     -3
```

```
BRF'1978- Nostress Site

***** Input file names **********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-NOSTR.SOL
Climate   :  C:\GAPS3\BR1979.CLI        File not found
Plant 1   :  C:\GAPS3\BR-OAK.PLT        File not found
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1979.SUM
Model        : C:\GAPS3\1979.DET

***** Simulation procedures ******************

Soil temperature     : not simulated
Evapo-transpiration  : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff       : not simulated
Soil water flow      : Tipping Bucket (Tipping_Bucket)
Plant water uptake   : Plant-available water (SimpleWaterUptake)
Field hours          : not simulated


***** Beginning simulation year  1 *************

First day                 :      1
Last day                  :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation              :   1586
Total Runoff                     :      0
Total Water Input to Surface     :   1342
Total Potential ET               :    991
Total Potential Transpiration    :    414
Total Actual Transpiration       :    218
Total Potential Evaporation      :    335
Total Actual Soil Evaporation    :    303
Accumulated Deep Drainage        :    824
Initially in profile             :     57
Finally in profile               :     54
Change in Storage                :     -3
```

```
BRF, 1979- Stress Site

***** Input file names ***********************
Site       :  C:\GAPS3\BRF.LOC
Soil       :  C:\GAPS3\BR-STRES.SOL
Climate    :  C:\GAPS3\BR1979.CLI
Plant 1    :  C:\GAPS3\BR-OAK.PLT
Save       :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1979S.SUM
Model        : C:\GAPS3\1979S.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration    : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation                :   1586
Total Runoff                       :      0
Total Water Input to Surface       :   1344
Total Potential ET                 :    991
Total Potential Transpiration      :    414
Total Actual Transpiration         :    189
Total Potential Evaporation        :    335
Total Actual Soil Evaporation      :    302
Accumulated Deep Drainage          :    856
Initially in profile               :     37
Finally in profile                 :     35
Change in Storage                  :     -3
```

```
BRF' 1979- Nonstress Site

***** Input file names ***********************
Site     :  C:\GAPS3\BRF.LOC
Soil     :  C:\GAPS3\BR-NOSTR.SOL
Climate  :  C:\GAPS3\BR1979.CLI         File not found
Plant 1  :  C:\GAPS3\BR-OAK.PLT         File not found
Save     :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary     : C:\GAPS3\1979.SUM
Model       : C:\GAPS3\1979.DET

***** Simulation procedures *****************

Soil temperature    : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff      : not simulated
Soil water flow     : Tipping Bucket (Tipping_Bucket)
Plant water uptake  : Plant-available water (SimpleWaterUptake)
Field hours         : not simulated


***** Beginning simulation year  1 *************

First day              :      1
Last day               :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation            :   1586
Total Runoff                   :      0
Total Water Input to Surface   :   1342
Total Potential ET             :    991
Total Potential Transpiration  :    414
Total Actual Transpiration     :    218
Total Potential Evaporation    :    335
Total Actual Soil Evaporation  :    303
Accumulated Deep Drainage      :    824
Initially in profile           :     57
Finally in profile             :     54
Change in Storage              :     -3
```

```
BRF'1980- Nonstress Site

***** Input file names **********************
Site       :  C:\GAPS3\BRF.LOC
Soil       :  C:\GAPS3\BR-NOSTR.SOL
Climate    :  C:\GAPS3\BR1980.CLI
Plant 1    :  C:\GAPS3\BR-OAK.PLT
Save       :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1980.SUM
Model        : C:\GAPS3\1980.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration    : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation               :     994
Total Runoff                      :       0
Total Water Input to Surface      :     764
Total Potential ET                :     999
Total Potential Transpiration     :     441
Total Actual Transpiration        :      84
Total Potential Evaporation       :     329
Total Actual Soil Evaporation     :     282
Accumulated Deep Drainage         :     399
Initially in profile              :      57
Finally in profile                :      55
Change in Storage                 :      -1
```

```
BRF 1981- Stress Site

***** Input file names **********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1981.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1981S.SUM
Model        : C:\GAPS3\1981S.DET

***** Simulation procedures ******************

Soil temperature    : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff      : not simulated
Soil water flow     : Tipping Bucket (Tipping_Bucket)
Plant water uptake  : Plant-available water (SimpleWaterUptake)
Field hours         : not simulated


***** Beginning simulation year  1 *************

First day              :      1
Last day               :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183).

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation             :    993
Total Runoff                    :      0
Total Water Input to Surface    :    756
Total Potential ET              :    998
Total Potential Transpiration   :    425
Total Actual Transpiration      :    103
Total Potential Evaporation     :    336
Total Actual Soil Evaporation   :    269
Accumulated Deep Drainage       :    387
Initially in profile            :     37
Finally in profile              :     35
Change in Storage               :     -2

**********************************************
Ending simulation on 2/18/1997 at 23:32:45
```

```
BRF,1981- Nonstress Site

***** Input file names **********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-NOSTR.SOL
Climate   :  C:\GAPS3\BR1981.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1981.SUM
Model        : C:\GAPS3\1981.DET

***** Simulation procedures *****************

Soil temperature        : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff          : not simulated
Soil water flow         : Tipping Bucket (Tipping_Bucket)
Plant water uptake      : Plant-available water (SimpleWaterUptake)
Field hours             : not simulated


***** Beginning simulation year  1 *************

First day                  :       1
Last day                   :     365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation                :    993
Total Runoff                       :      0
Total Water Input to Surface       :    756
Total Potential ET                 :    998
Total Potential Transpiration      :    425
Total Actual Transpiration         :    120
Total Potential Evaporation        :    336
Total Actual Soil Evaporation      :    270
Accumulated Deep Drainage          :    369
Initially in profile               :     57
Finally in profile                 :     54
Change in Storage                  :     -2

***********************************************
Ending simulation on 2/18/1997 at 23:32:23
```

```
BRF.1982- Stress Site

***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1982.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1982S.SUM
Model        : C:\GAPS3\1982S.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation                :     980
Total Runoff                       :       0
Total Water Input to Surface       :     732
Total Potential ET                 :     973
Total Potential Transpiration      :     392
Total Actual Transpiration         :     223
Total Potential Evaporation        :     333
Total Actual Soil Evaporation      :     257
Accumulated Deep Drainage          :     255
Initially in profile               :      37
Finally in profile                 :      35
Change in Storage                  :      -3

**********************************************
Ending simulation on 2/18/1997 at 23:33:47
```

```
BRF 1982- Nonstress Site

***** Input file names ***********************
Site     :  C:\GAPS3\BRF.LOC
Soil     :  C:\GAPS3\BR-NOSTR.SOL
Climate  :  C:\GAPS3\BR1982.CLI
Plant 1  :  C:\GAPS3\BR-OAK.PLT
Save     :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary     : C:\GAPS3\1982.SUM
Model       : C:\GAPS3\1982.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration    : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation              :    980
Total Runoff                     :      0
Total Water Input to Surface     :    732
Total Potential ET               :    973
Total Potential Transpiration    :    392
Total Actual Transpiration       :    246
Total Potential Evaporation      :    333
Total Actual Soil Evaporation    :    257
Accumulated Deep Drainage        :    232
Initially in profile             :     57
Finally in profile               :     54
Change in Storage                :     -3

**********************************************
Ending simulation on 2/18/1997 at 23:33:23
```

```
BRF, 1983- Stress Site

***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1983.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1983S.SUM
Model        : C:\GAPS3\1983S.DET

***** Simulation procedures *****************

Soil temperature        : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff          : not simulated
Soil water flow         : Tipping Bucket (Tipping_Bucket)
Plant water uptake      : Plant-available water (SimpleWaterUptake)
Field hours             : not simulated


***** Beginning simulation year  1 *************

First day                    :      1
Last day                     :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation               :   1783
Total Runoff                      :      0
Total Water Input to Surface      :   1529
Total Potential ET                :   1003
Total Potential Transpiration     :    409
Total Actual Transpiration        :    129
Total Potential Evaporation       :    339
Total Actual Soil Evaporation     :    323
Accumulated Deep Drainage         :   1079
Initially in profile              :     37
Finally in profile                :     35
Change in Storage                 :     -2

**********************************************
Ending simulation on 2/18/1997 at 23:34:51
```

```
BRF'1983- Nonstress Site

***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-NOSTR.SOL
Climate   :  C:\GAPS3\BR1983.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1983.SUM
Model        : C:\GAPS3\1983.DET

***** Simulation procedures *****************

Soil temperature        : not simulated
Evapo-transpiration     : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff          : not simulated
Soil water flow         : Tipping Bucket (Tipping_Bucket)
Plant water uptake      : Plant-available water (SimpleWaterUptake)
Field hours             : not simulated


***** Beginning simulation year  1 *************

First day                  :       1
Last day                   :     365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation               :   1783
Total Runoff                      :      0
Total Water Input to Surface      :   1529
Total Potential ET                :   1003
Total Potential Transpiration     :    409
Total Actual Transpiration        :    148
Total Potential Evaporation       :    339
Total Actual Soil Evaporation     :    324
Accumulated Deep Drainage         :   1059
Initially in profile              :     57
Finally in profile                :     55
Change in Storage                 :     -2

*********************************************
Ending simulation on 2/18/1997 at 23:34:29
```

```
BRF 1984- Stress Site

***** Input file names **********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1984.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary     : C:\GAPS3\1984S.SUM
Model       : C:\GAPS3\1984S.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration    : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation              :   1131
Total Runoff                     :      0
Total Water Input to Surface     :    882
Total Potential ET               :    991
Total Potential Transpiration    :    409
Total Actual Transpiration       :    122
Total Potential Evaporation      :    335
Total Actual Soil Evaporation    :    281
Accumulated Deep Drainage        :    481
Initially in profile             :     37
Finally in profile               :     35
Change in Storage                :     -2

*********************************************
Ending simulation on 2/18/1997 at 23:35:53
```

```
BRF'1984- Nonstress Site

***** Input file names **********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-NOSTR.SOL
Climate   :  C:\GAPS3\BR1984.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1984.SUM
Model        : C:\GAPS3\1984.DET

***** Simulation procedures *****************

Soil temperature      : not simulated
Evapo-transpiration   : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff        : not simulated
Soil water flow       : Tipping Bucket (Tipping_Bucket)
Plant water uptake    : Plant-available water (SimpleWaterUptake)
Field hours           : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation             :   1131
Total Runoff                    :      0
Total Water Input to Surface    :    882
Total Potential ET              :    991
Total Potential Transpiration   :    409
Total Actual Transpiration      :    151
Total Potential Evaporation     :    335
Total Actual Soil Evaporation   :    281
Accumulated Deep Drainage       :    451
Initially in profile            :     57
Finally in profile              :     55
Change in Storage               :     -2

*********************************************
Ending simulation on 2/18/1997 at 23:35:19
```

```
BRF,1985- Stress Site

***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1985.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1985S.SUM
Model        : C:\GAPS3\1985S.DET

***** Simulation procedures ******************

Soil temperature       : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm)  *****
Total Precipitation               :   1086
Total Runoff                      :      0
Total Water Input to Surface      :    833
Total Potential ET                :   1001
Total Potential Transpiration     :    408
Total Actual Transpiration        :    248
Total Potential Evaporation       :    340
Total Actual Soil Evaporation     :    294
Accumulated Deep Drainage         :    294
Initially in profile              :     37
Finally in profile                :     35
Change in Storage                 :     -2

**********************************************
Ending simulation on 2/18/1997 at 23:37:40
```

```
 BRF 1985- Nonstress Site

***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-NOSTR.SOL
Climate   :  C:\GAPS3\BR1985.CLI         File not found
Plant 1   :  C:\GAPS3\BR-OAK.PLT         File not found
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1985.SUM
Model        : C:\GAPS3\1985.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                 :       1
Last day                  :     365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation                :   1086
Total Runoff                       :      0
Total Water Input to Surface       :    831
Total Potential ET                 :   1001
Total Potential Transpiration      :    408
Total Actual Transpiration         :    273
Total Potential Evaporation        :    340
Total Actual Soil Evaporation      :    292
Accumulated Deep Drainage          :    268
Initially in profile               :     57
Finally in profile                 :     55
Change in Storage                  :     -2

**********************************************
Ending simulation on 2/18/1997 at 23:36:34
```

BRF, 1986- Nonstressed Site

```
***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1986.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1986S.SUM
Model        : C:\GAPS3\1986S.DET

***** Simulation procedures *****************

Soil temperature        : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff          : not simulated
Soil water flow         : Tipping Bucket (Tipping_Bucket)
Plant water uptake      : Plant-available water (SimpleWaterUptake)
Field hours             : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)   :    4.00
Accumulated root dry matter (kg/m2)  :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation                :   1109
Total Runoff                       :      0
Total Water Input to Surface       :    877
Total Potential ET                 :    992
Total Potential Transpiration      :    424
Total Actual Transpiration         :    204
Total Potential Evaporation        :    336
Total Actual Soil Evaporation      :    305
Accumulated Deep Drainage          :    370
Initially in profile               :     37
Finally in profile                 :     35
Change in Storage                  :     -3

***********************************************
Ending simulation on 2/18/1997 at 23:38:36
```

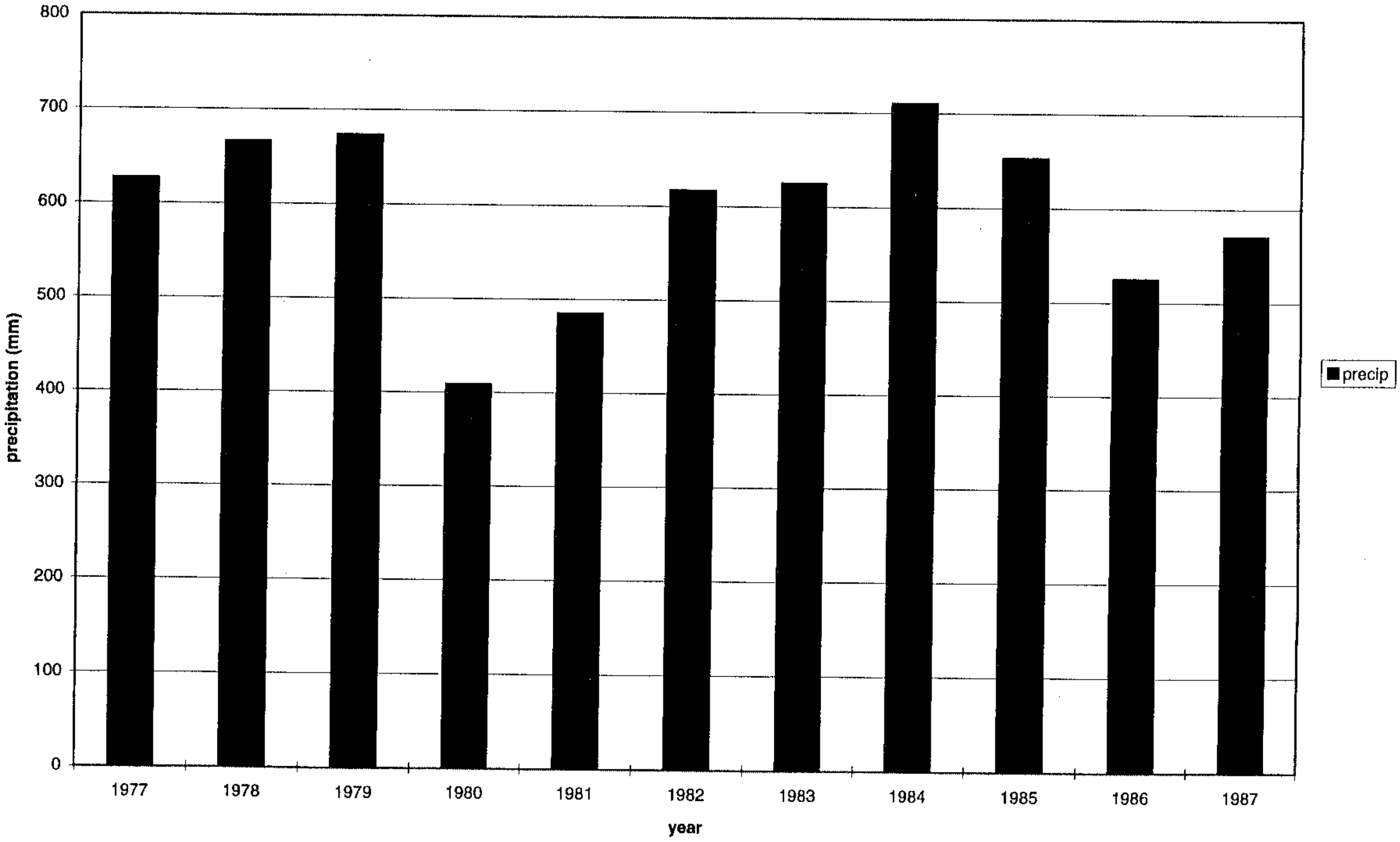
```
BRF,1986- Nonstressed Site

***** Input file names **********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-NOSTR.SOL
Climate   :  C:\GAPS3\BR1986.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1986.SUM
Model        : C:\GAPS3\1986.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration    : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                  :      1
Last day                   :    365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation                :   1109
Total Runoff                       :      0
Total Water Input to Surface       :    877
Total Potential ET                 :    992
Total Potential Transpiration      :    424
Total Actual Transpiration         :    222
Total Potential Evaporation        :    336
Total Actual Soil Evaporation      :    306
Accumulated Deep Drainage          :    351
Initially in profile               :     57
Finally in profile                 :     54
Change in Storage                  :     -3

**********************************************
Ending simulation on 2/18/1997 at 23:38: 7
```

```
BRF,1987- Stress Site
***** Input file names **********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-STRES.SOL
Climate   :  C:\GAPS3\BR1987.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1987S.SUM
Model        : C:\GAPS3\1987S.DET

***** Simulation procedures *****************

Soil temperature       : not simulated
Evapo-transpiration    : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff         : not simulated
Soil water flow        : Tipping Bucket (Tipping_Bucket)
Plant water uptake     : Plant-available water (SimpleWaterUptake)
Field hours            : not simulated


***** Beginning simulation year  1 *************

First day                   :       1
Last day                    :     365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm) *****
Total Precipitation              :   1173
Total Runoff                     :      0
Total Water Input to Surface     :    921
Total Potential ET               :    996
Total Potential Transpiration    :    407
Total Actual Transpiration       :    164
Total Potential Evaporation      :    338
Total Actual Soil Evaporation    :    298
Accumulated Deep Drainage        :    462
Initially in profile             :     37
Finally in profile               :     35
Change in Storage                :     -3

***********************************************
Ending simulation on 2/18/1997 at 23:39:33
```

```
BRF, 1987- Nonstressed Site

***** Input file names ***********************
Site      :  C:\GAPS3\BRF.LOC
Soil      :  C:\GAPS3\BR-NOSTR.SOL
Climate   :  C:\GAPS3\BR1987.CLI
Plant 1   :  C:\GAPS3\BR-OAK.PLT
Save      :  C:\GAPS3\MONTHLY.SAV

***** Output file names *********************
Summary      : C:\GAPS3\1987.SUM
Model        : C:\GAPS3\1987.DET

***** Simulation procedures *****************

Soil temperature        : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley_Taylor_ETP)
Surface runoff          : not simulated
Soil water flow         : Tipping Bucket (Tipping_Bucket)
Plant water uptake      : Plant-available water (SimpleWaterUptake)
Field hours             : not simulated


***** Beginning simulation year  1 *************

First day                :       1
Last day                 :     365

Constant
Model options: > Waterinterception
>> Crop planted, beginning growth on real day 105 (= elapsed day 0)
>> Crop harvested on real day 288 (= elapsed day 183)

***** generic crop model summary *************
Accumulated top dry matter (kg/m2)    :    4.00
Accumulated root dry matter (kg/m2)   :    1.00

****** summary water budget (kg/m2 or mm)  *****
Total Precipitation                 :    1173
Total Runoff                        :       0
Total Water Input to Surface        :     921
Total Potential ET                  :     996
Total Potential Transpiration       :     407
Total Actual Transpiration          :     174
Total Potential Evaporation         :     338
Total Actual Soil Evaporation       :     299
Accumulated Deep Drainage           :     451
Initially in profile                :      57
Finally in profile                  :      54
Change in Storage                   :      -3

**********************************************
Ending simulation on 2/18/1997 at 23:39: 2
```

Appendix C

Yearly BRF Precipitation Values



	April	May	June	July	August	Septembe	October
1977	113.5	80	93.2	55.6	63	200.4	173.7
1978	46.7	245.9	59.4	95.5	128.8	96.3	40.6
1979	132.1	141.28	45.2	42.4	154.9	148.1	172.2
1980	234.12	43.89	90.64	86.4	32.94	21.48	71.36
1981	127.08	155.65	76.64	97.5	27.63	34.44	79.68
1982	127.08	155.65	160.57	80.73	118.44	37.8	20.72
1983	309.72	143.66	51.04	83.1	107.91	44.94	130.08
1984	50.28	312.4	66.88	219.7	42.48	30.96	33.36
1985	50.28	177.43	102.8	150.1	101.97	79.38	39.6
1986	83.88	37.95	142.48	178.1	87.3	17.52	53.04
1987	167.28	52.58	147.78	112.23	120.42	134.96	74.03