

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

**Katherine DeWitt
Senior Thesis
Barnard College
Environmental Science Department
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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 gauge 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 basal 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 its 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

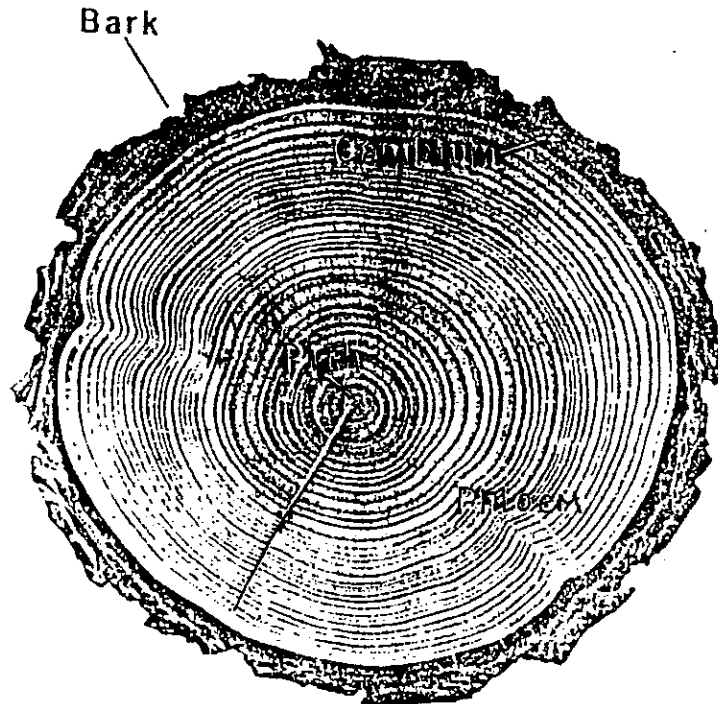
Dendrochronology, or the study of tree-rings, was developed by Andrew E. Douglass in the 1900's, and is primarily used for expanding paleoclimatic records (Stokes, 1968). In the past, it could only be hypothesized what climate existed before temperature and precipitation data was kept. However, now there 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

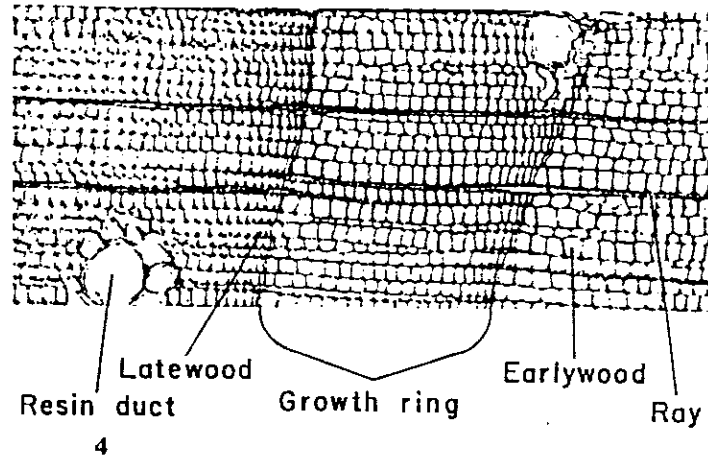


From Stokes and Smiley 1968

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 runoff (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 plant parts (Starr, 1994). This process is so important to dendrochronology because when actual transpiration falls below potential transpiration of the plant metabolic process begins to slow, in turn forming narrower rings (Figure 3) (Kozlowski et al., 1991).

Figure 3

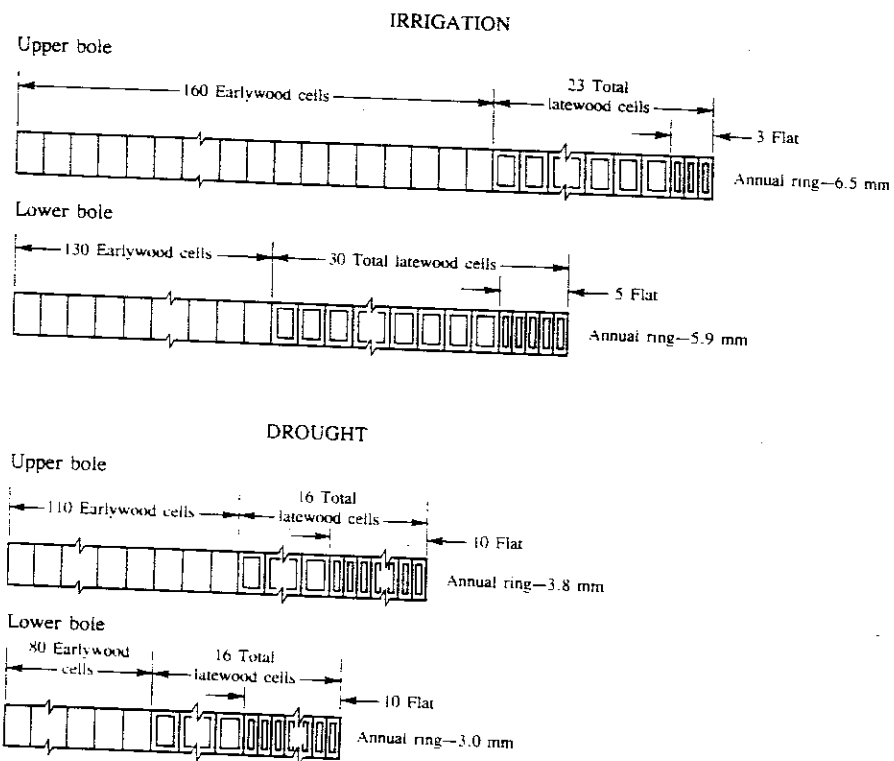


Figure 7.8 Difference in width of tracheids and in proportion of latewood in xylem rings of red pine grown with irrigation and under water stress. Also note differences between upper and lower bole. (From Zahner, 1968.)

Zahner, 1968

C. Regional Variations

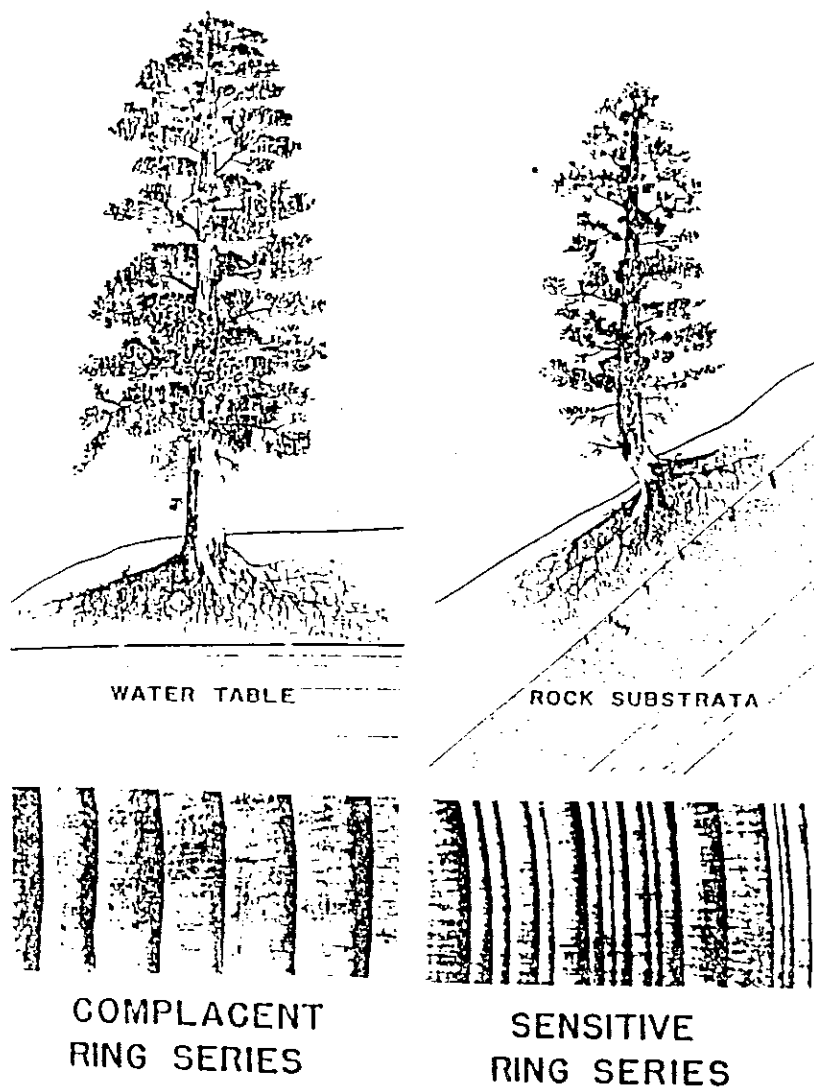
Historically, most dendrochronology studies were limited to Southwest areas composed of large conifer populations. Conifers, in general, are characterized by their high ring width correlation to seasonal variabilities. Southwestern climate has predictable contrasting seasonal trends; cold, wet winters 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, then 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.

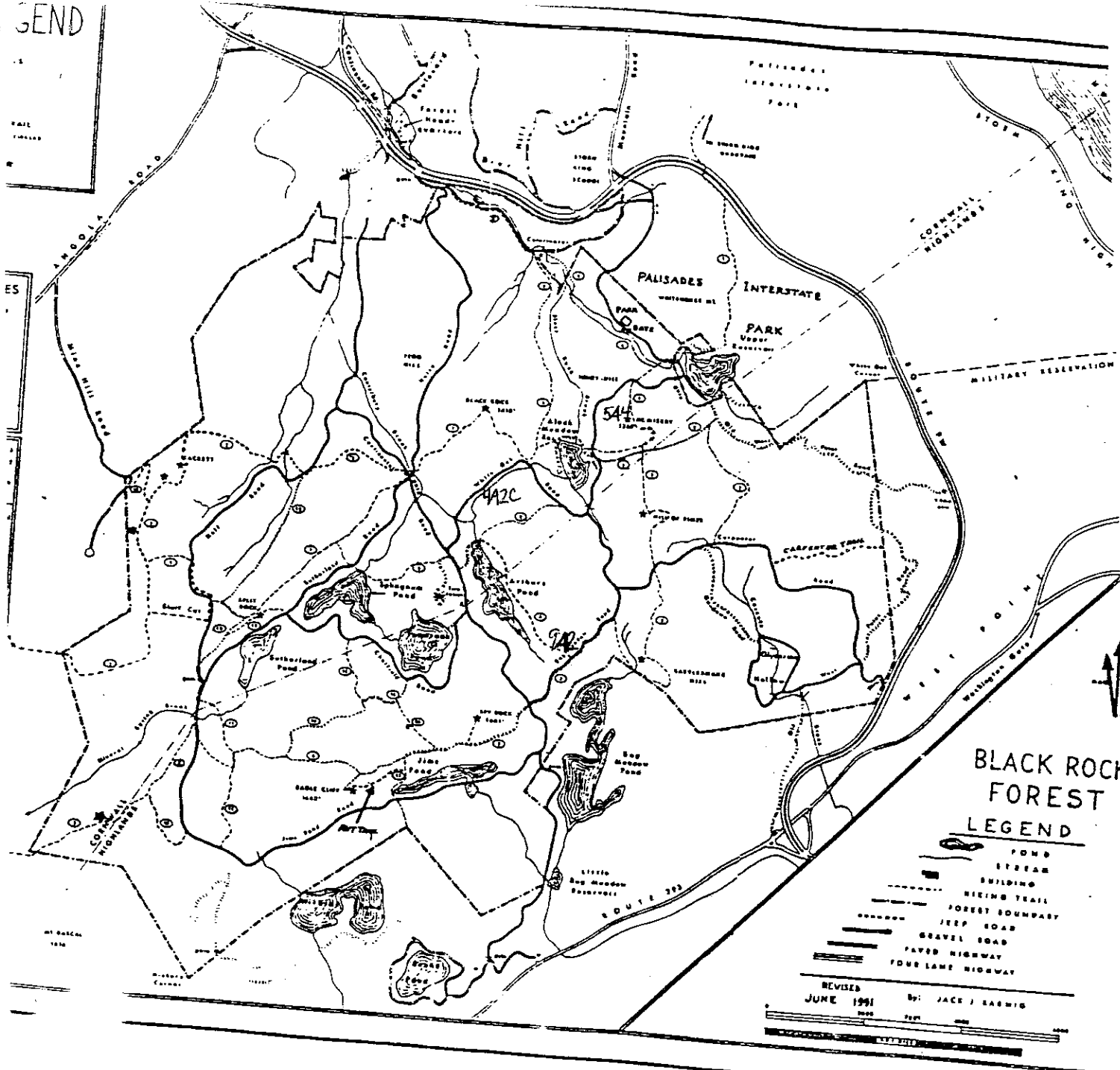
A. Dendrochronology

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),

GENE

PALE
TERRACE

ES



**BLACK ROCK
FOREST
LEGEND**

- POND
 - STREAM
 - BUILDING
 - HIKING TRAIL
 - FOREST BOUNDARY
 - JEEP ROAD
 - GRAVEL ROAD
 - PAVED HIGHWAY
 - FOUR LANE HIGHWAY
- REVISED
JUNE 1991 By: JACE J. SAENIG
- 0 1000 2000 3000 4000
- SCALE

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 slopes, as mentioned earlier, the sampling often ventured off the long term plots to find samples that had a signal.

Data collection took place 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:

$$\text{sim.ETP} = \text{loca.ALPHA} * (\text{NetRad} - G) * (\text{SSVD} / (\text{SSVD} + \text{PSYCON})) / \text{LAMB}$$

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]root radius
2.5E+0010	# crop.RootRes	(s) [m ⁴ /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 ³ /m ³]; 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 equidistance 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 m^3 water/ m^3 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 gravelly 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, gravelly 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.

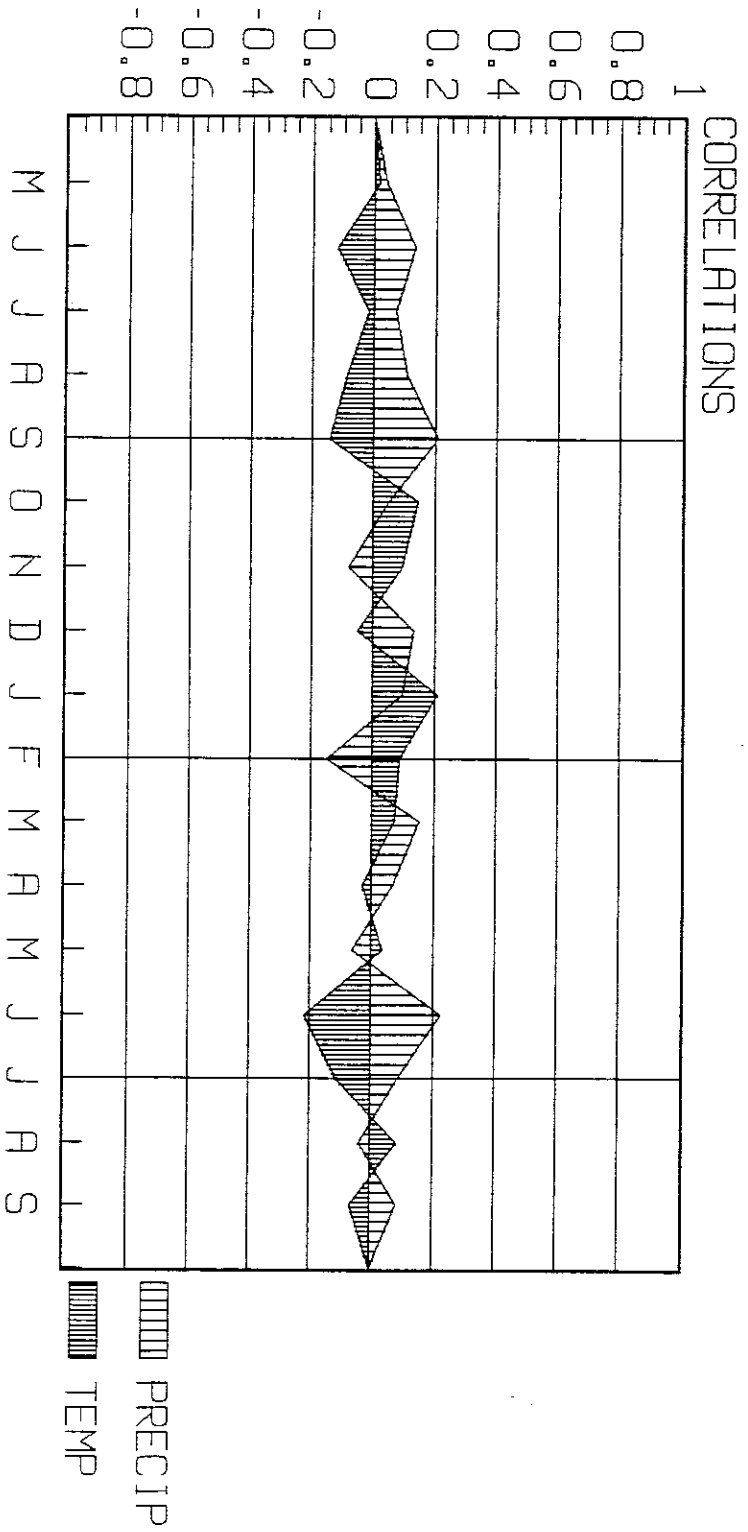
A.i. Arthur's Brook

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 dendrochronological 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.

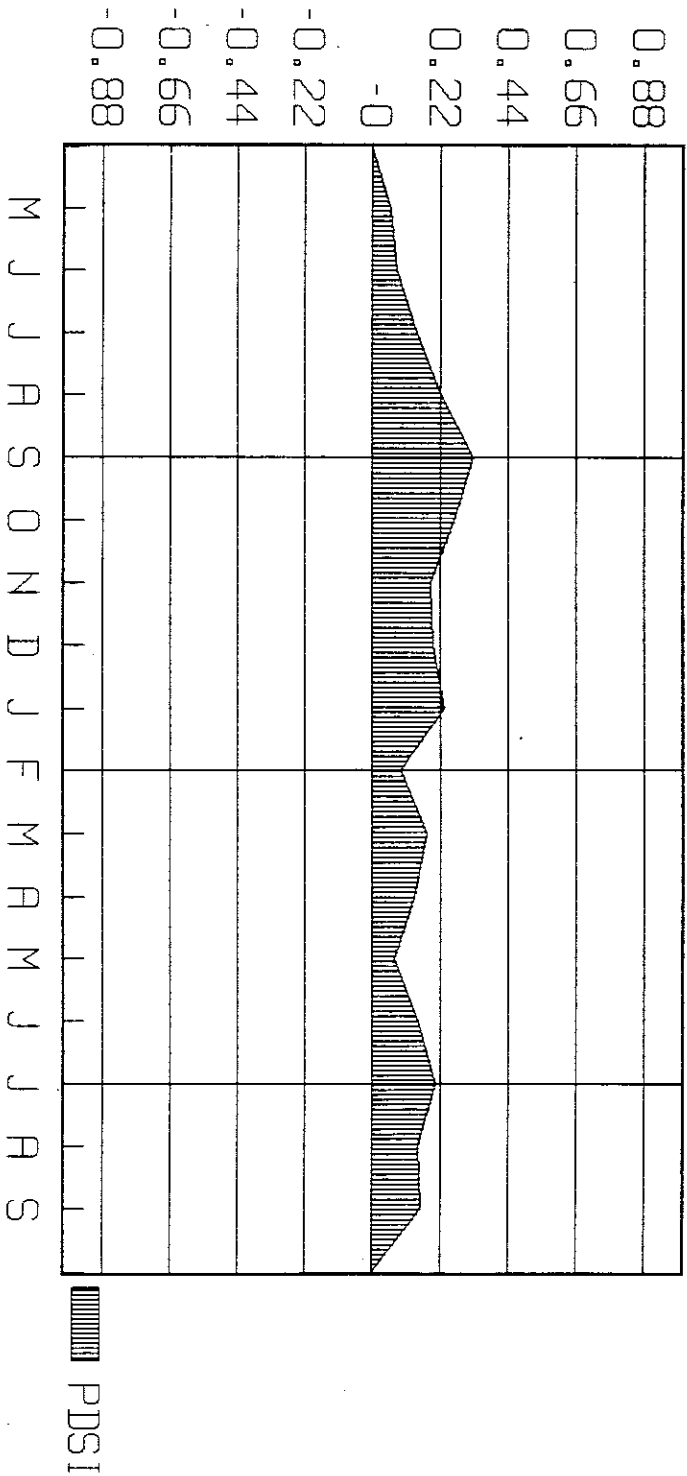
ARTHUR'S BROOK
 TEMP & PRECIP, 1891-1990
 FOR MAY - SEP, N:100
 SIG SIMPLE R: .200



NUMBER 1, 17 MONTHS, MAY-SEP

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

CORRELATIONS

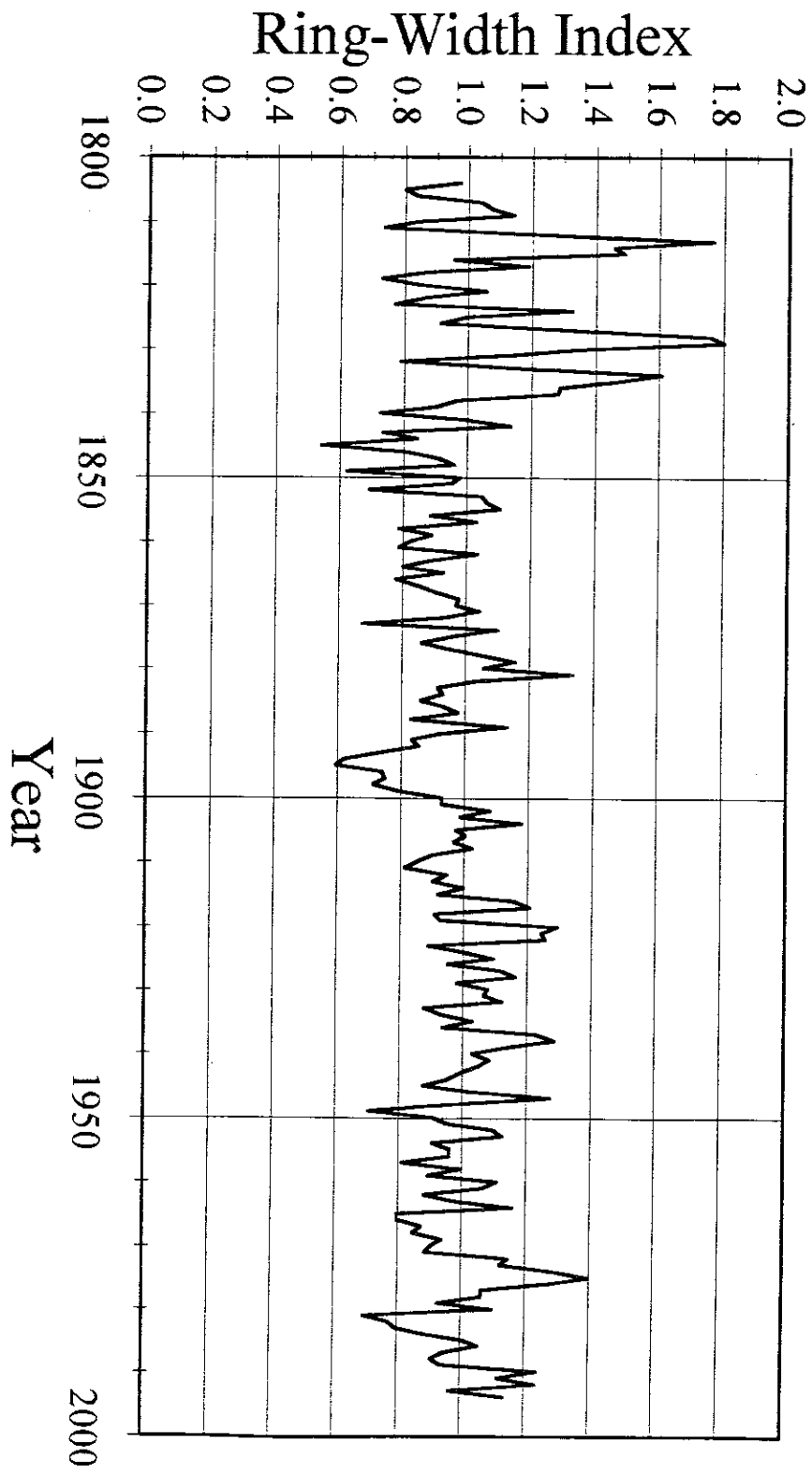


NUMBER 1, 17 MONTHS, MAY-SEP

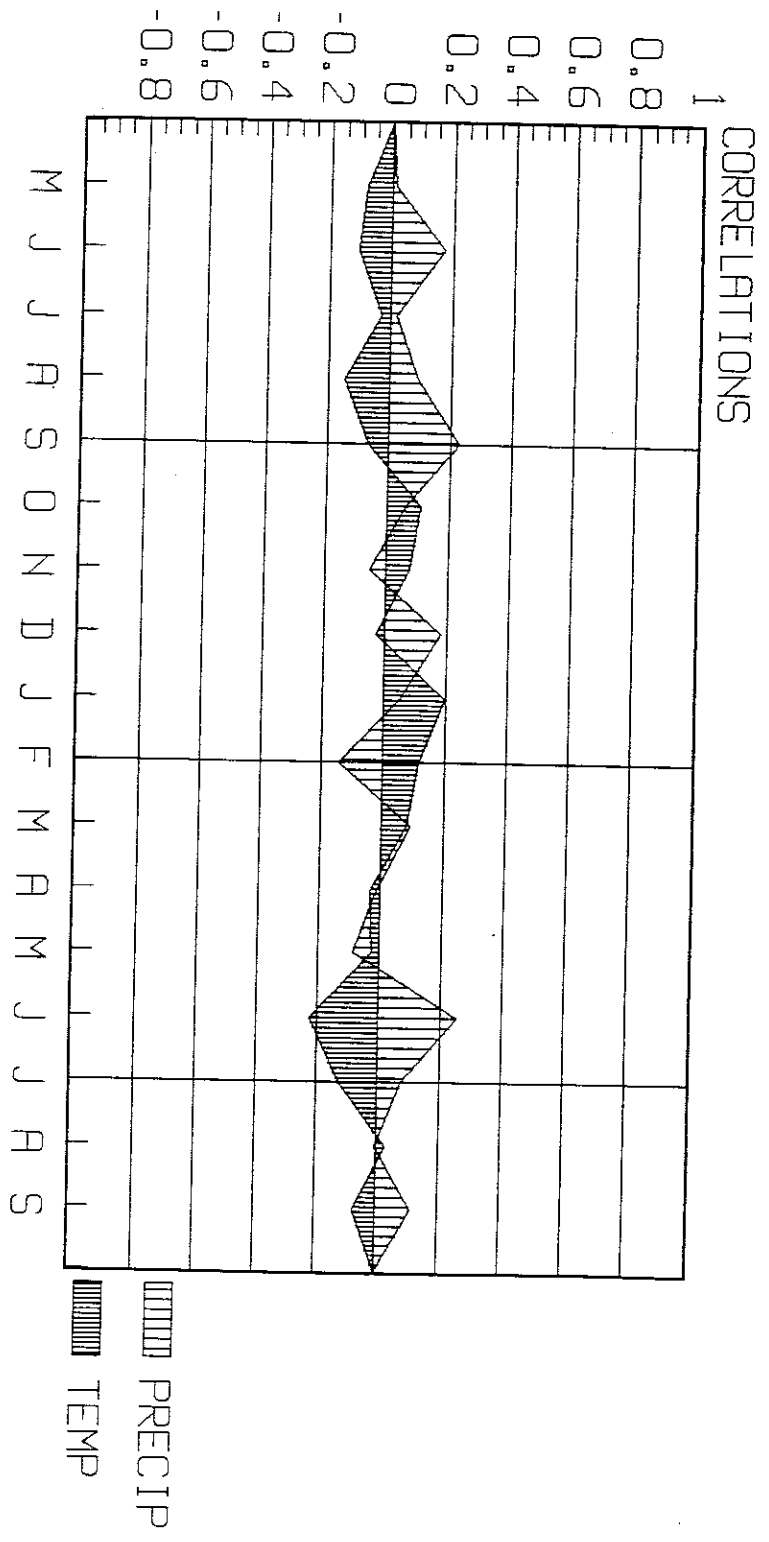
A.11. Mount Misery

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



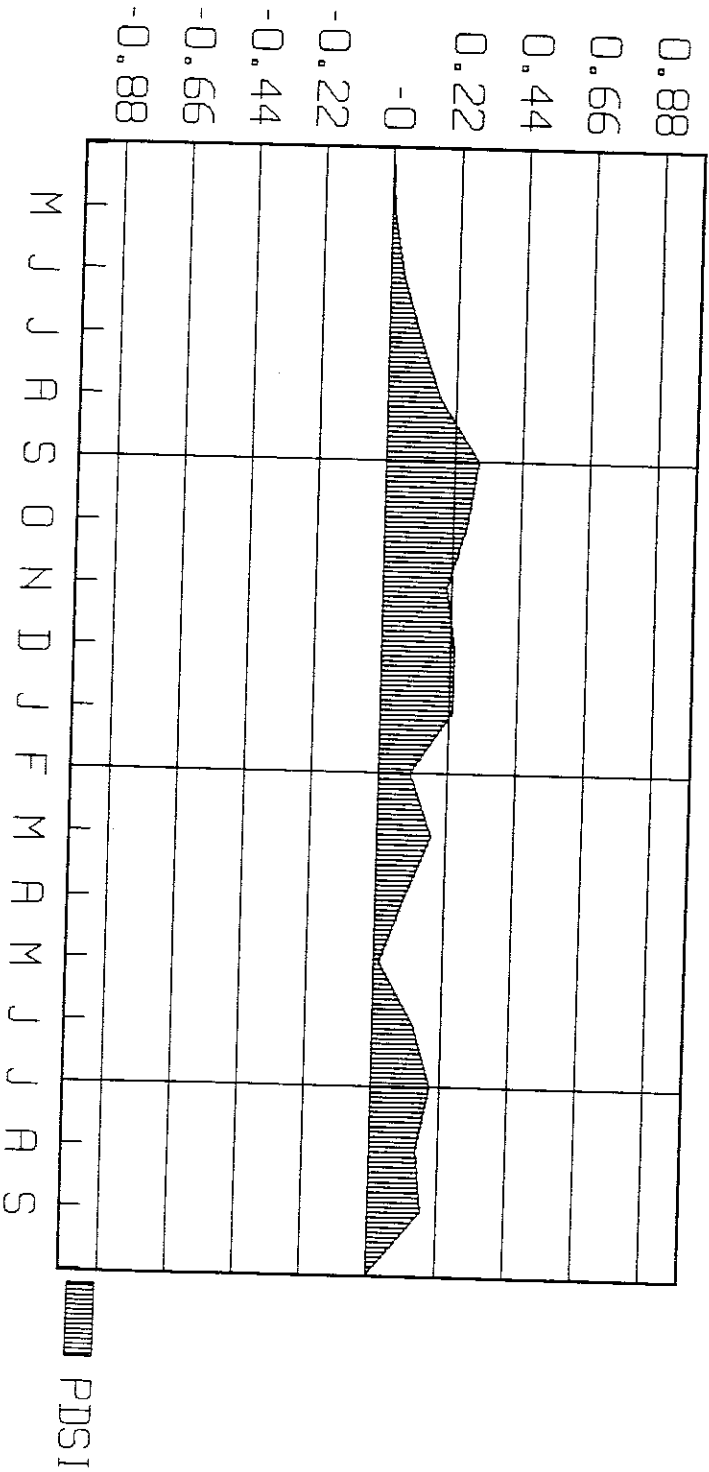
MOUNT MISERY
 TEMP & PRECIP, 1891-1990
 FOR MAY - SEP, N:100
 SIG SIMPLE R: .200



NUMBER 1, 17 MONTHS, MAY-SEP

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

CORRELATIONS



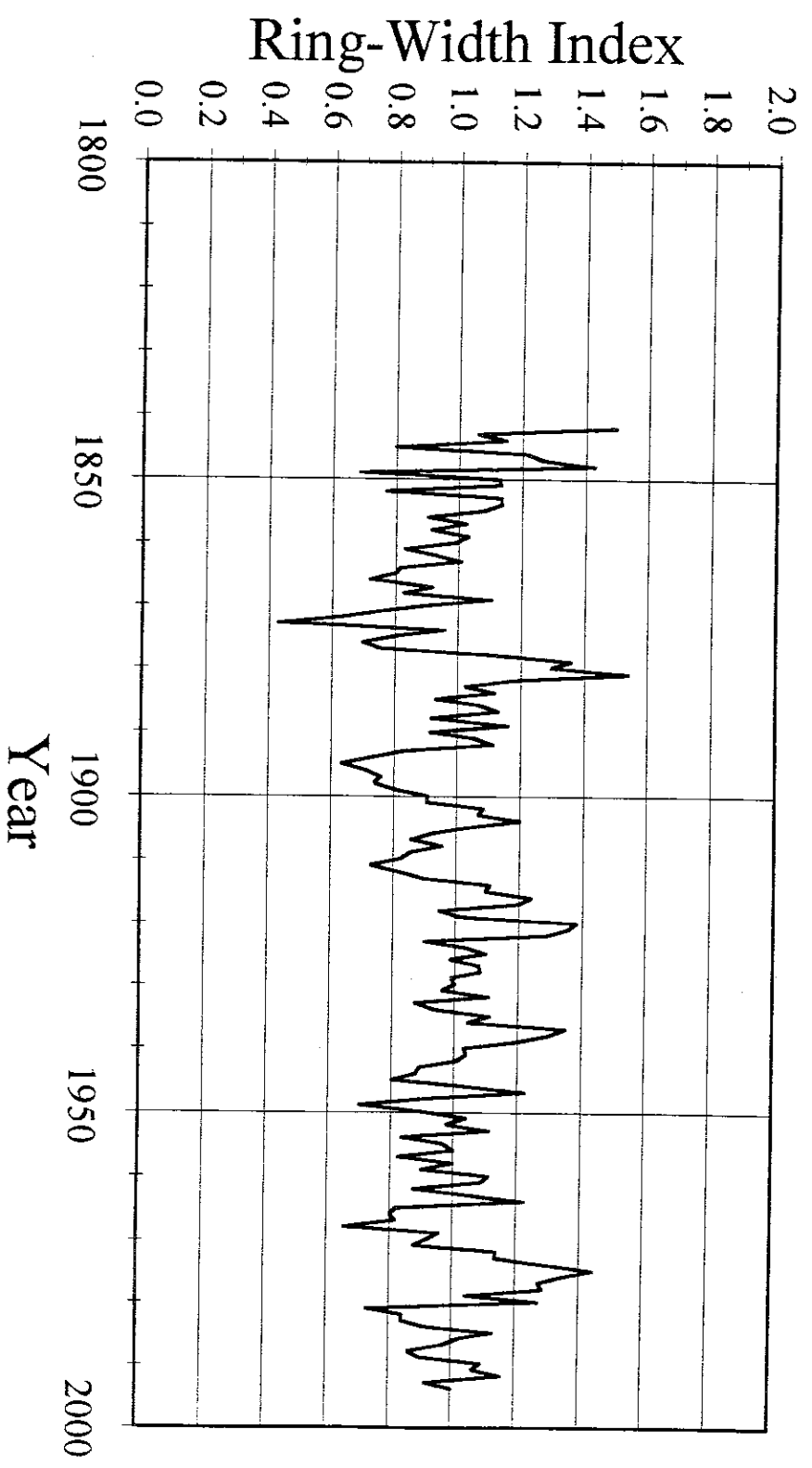
NUMBER 1, 17 MONTHS, MAY-SEP

A.iii. Bog Spring

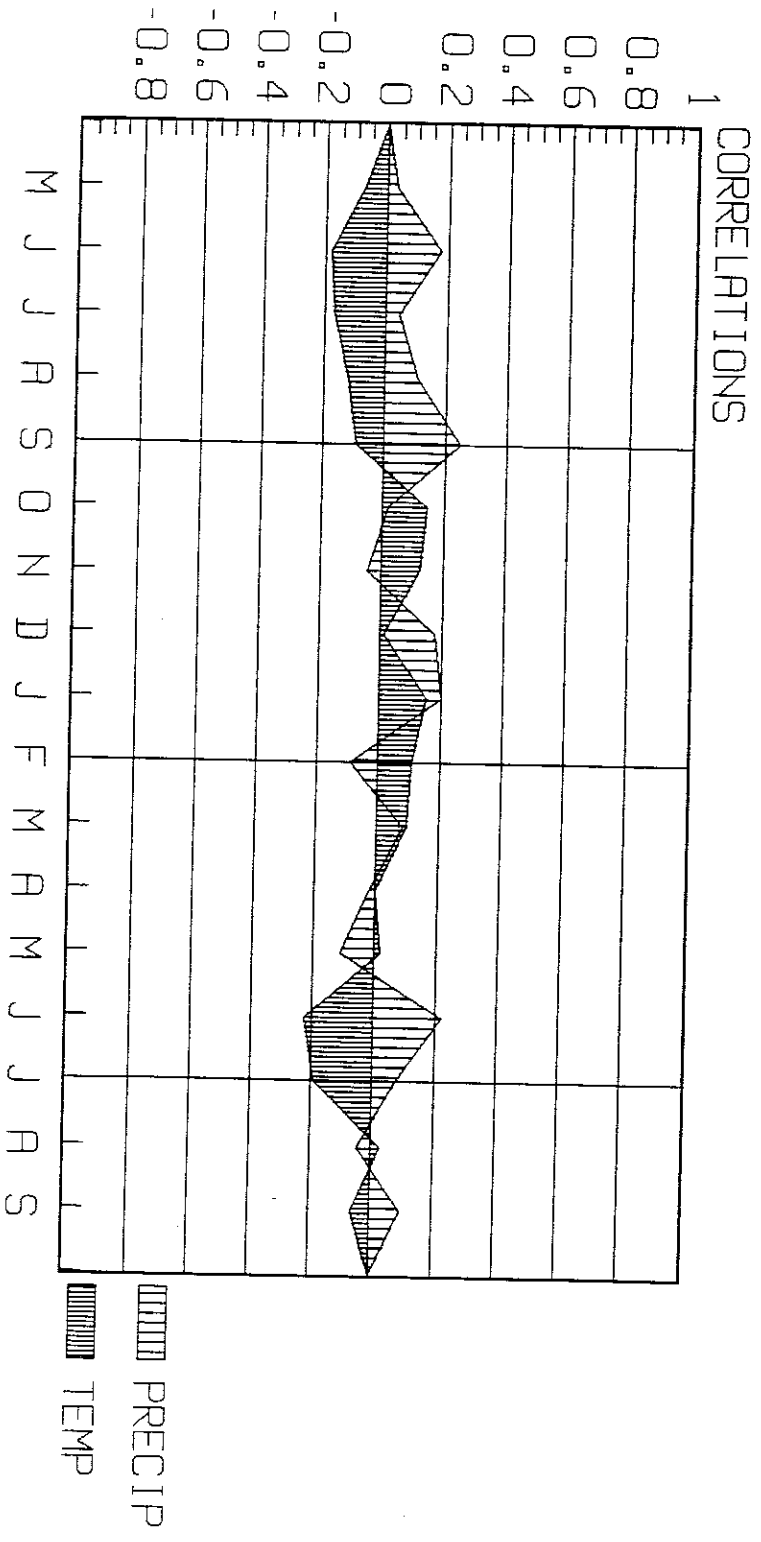
Bog Spring is located on a rise across from the Hill of Pines. There is a moderate incline going up from the road. From the topography it looks as if an old logging road at one time ran near to the plots. There were 46 cores analyzed from site 9A2. Figure 13, depicts the Artisan chronology. The master 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



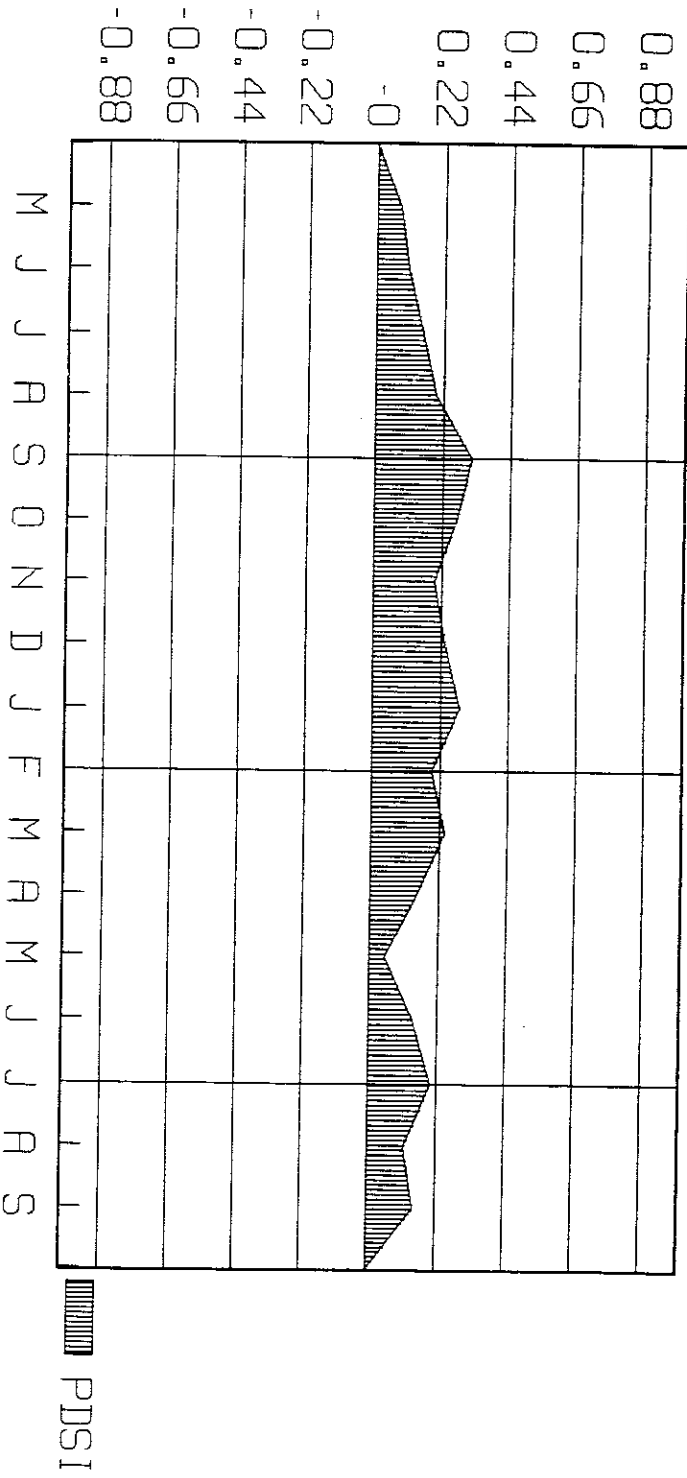
BOG SPRING
 TEMP & PRECIP, 1891-1990
 FOR MAY - SEP, N:100
 SIG SIMPLE R: .200



NUMBER 1, 17 MONTHS, MRY-SEP

BOG SPRING
 PDSI, 1908-1990
 FOR MAY - SEP, N: 83
 SIC SIMPLE R. .220

CORRELATIONS



NUMBER 1, 17 MONTHS, MAY-SEP

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

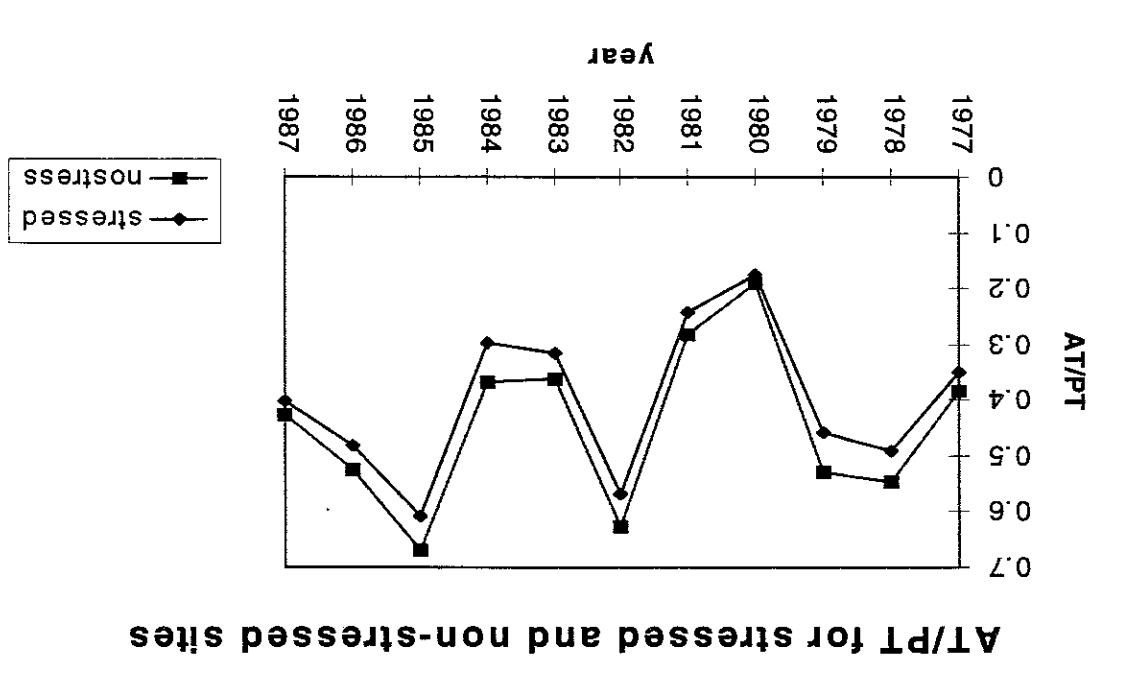
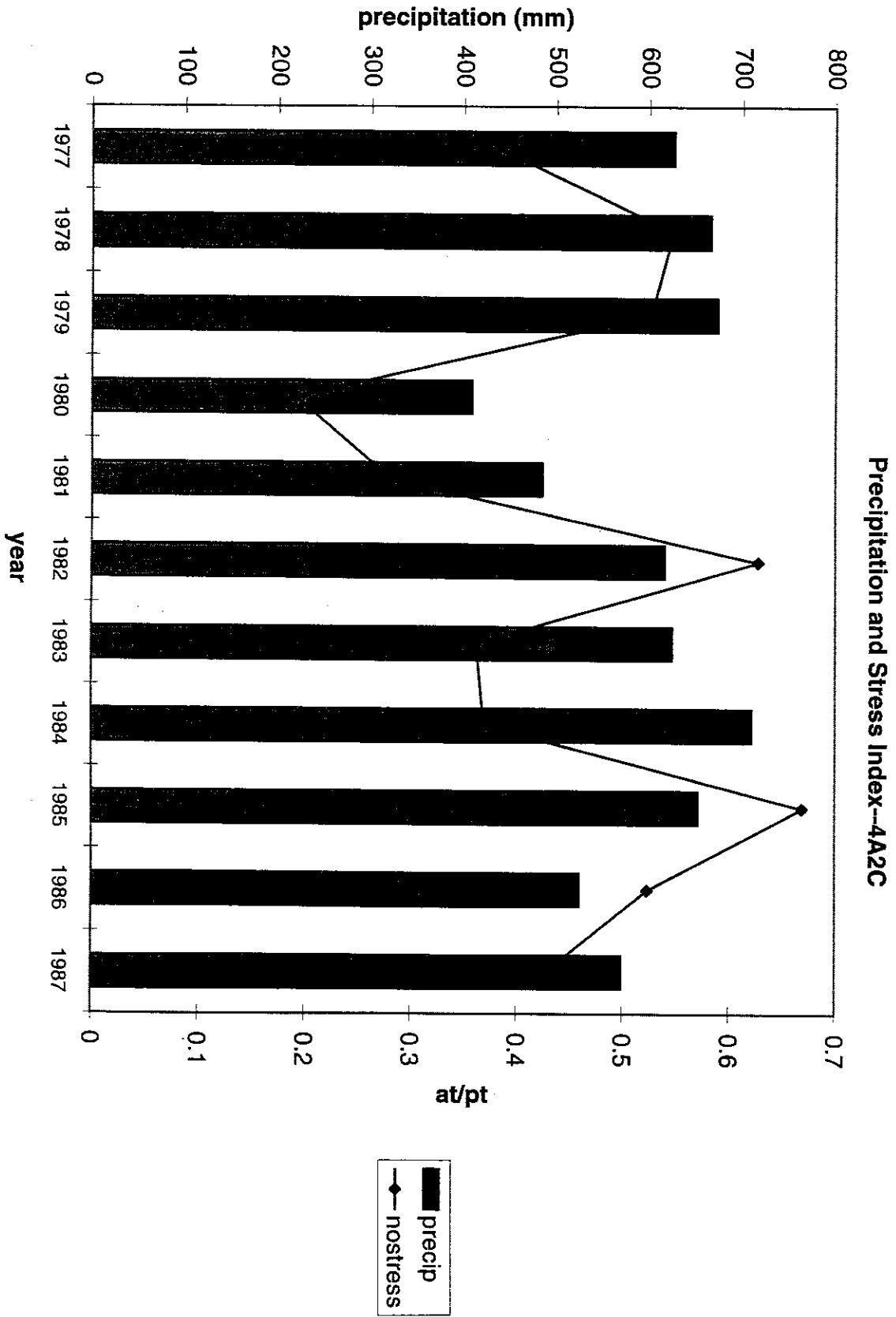


Figure 16

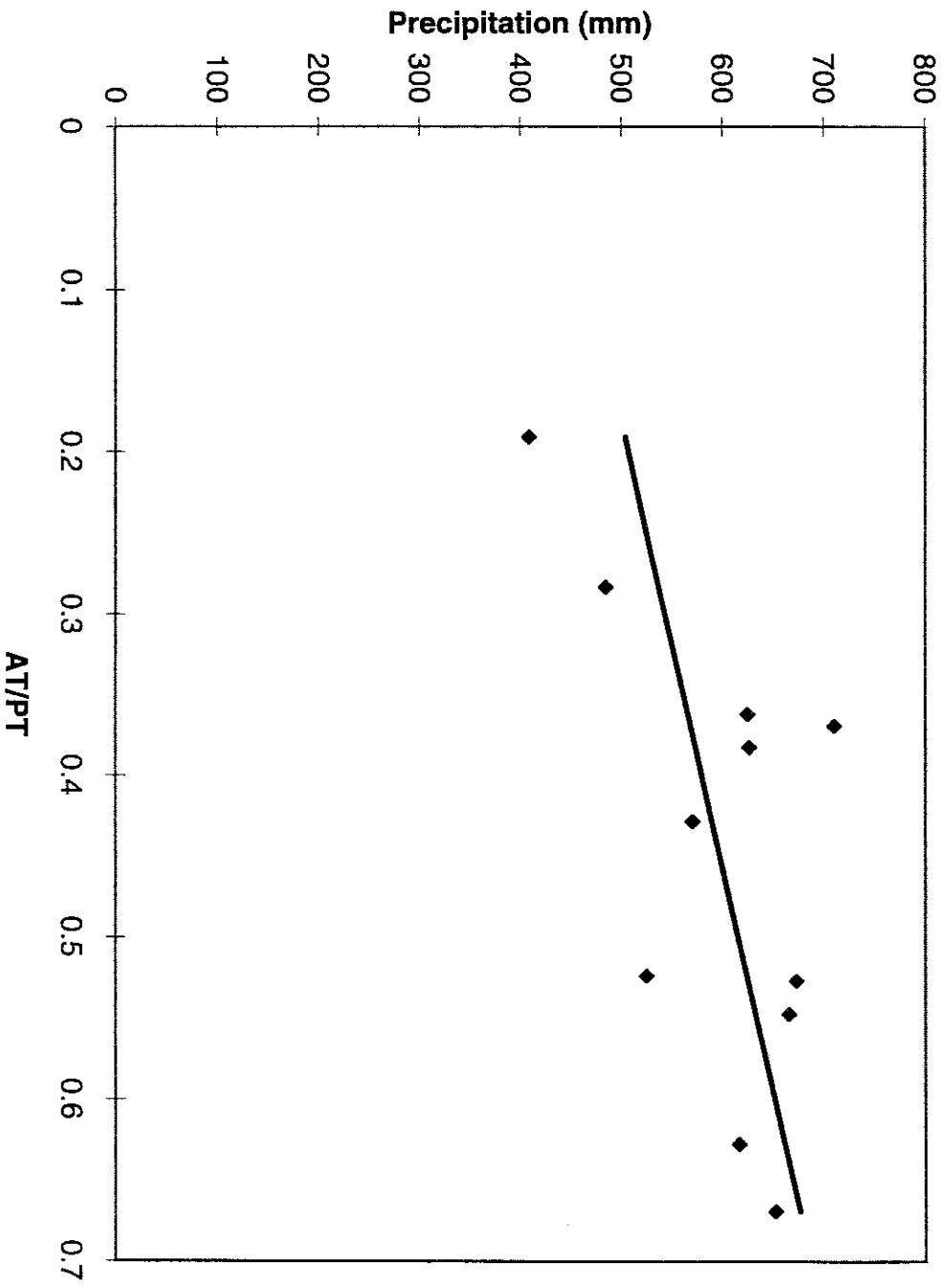
Figure 16 shows the ratio of actual over potential transpiration. Although soil profiles were different for each site, the stress index appears very close. My results do not fall over a wide range. However, such a stressed environment is accurate for BRP considering that the majority of the forest soils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

B.1. 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

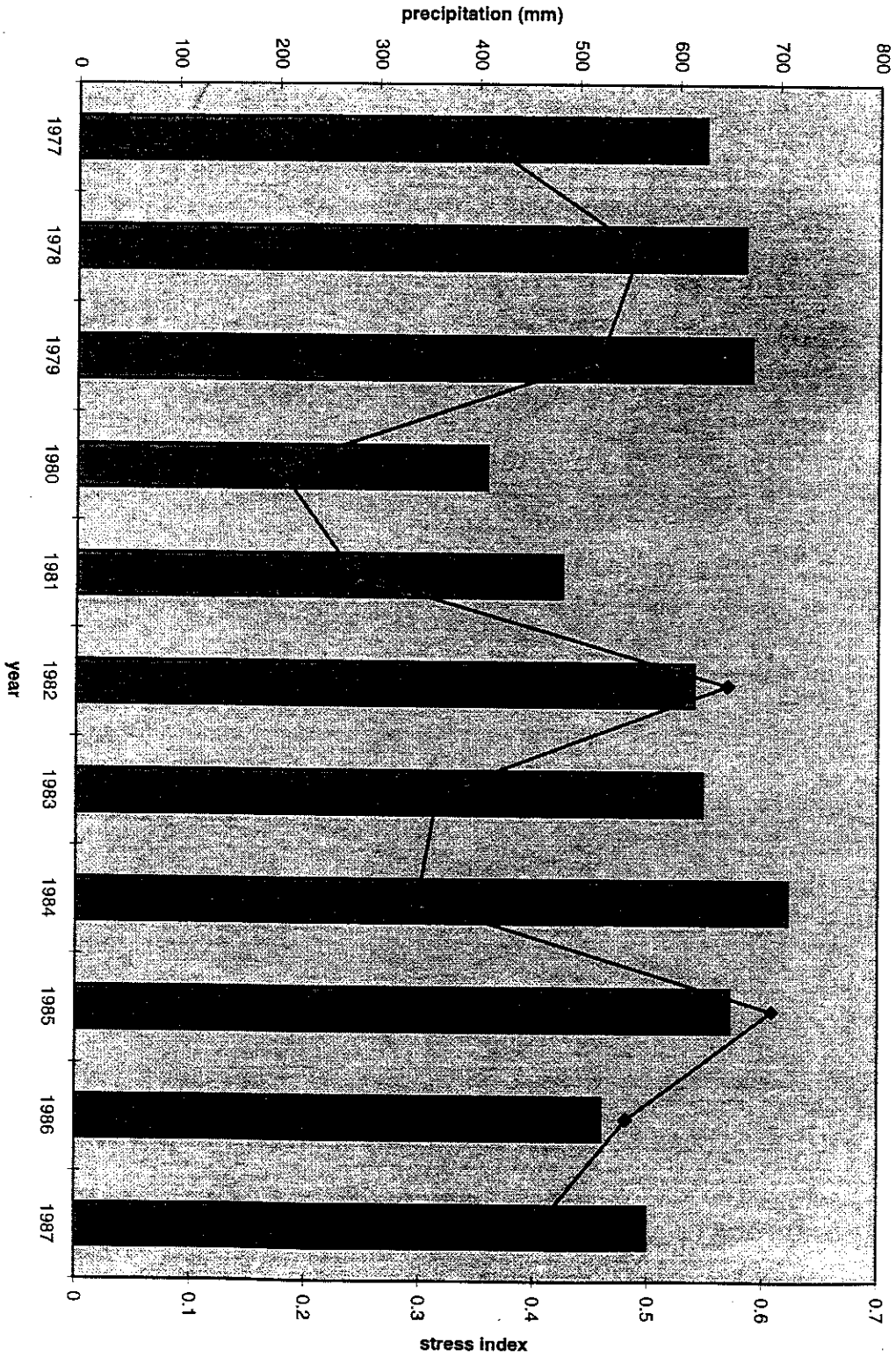


Correlation between Stress Index and Precipitation-- 4A2C



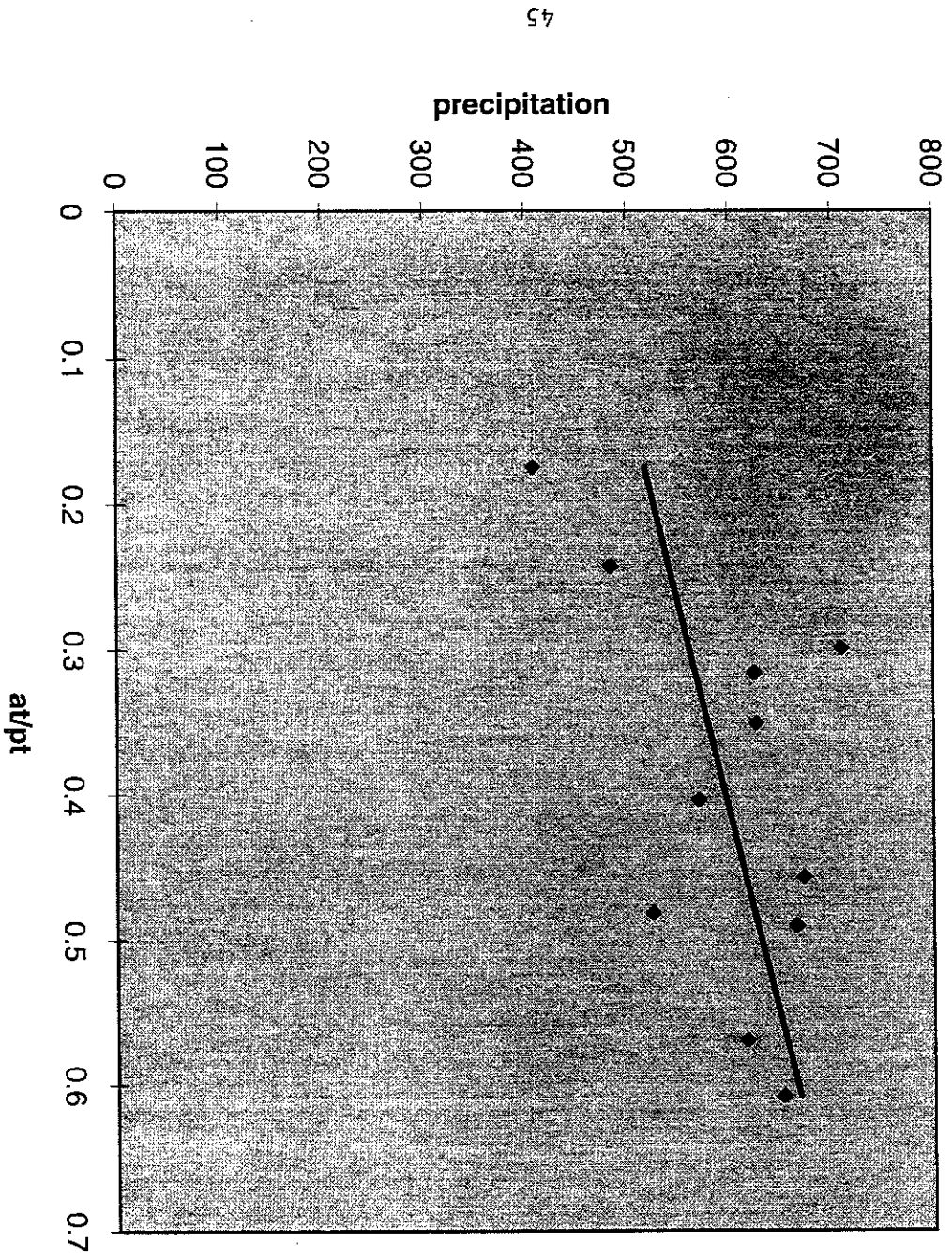
$$y = 360.68x + 435.16$$
$$R^2 = 0.3394$$

Precipitation and Stress Index--5A4C



■ precip
◆ a/p/t

Correlation between Stress Index and Precipitation-- 5A4



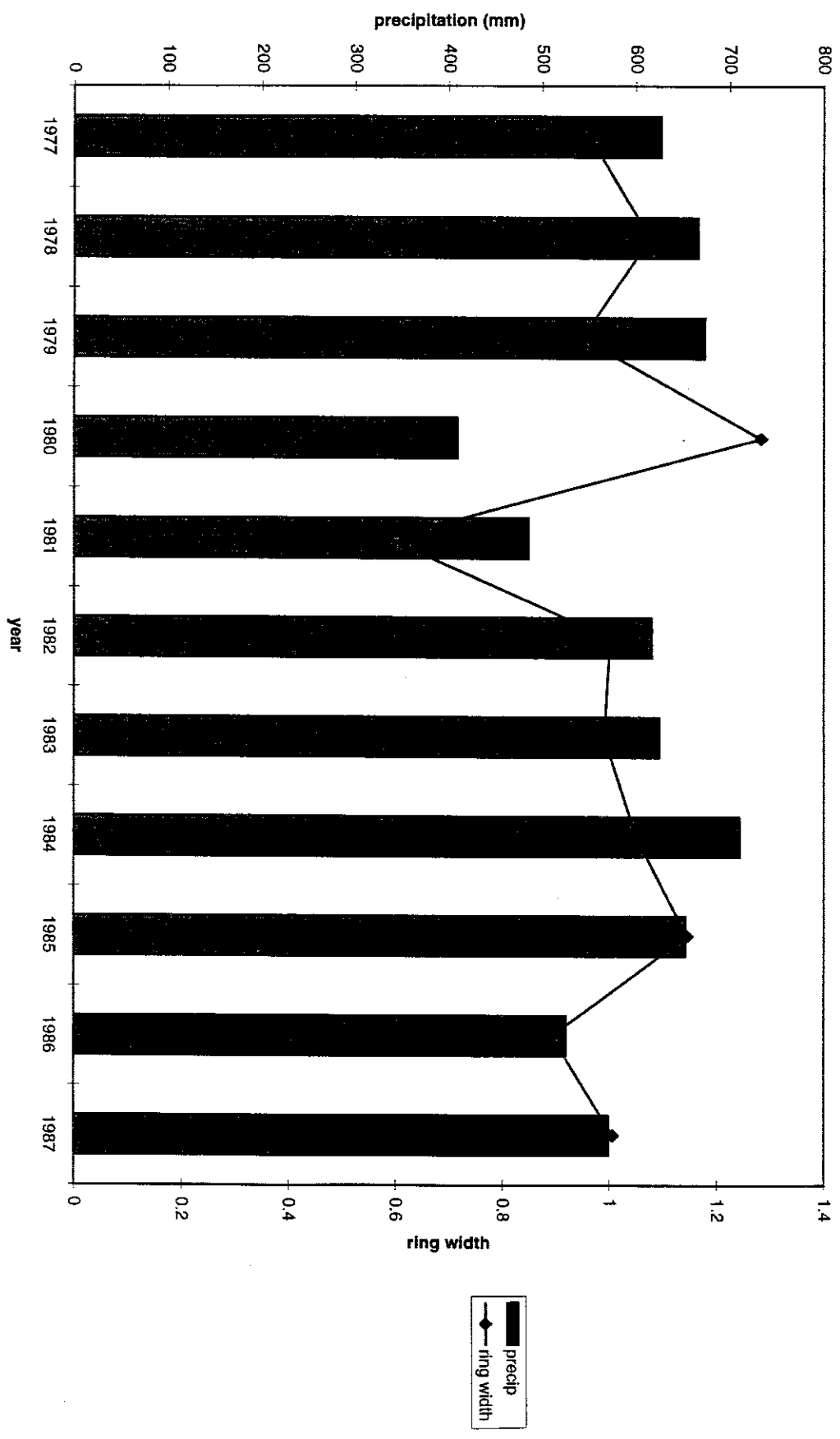
$$y = 346.8x + 457.73$$
$$R^2 = 0.2703$$

number indicates that seasonal patterns of rainfall may influence the seasonal cumulative stress experienced by the trees.

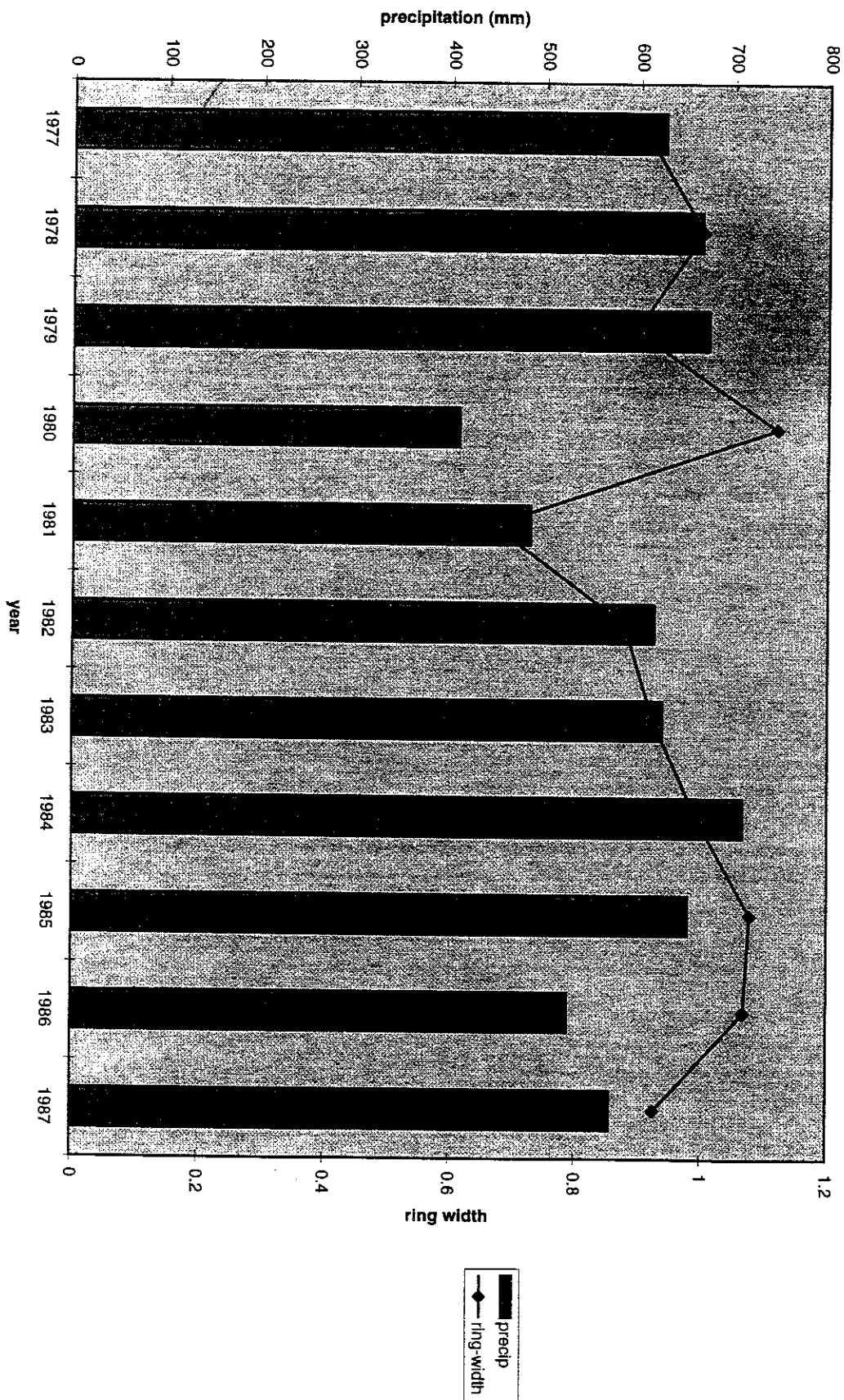
B.ii. Stress, Precipitation and Ring Width Correlation

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.

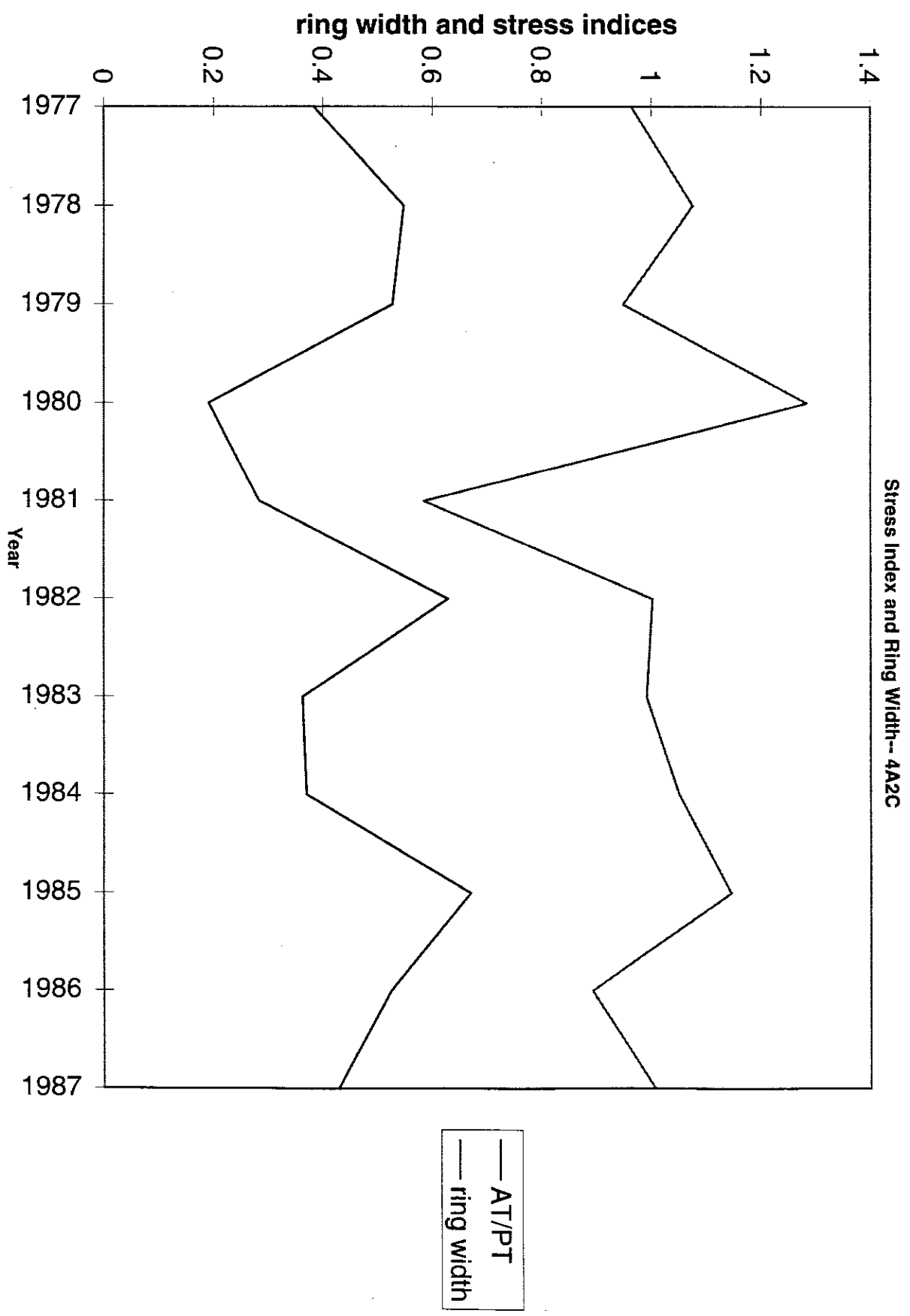
Ring Width and Precipitation--4A2C

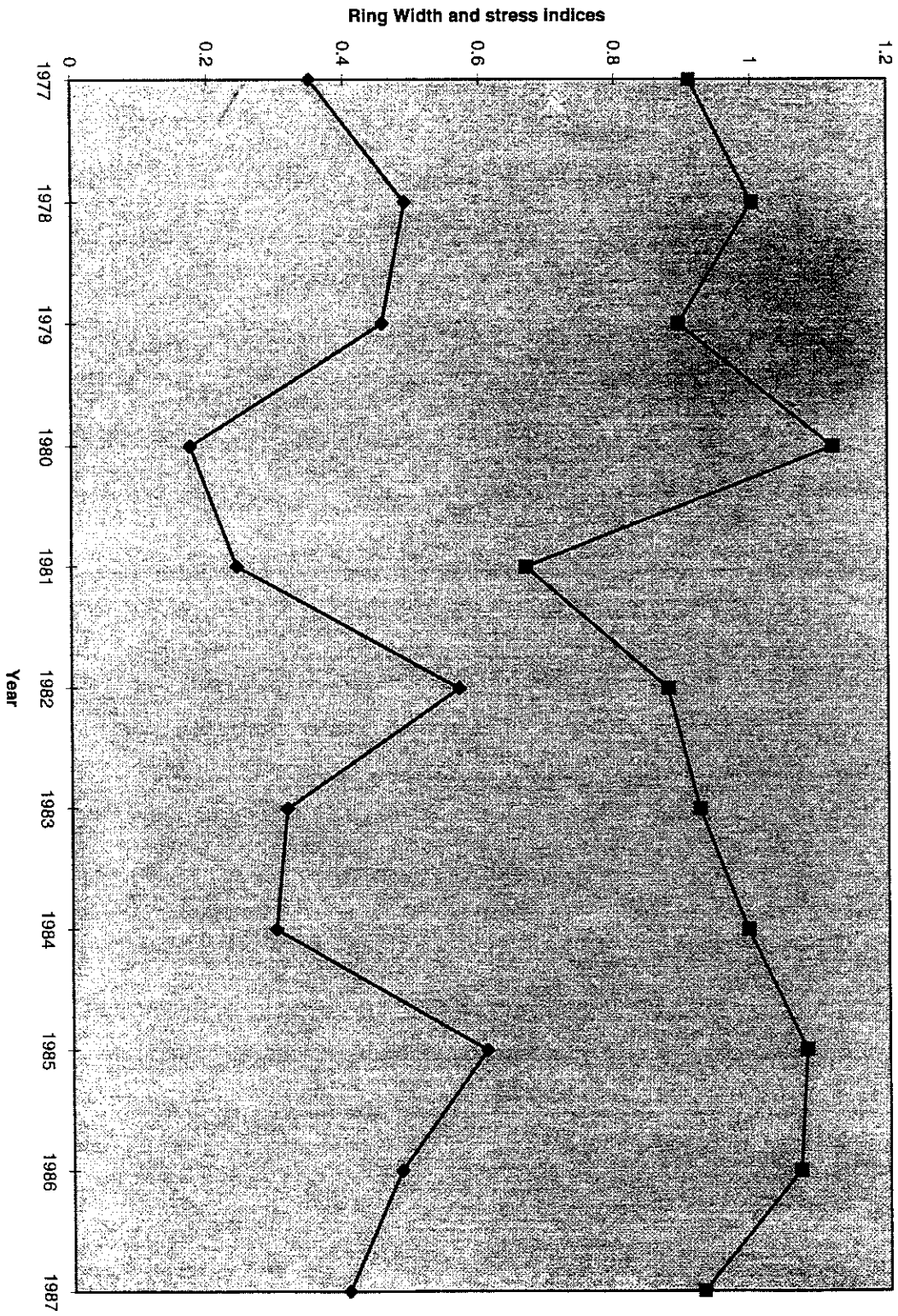


Ring Width and Precipitation-- 5A4



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.

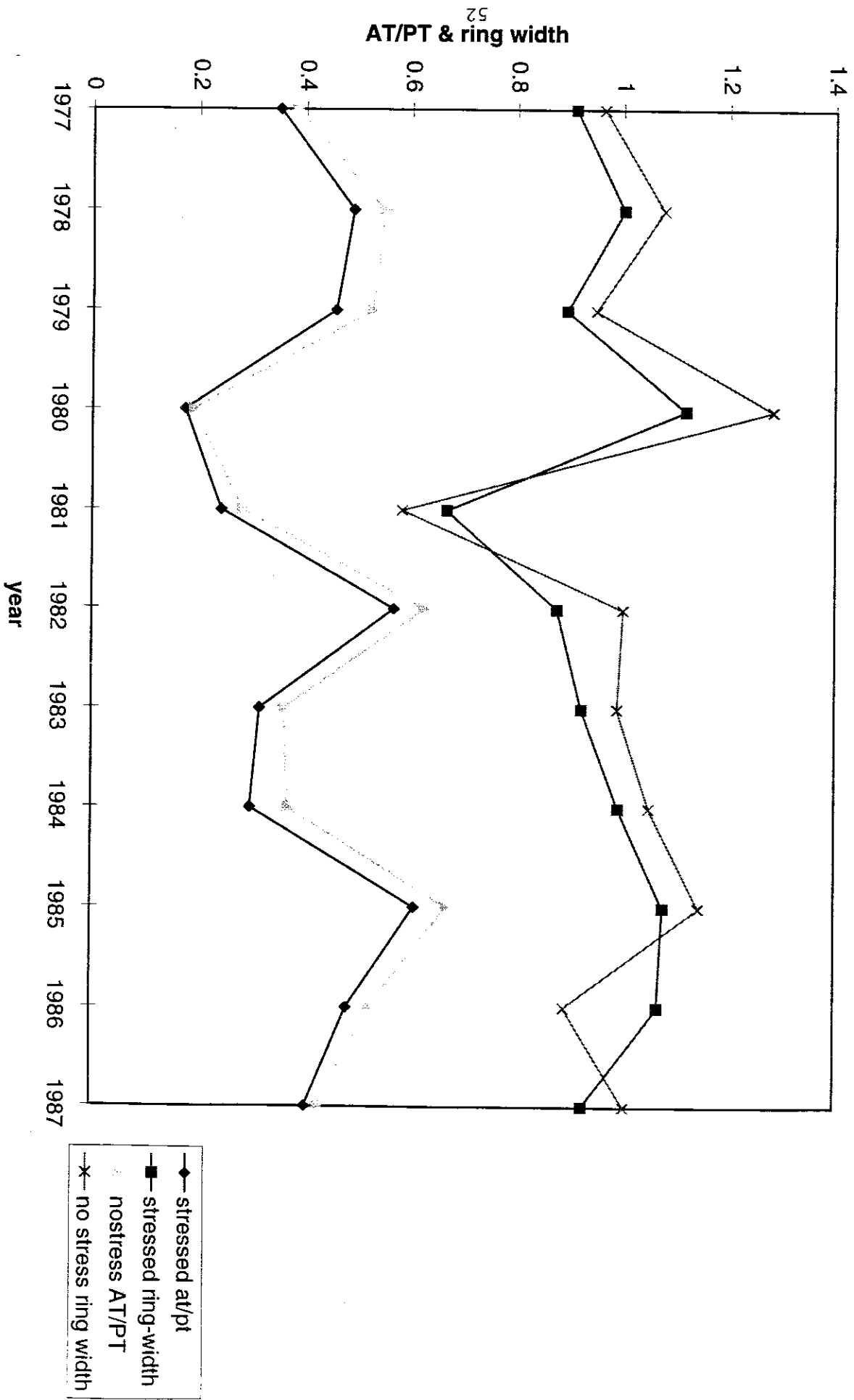


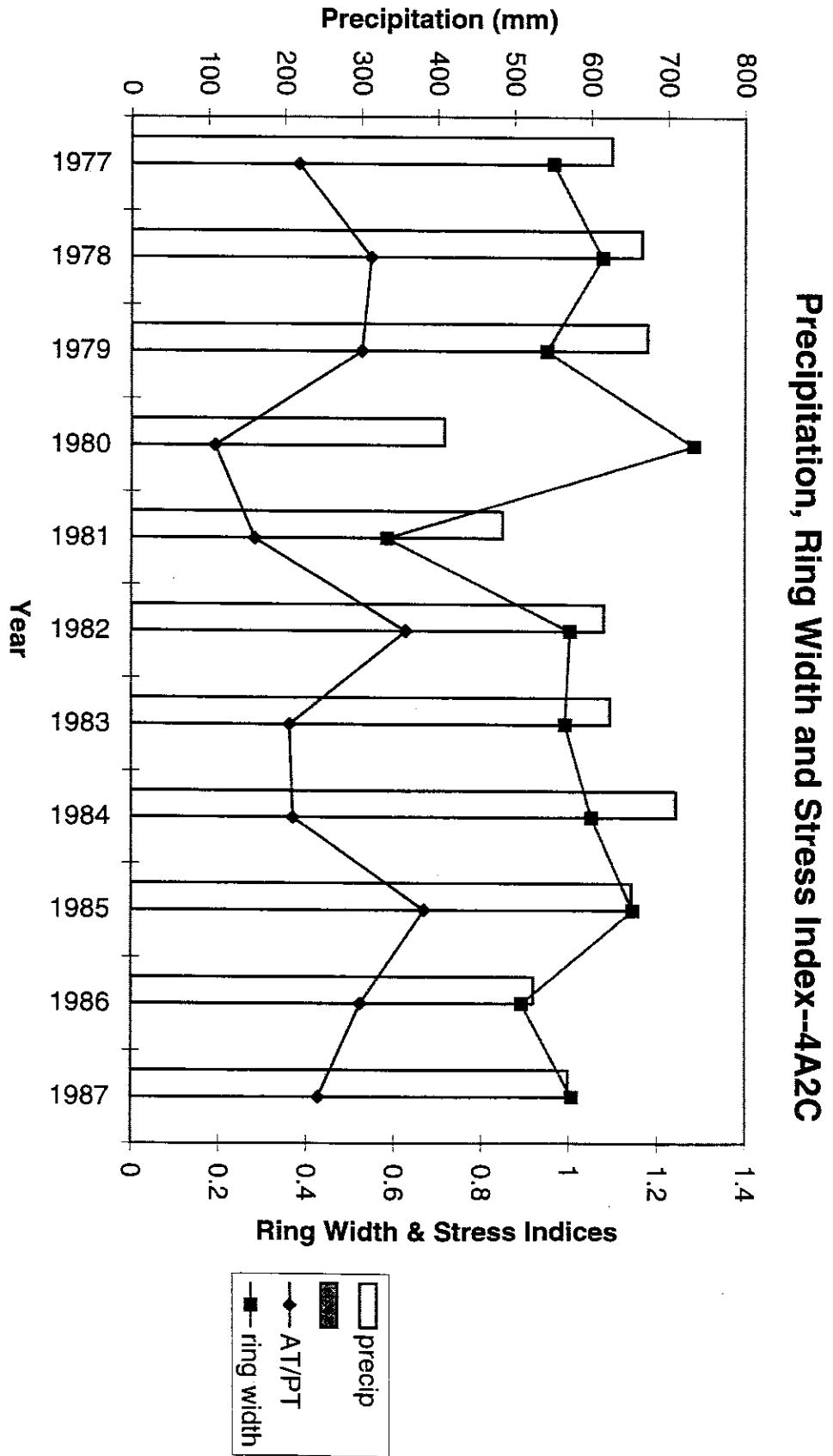


Stress Index and Ring Width-- 5A4

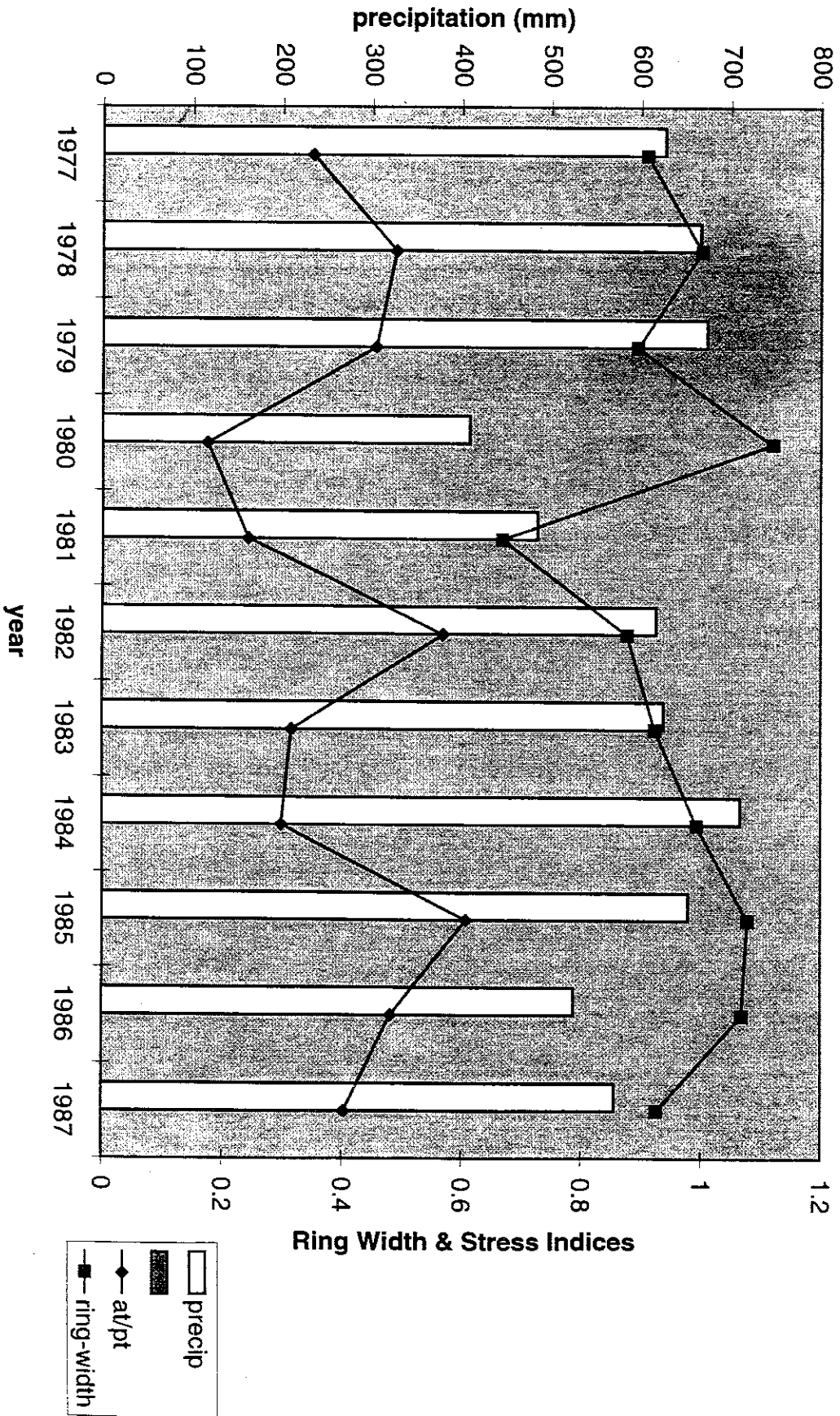
at/pi
ring-width

Stressed and Non-stressed Sites Compared





Precipitation, Ring Width and Stress Index-- 5A4



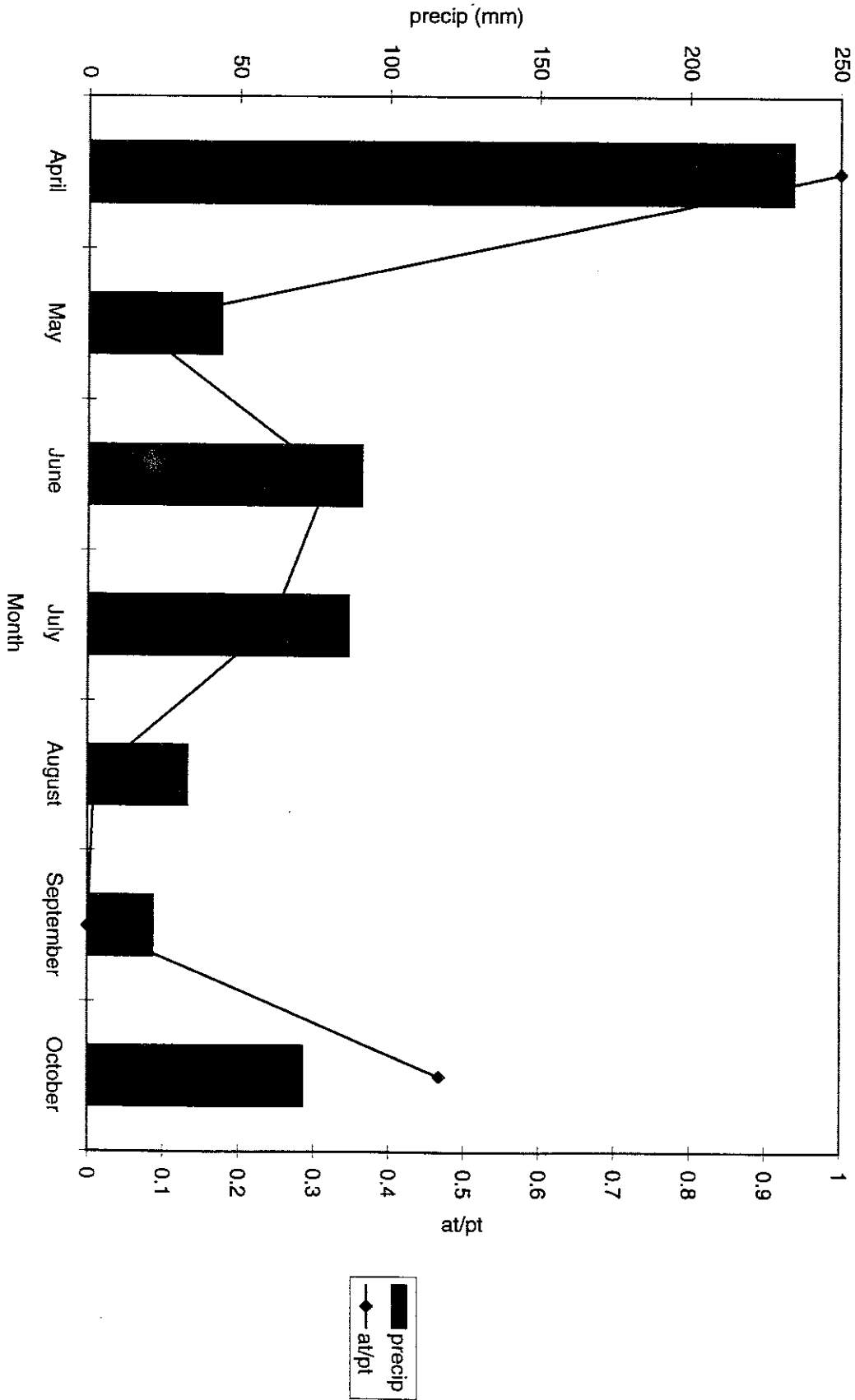
To account for the most anomalous points; points where there is a drastic inverse relationship between stress and the ring-width and precipitation data, mainly 1982-1983 and 1984-1985, we can analyze the monthly precipitation values from West Point. If we consider the tree-ring growth correlations correct, 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 do 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

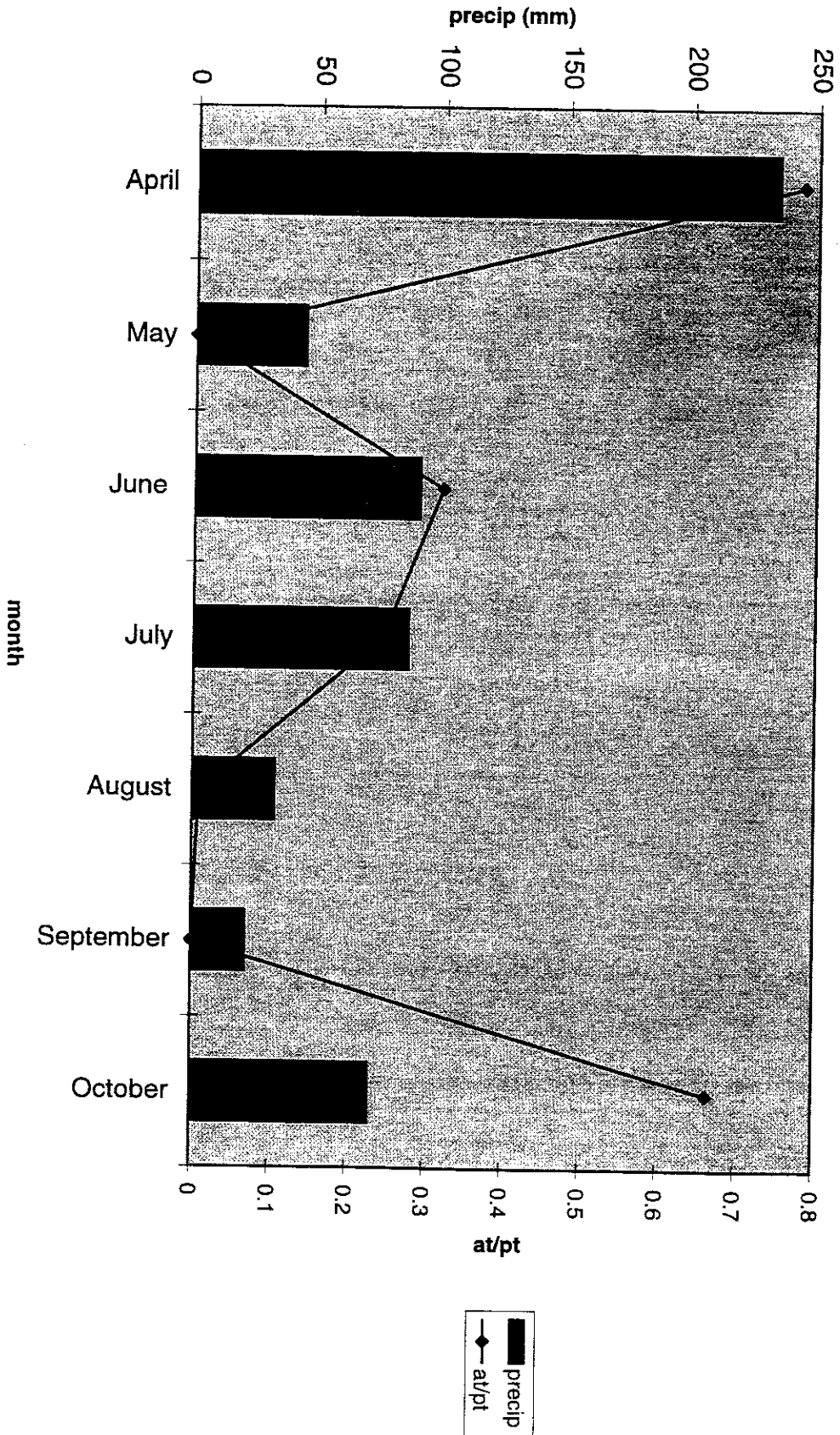
B.iii. Explaining anomalies

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.

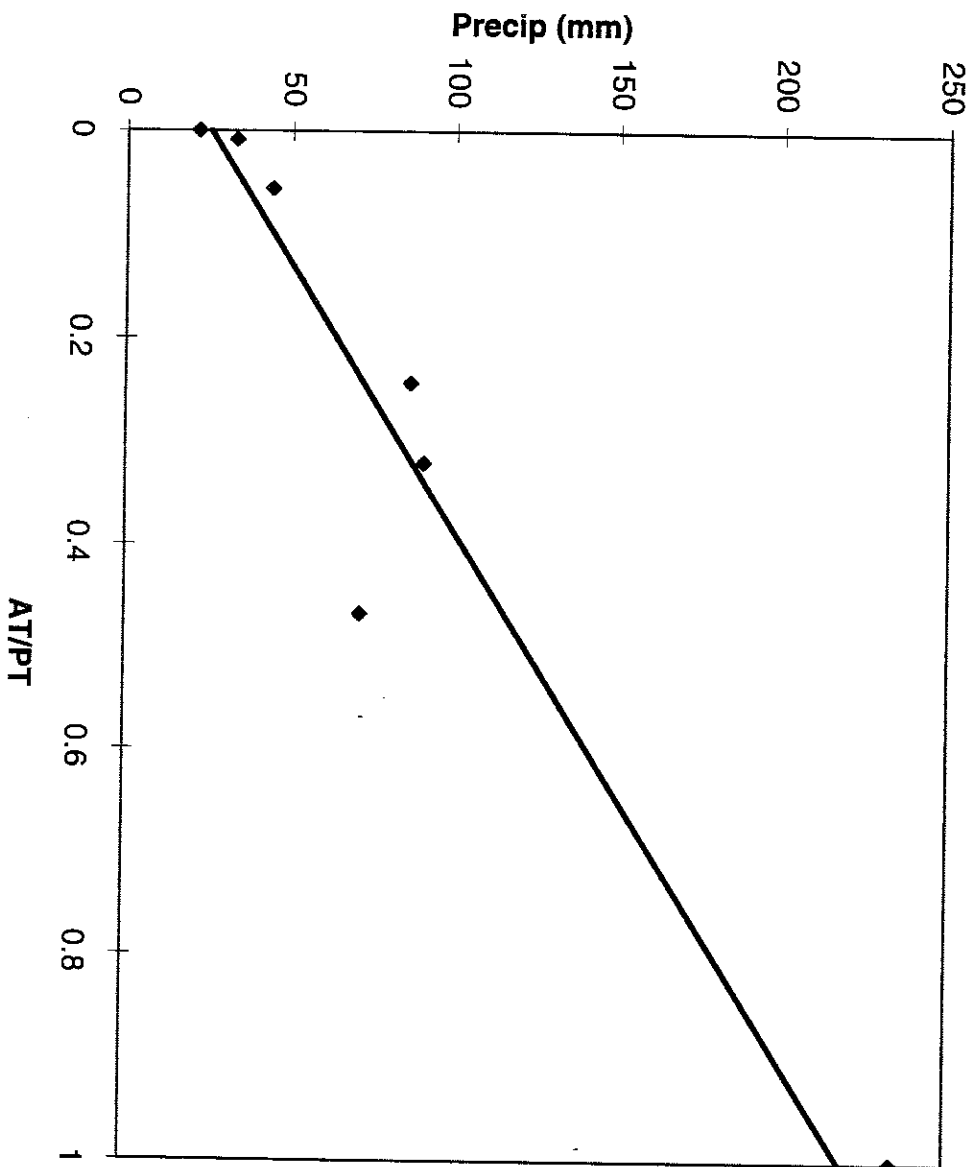
1980 Monthly Precipitation and AT/PT-- 4A2C



1980 Monthly Precipitation and AT/PT-- 5A4

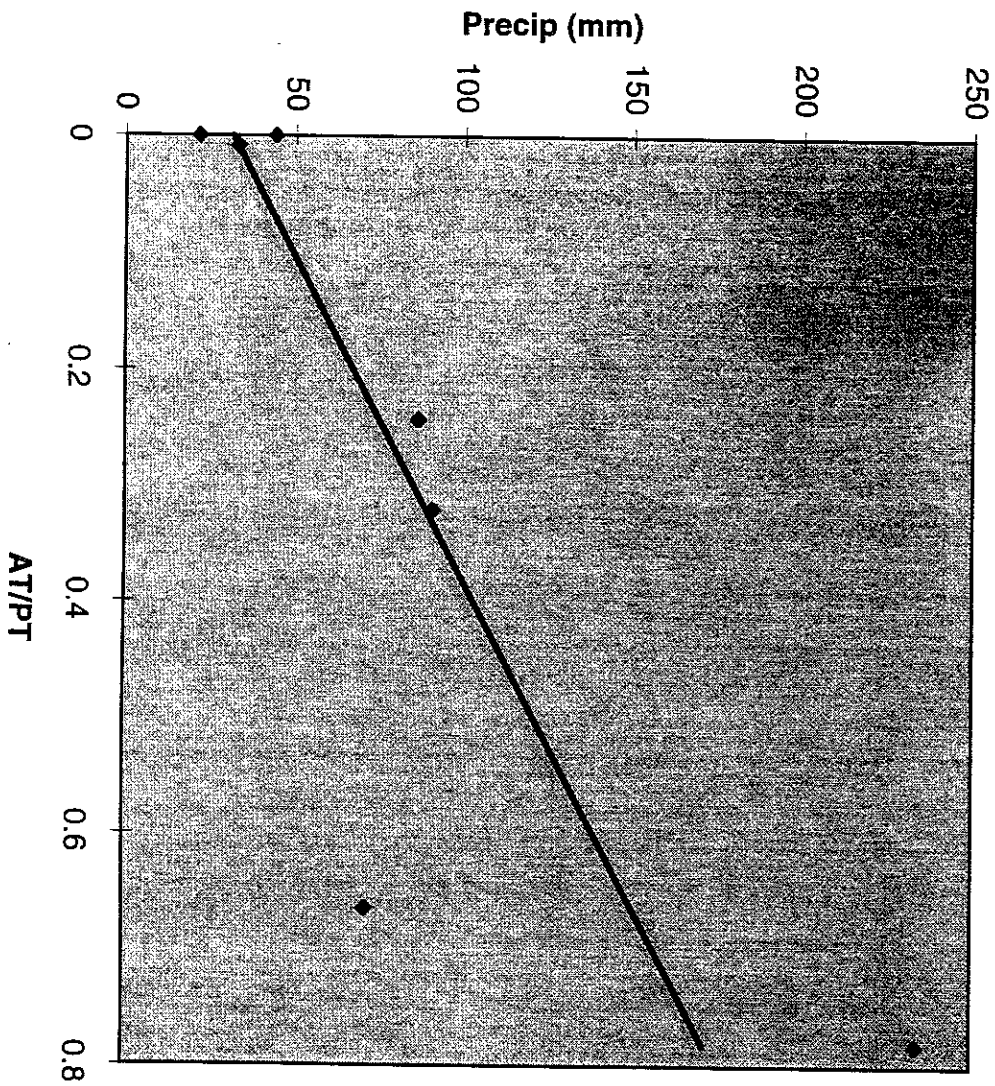


Correlation of monthly Precipitation and AT/PT--4A2C



$Y = 193.57X + 25.062$
 $R^2 = 0.9182$

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



$Y = 179.12x + 31.342$
 $R^2 = 0.6578$

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

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

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

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.

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.



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 rings 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).

A. Tree-Ring Correlations

V. DISCUSSION

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 site 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.

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

C. Correlations of Tree Ring and Simulations

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 its 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.

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

relationships of previous September stress with following year than a stress index. In the long run, this would make the proven further model development to actually calculate ring width rather bud the following spring, this was not modeled. It would take amount of carbon, water and nutrients which allows the tree to photosynthesis has stopped. It is assumed that there is a stored processes were occurring in the tree during the winter when It also would be important to understand what metabolic could not be calculated (Landsberg, 1986).

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

VI. Recommendations

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.

References

- Black Rock Forest Notes (Taken summer 1995 from 1940's)
- Botkin, D.B., Janak, J.F., & Wallis, J.R. "Some Ecological Consequences of a Computer Model of Forest Growth," Journal of Ecology 60. 1972, pp.849-872.
- Campbell, Gaylon S. An Introduction to Environmental Biophysics. Springer-Verlag: New York, 1986.
- Cook, E.R., Julie Cook. "On Predicting the Response of Forests in Eastern North America to Future Climatic Change," Climatic Change 19. October 1991, pp.271-282
- Cook, E.R., G.C. Jacoby. "Tree-Ring--Drought Relationships in the Hudson Valley," Science Vol.198. 28 October 1977, pp.399-401.
- D'Arrigo, R, and Cook, E. "Using Tree-Ring and Long Term Plot Analysis to Evaluate Forest Growth response to Recent Atmospheric and Climatic change in the Northeastern United States." Proposal to NIGEC Board, Spring 1995.
- D'Arrigo, R. Data from Mohonk Study
- Fritts, H.C. and Swetnam, T.W. Dendroecology, 1988, pp.160-170.
- Hughes, M.K., P.M. Kelly, J.R. Pilcher & V.C. Lamarche Jr. (eds.). Climate From Tree Rings. Cambridge University Press: 1982, pp.163-165.
- Kozlowski, T.T., P.J.Kramer, S.G.Pallardy. The Physiological Ecology of Woody Plants. Academic Press: New York, 1991. pp213-312.

- Lawrence, D.M., R.D. D'Arrigo, E.R. Cook and R.D. Thetford, W. Schuster. "Climate-growth relationships of Eastern Hemlock and Chestnut Oak from Black Rock Forest, Cornwall, New York. Submitted Canadian Journal of Forestry, 1995.
- Landisberg, J.J. Physiological Ecology of Forest Production. Academic Press: New York, 1986.
- Maeglin, Robert R. "Increment Cores," USDA: General Technical Report FPL 25. 1979, pp.1-18.
- Orange County Soil Survey
- Riha, Susan J., D.G. Rossiter, P. Simons. GAPS: General-purpose Atmosphere-Plant-Soil Simulator. Cornell Research Foundation: Ithaca, 1994.
- Sargent, Charles Sprague. Manual of the Trees of North America. Vol. 1. Dover Publications: New York, 1965. pp.305-306.
- Starr, Cecie. Biology: Concepts and Applications. Wadsworth Publishing: California. 1994, pp.326-352.
- Stokes, Marvin A., Terah L. Smiley, An Introduction to Tree-ring Dating. University of Chicago Press: Chicago, 1968.
- Thetford, R.D., Cook E.R., D'Arrigo, R.D., "Development of Tree-ring Records From the Black Rock Forest," Project Report submitted to BRF Consortium, 1993.
- Treftl, James S. "Concentric Clues from Growth Rings Unlock the Past," Smithsonian. July 1985, pp.47-54.

Appendix A

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

QUALITY CONTROL AND DATING CHECK OF TREE-RING MEASUREMENTS

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

File of DATED series: ABQUPP.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
- 2 Segments examined are
- 3 Autoregressive model applied
- 4 Series transformed to logarithms
- 5 Critical correlation, 99% confidence level .5281
- 6 Master dating series saved
- 7 Listing of ring measurements in Part 6
- 8 Parts printed
- 9 Absent rings included in master series

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 at zero value

Year	Value	No	Ab	Year	Value	No	Ab
1950	.315	43		1900	1.042	40	
1951	-.065	43		1901	.459	40	
1952	1.035	43		1902	-.595	41	
1953	1.353	43		1903	.622	41	
1954	-.620	43		1904	1.651	41	
1955	.068	43		1905	-.292	41	
1956	.344	43		1906	.179	41	
1957	-.848	43		1907	-.050	41	
1958	.072	43		1908	.330	41	
1959	-.716	43		1909	-.836	41	
1960	1.165	43		1910	-.799	41	
1961	.640	43		1911	-.770	41	
1962	-.839	43		1912	-.958	41	
1963	.612	43		1913	-1.277	41	
1964	1.332	43		1914	.881	40	
1965	-1.421	43		1915	-.761	40	
1966	-1.004	43		1916	1.258	40	
1967	-1.107	43		1917	1.236	40	
1968	-2.122	43		1918	-1.061	41	
1969	-.237	43		1919	-.195	41	
1970	-.407	43		1920	2.064	43	
1971	-.926	43		1921	1.643	43	
1972	.490	43		1922	.934	43	
1973	.097	43		1923	-.793	43	
1974	.722	43		1924	-.213	43	
1975	1.109	43		1925	.447	43	
1976	1.695	43		1926	-.854	43	
1977	.803	43		1927	.405	43	
1978	.921	43		1928	-.427	43	
1979	.072	43		1929	-.993	43	
1980	1.639	42		1930	-1.435	43	
1981	-2.287	42		1931	-1.775	43	
1982	-.823	42		1932	1.212	43	
1983	-.750	42		1933	-.864	43	
1984	-.320	42		1934	.077	43	
1985	.671	42		1935	.327	43	
1986	-.595	42		1936	-.324	43	
1987	-.288	42		1937	1.829	43	
1988	-.624	42		1938	1.430	43	
1989	-.314	42		1939	1.304	43	
1890	.772	38		1940	.069	43	
1891	-.613	38		1941	.141	43	
1892	-1.597	39		1942	-.768	43	
1893	-1.800	39		1943	-.627	43	
1894	-2.256	39		1944	-.956	43	
1895	-1.207	39		1945	-1.618	43	
1896	.073	40		1946	.662	43	
1897	-1.180	40		1947	2.032	43	
1898	-.770	40		1948	-.641	43	
1899	.256	40		1949	-1.501	43	
1880	.466	32		1950	-.069	43	
1881	1.777	32		1951	-.065	43	
1882	.288	32		1952	1.035	43	
1883	-.014	32		1953	1.353	43	
1884	-.592	33		1954	-.620	43	
1885	-.693	34		1955	.068	43	
1886	-.033	34		1956	.344	43	
1887	.772	34		1957	-.848	43	
1888	.404	36		1958	.072	43	
1889	1.489	37		1959	-.716	43	
1880	.466	32		1960	1.165	43	
1881	1.777	32		1961	.640	43	
1882	.288	32		1962	-.839	43	
1883	-.014	32		1963	.612	43	
1884	-.592	33		1964	1.332	43	
1885	-.693	34		1965	-1.421	43	
1886	-.033	34		1966	-1.004	43	
1887	.772	34		1967	-1.107	43	
1888	.404	36		1968	-2.122	43	
1889	1.489	37		1969	-.237	43	
1890	.772	38		1970	-.407	43	
1891	-.613	38		1971	-.926	43	
1892	-1.597	39		1972	.490	43	
1893	-1.800	39		1973	.097	43	
1894	-2.256	39		1974	.722	43	
1895	-1.207	39		1975	1.109	43	
1896	.073	40		1976	1.695	43	
1897	-1.180	40		1977	.803	43	
1898	-.770	40		1978	.921	43	
1899	.256	40		1979	.072	43	

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

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

AB0904SE	1888 to 1994	107 years	[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
AB0920W	1877 to 1994	118 years	[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
AB0915NW	1874 to 1994	121 years	[B] Entire series, effect on correlation (.546) is: Lower 1988 -.031 1879 -.020 1930 -.014 1931 -.012 Higher 1965 .016 1947 .016 1920 .017 1894 .015 1968 .013
AB0915SE	1875 to 1994	120 years	[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
AB0905NW	1854 to 1994	141 years	[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
AB0907SE	1863 to 1994	132 years	[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
AB0911SE	1877 to 1994	118 years	[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
AB0908SE	1860 to 1994	135 years	[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

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

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

Series 18	AB0902	1920 to 1994	75 years	[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
Series 19	AB0910SE	1858 to 1994	137 years	[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
Series 20	AB0918S	1878 to 1994	117 years	[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
Series 21	AB0905SE	1877 to 1994	118 years	[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
Series 22	AB0902SE	1896 to 1994	99 years	[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
Series 23	AB0917SE	1876 to 1994	119 years	[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
Series 24	AB0901N	1889 to 1994	106 years	[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
Series 25	AB0911NW	1865 to 1994	130 years	[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
Series 26	AB0919	1870 to 1994	125 years	[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
Series 27	AB0920E	1876 to 1994	119 years	[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
Series 28	AB0914NW	1854 to 1994	141 years	[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
Series 29	AB0918N	1879 to 1994	116 years	[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

Series 30	ABQ912W	1860 to 1994	135 years	[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
Series 31	ABQ904NW	1888 to 1994	107 years	[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
Series 32	ABQ911NW	1865 to 1994	130 years	[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																		
Series 33	ABQ917NW	1875 to 1994	120 years	[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
Series 34	ABQ910NW	1859 to 1994	136 years	[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
Series 35	ABQ919NE	1879 to 1994	116 years	[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																		
Series 36	ABQ919SE	1862 to 1994	133 years	[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
Series 37	ABQ909SE	1861 to 1994	134 years	[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
Series 38	ABQ901S	1902 to 1994	93 years	[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
Series 39	ABQ906NW	1858 to 1994	137 years	[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:																				
Series 40	ABQ908NW	1860 to 1994	135 years	[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

ABQ903NM	1890 to 1994	105 years	[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	Series 41
ABQ916NM	1885 to 1994	110 years	[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	Series 42
ABQ912E	1854 to 1913	60 years	[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	Series 43
ABQ912E	1920 to 1994	75 years	[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	Series 44

Seq Series	Interval	No.	Segment	No.	Flags	Master	Mean	Max	Std	Auto	Mean	sens	Value	Std	Auto	dev	corr	Mean	sens	Value	Std	Auto	dev	corr
1	1888 1994	107	4	0	0	1.76	1.28	2.15	.414	.765	1.75	1.84	.323	1.007	1	1	1	1.84	1.99	.402	1.008	1	1	1
2	1877 1994	118	4	0	0	.730	1.74	2.94	.528	.583	1.99	2.06	.325	1.008	1	1	1	1.99	2.06	.404	1.008	1	1	1
3	1874 1994	121	5	0	0	1.03	4.76	7.95	.595	.788	1.87	2.06	.325	1.008	1	1	1	1.87	2.06	.404	1.008	1	1	1
4	1875 1994	120	4	0	0	1.06	4.47	7.95	.595	.788	1.87	2.06	.325	1.008	1	1	1	1.87	2.06	.404	1.008	1	1	1
5	1854 1994	141	5	0	0	.700	1.89	3.13	.313	.607	2.24	2.11	.409	1.044	1	1	1	1.90	2.25	.437	1.037	1	1	1
6	1853 1994	132	5	0	0	.573	.72	2.65	.487	.831	2.64	2.25	.365	1.029	1	1	1	1.90	2.25	.437	1.037	1	1	1
7	1877 1994	118	4	0	0	1.74	2.08	3.59	.359	.710	1.77	2.18	.502	1.027	1	1	1	1.77	2.18	.444	1.027	1	1	1
8	1875 1994	135	5	1	1	.608	1.72	2.72	.323	.724	2.29	2.03	.327	1.017	2	2	1	2.03	2.29	.444	1.027	1	1	1
9	1875 1994	120	4	0	0	1.02	2.22	3.54	.354	.710	1.77	2.18	.502	1.027	1	1	1	2.03	2.29	.444	1.027	1	1	1
10	1862 1994	133	5	0	0	.660	1.35	2.54	.426	.592	1.98	2.00	.328	1.042	2	2	1	1.98	2.00	.444	1.042	2	2	1
11	1918 1994	77	3	0	0	1.99	3.94	7.26	.726	.641	1.82	1.82	.334	1.076	1	1	1	1.82	1.82	.444	1.076	1	1	1
12	1860 1994	129	5	0	0	1.02	2.44	3.75	.446	.754	1.95	2.14	.397	1.005	1	1	1	1.95	2.14	.444	1.005	1	1	1
13	1860 1994	135	5	0	0	.645	.69	1.63	.550	.534	2.01	2.04	.433	1.024	1	1	1	2.01	2.04	.433	1.024	1	1	1
14	1884 1994	111	4	0	0	.571	.95	1.63	.550	.534	2.01	2.04	.433	1.024	1	1	1	2.01	2.04	.433	1.024	1	1	1
15	1856 1994	139	5	0	0	1.01	2.21	3.34	.334	.781	2.14	2.11	.426	1.015	1	1	1	2.11	2.14	.426	1.015	1	1	1
16	1855 1994	140	5	0	0	.614	.69	1.63	.550	.534	2.01	2.04	.433	1.024	1	1	1	2.01	2.04	.433	1.024	1	1	1
17	1892 1979	88	4	0	0	1.01	2.30	3.34	.334	.781	2.14	2.11	.426	1.015	1	1	1	2.11	2.14	.426	1.015	1	1	1
18	1920 1994	75	3	0	0	1.06	2.95	4.50	.450	.764	2.44	1.90	.290	1.015	1	1	1	1.90	2.05	.398	1.031	1	1	1
19	1878 1994	137	5	0	0	.88	3.96	6.36	.636	.930	1.80	2.08	.397	1.015	1	1	1	1.80	2.08	.397	1.015	1	1	1
20	1878 1994	117	4	0	0	.703	1.24	2.54	.369	.615	1.94	2.03	.318	1.064	1	1	1	1.94	2.03	.318	1.064	1	1	1
21	1877 1994	118	4	0	0	.612	.70	3.19	.441	.743	2.40	2.03	.318	1.064	1	1	1	2.03	2.03	.318	1.064	1	1	1
22	1896 1994	99	4	0	0	.523	1.12	2.47	.562	.853	2.20	1.98	.339	1.025	1	1	1	1.98	2.20	.339	1.025	1	1	1
23	1876 1994	119	4	0	0	.791	1.09	3.45	.496	.764	2.22	1.93	.342	1.023	2	2	1	1.93	2.22	.342	1.023	2	2	1
24	1889 1994	106	4	0	0	.697	1.59	2.79	.394	.533	1.86	2.18	.460	1.024	1	1	1	1.86	2.18	.460	1.024	1	1	1
25	1865 1994	130	5	0	0	.727	1.38	2.52	.423	.756	1.70	1.97	.394	1.024	1	1	1	1.70	1.97	.394	1.024	1	1	1
26	1870 1994	125	5	0	0	.719	1.02	2.27	.342	.565	2.22	2.22	.470	1.002	1	1	1	2.22	2.22	.470	1.002	1	1	1
27	1876 1994	119	4	0	0	.707	1.10	2.18	.321	.439	1.89	2.07	.335	1.021	1	1	1	1.89	2.07	.335	1.021	1	1	1
28	1854 1994	141	5	0	0	.571	.90	3.75	.499	.843	1.93	2.07	.322	1.048	1	1	1	1.93	2.07	.322	1.048	1	1	1
29	1879 1994	116	4	0	0	.665	1.34	2.59	.428	.618	2.13	1.96	.390	1.053	1	1	1	1.96	2.13	.390	1.053	1	1	1
30	1894 1994	135	5	0	0	.667	1.07	3.75	.694	.904	2.05	2.01	.349	1.021	1	1	1	2.05	2.01	.349	1.021	1	1	1
31	1888 1994	107	4	0	0	.730	1.59	3.21	.454	.699	1.83	2.07	.431	1.034	1	1	1	1.83	2.07	.431	1.034	1	1	1
32	1865 1994	130	5	0	0	.787	1.52	3.21	.520	.707	2.02	2.09	.408	1.011	2	2	1	2.02	2.09	.408	1.011	2	2	1
33	1875 1994	120	4	0	0	.655	1.17	3.18	.484	.784	2.08	1.97	.352	1.090	1	1	1	1.97	2.08	.352	1.090	1	1	1
34	1859 1994	136	5	0	0	.545	.96	2.83	.457	.829	2.02	1.90	.337	1.061	1	1	1	1.90	2.02	.337	1.061	1	1	1
35	1879 1994	116	4	0	0	.509	.89	1.83	.224	.456	1.99	1.95	.345	1.016	1	1	1	1.99	1.95	.345	1.016	1	1	1
36	1862 1994	133	5	0	0	.697	1.08	2.21	.328	.497	2.27	2.27	.388	1.016	1	1	1	2.27	2.27	.388	1.016	1	1	1
37	1861 1994	134	5	0	0	.669	.96	2.08	.407	.725	2.61	2.14	.396	1.031	1	1	1	2.14	2.61	.396	1.031	1	1	1
38	1902 1994	93	3	0	0	.576	2.11	4.76	.827	.742	2.11	1.97	.386	1.001	1	1	1	1.97	2.11	.386	1.001	1	1	1
39	1858 1994	137	5	0	0	.607	.71	2.46	.373	.793	2.64	2.02	.369	1.011	1	1	1	2.02	2.64	.369	1.011	1	1	1
40	1860 1994	135	5	0	0	.708	.96	3.38	.642	.794	1.89	1.89	.309	1.005	2	2	1	1.89	1.89	.309	1.005	2	2	1
41	1890 1994	105	4	0	0	.587	1.57	5.45	.959	.868	2.27	2.03	.370	1.044	1	1	1	2.03	2.27	.370	1.044	1	1	1
42	1885 1994	110	4	0	0	.709	1.14	1.83	.278	.452	2.02	1.93	.395	1.005	1	1	1	1.93	2.02	.395	1.005	1	1	1
43	1854 1913	60	2	0	0	.496	1.40	2.97	.531	.765	1.74	2.04	.382	1.031	1	1	1	2.04	1.74	.382	1.031	1	1	1
44	1920 1994	75	3	0	0	.609	.77	1.45	.321	.907	1.49	2.00	.415	1.014	1	1	1	1.49	2.00	.415	1.014	1	1	1

- = [COFECHA ABCOFC] = -

Total of mean:

Filtered ----\ \

BLACK ROCK FOREST NORMALIZED TREE-RING WIDTHS FOR THE CHESTNUT OAK											
MOUNT MISERY											
MMQ											
MMQRES1806	9990	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	

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

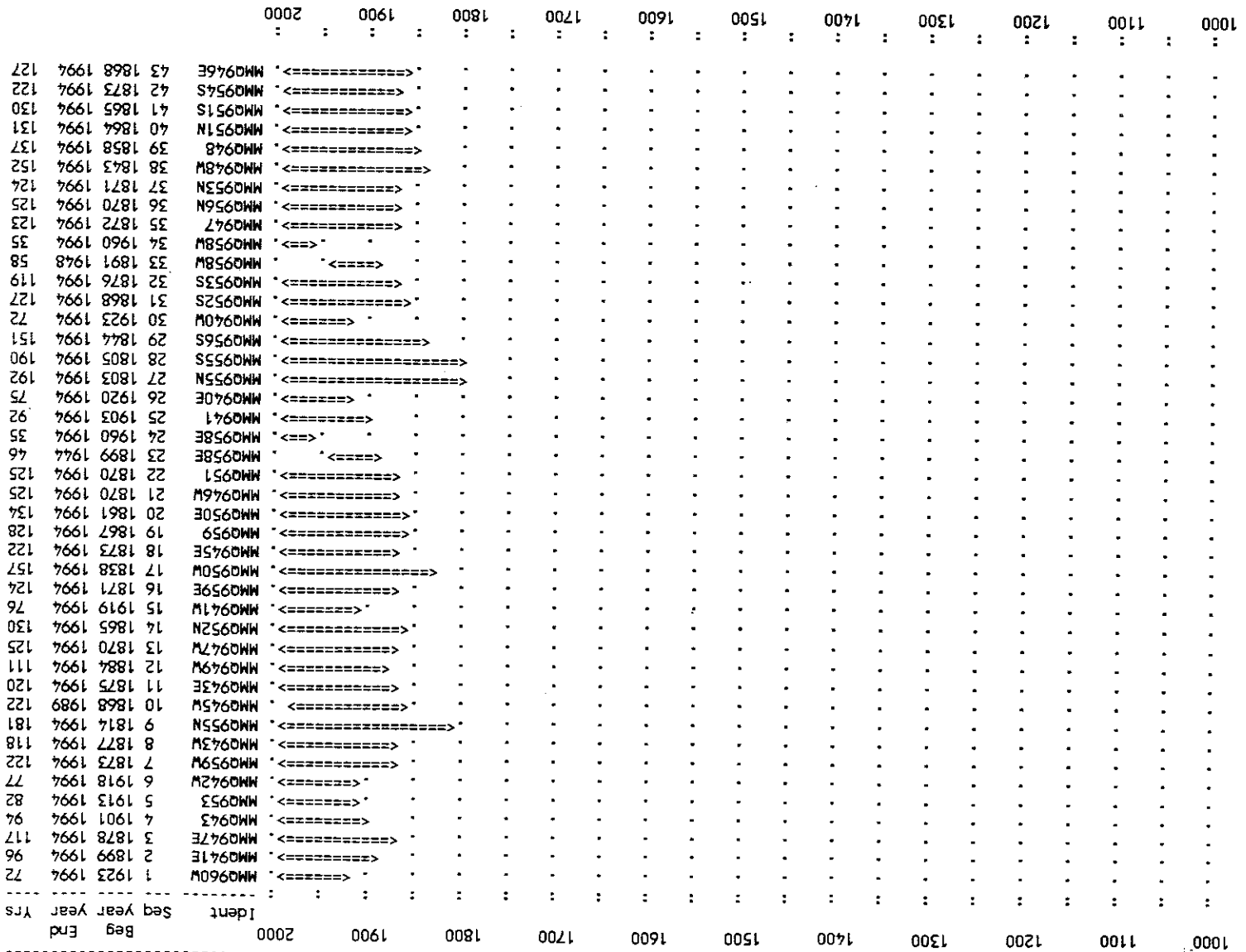
VALUE

- 1 Cubic smoothing spline 50% wavelength cutoff for filtering
- 2 Segments examined are
- 3 Autoregressive model applied
- 4 Series transformed to logarithms
- 5 Critical correlation, 99% confidence level .3281
- 6 Master dating series saved
- 7 Listing of ring measurements in Part 6
- 8 Parts printed
- 9 Absent rings included in master series

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



Year	Value	No	Ab	Year	Value	No	Ab
1850	.866	6		1900	-.357	33	
1851	.307	6		1901	.169	34	
1852	-1.043	6		1902	1.198	34	
1853	1.671	6		1903	1.560	35	
1854	1.405	6		1904	1.542	35	
1855	1.700	6		1905	.090	35	
1856	-.144	6		1906	.413	35	
1857	.394	6		1907	.315	35	
1858	-1.589	7		1908	.412	35	
1859	.243	7		1909	-.253	35	
1860	-.509	7		1910	-.663	35	
1861	-.654	8		1911	-.930	35	
1862	1.127	8		1912	1.126	35	
1863	-.020	8		1913	-.630	36	
1864	-.700	9		1914	-.027	36	
1865	.707	11		1915	-.764	36	
1866	-1.089	11		1916	.751	36	
1867	-.126	12		1917	.859	36	
1868	.113	15		1918	-.982	37	
1869	.608	15		1919	-.655	38	
1870	.399	19		1920	1.211	39	
1871	.717	21		1921	.761	39	
1872	1.26	22		1922	1.058	39	
1873	-2.215	25		1923	-1.545	41	
1874	.881	25		1924	-.241	41	
1875	-.471	26		1925	.268	41	
1876	-.959	27		1926	-.839	41	
1877	-.188	28		1927	.558	41	
1878	.289	29		1928	.709	41	
1879	.822	29		1929	-.789	41	
1880	.263	29		1930	.234	41	
1881	1.869	29		1931	.219	41	
1882	.215	29		1932	.595	41	
1883	-.351	29		1933	-1.467	41	
1884	.077	30		1934	-.734	41	
1885	-.381	30		1935	-.124	41	
1886	.052	30		1936	-.961	41	
1887	.416	30		1937	1.292	41	
1888	-.487	30		1938	1.611	41	
1889	1.540	30		1939	.760	41	
1890	.163	30		1940	.084	41	
1891	-.148	31		1941	.566	41	
1892	.070	31		1942	.272	41	
1893	-.752	31		1943	-.173	41	
1894	-1.547	31		1944	-.402	41	
1895	-1.897	31		1945	-1.196	40	
1896	-.678	31		1946	.243	40	
1897	-.519	31		1947	1.840	40	
1898	-.981	31		1948	-.535	40	
1899	-.525	33		1949	-2.482	39	
1840	-1.956	4		1890	1.469	40	
1841	.429	4		1891	-.372	40	
1842	1.372	4		1892	1.309	40	
1843	-1.386	5		1893	-.837	40	
1844	.358	6		1894	.777	40	
1845	-1.920	6					
1846	-.219	6					
1847	.014	6					
1848	.165	6					
1849	-2.218	6					

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
1	1923 1994	.69	.65	.65	.65	.65	.65	.65
2	1899 1994	.58	.62	.63	.63	.63	.63	.63
3	1878 1994	.50	.59	.59	.59	.59	.59	.59
4	1901 1994	.65	.74	.74	.74	.74	.74	.74
5	1913 1994	.61	.65	.65	.65	.65	.65	.65
6	1918 1994	.64	.64	.64	.64	.64	.64	.64
7	1873 1994	.46	.60	.60	.60	.60	.60	.60
8	1877 1994	.55	.74	.74	.74	.74	.74	.74
9	1814 1994	.61	.80	.80	.80	.80	.80	.80
10	1868 1989	.35	.38	.38	.38	.38	.38	.38
11	1875 1994	.43	.68	.68	.68	.68	.68	.68
12	1875 1994	.43	.68	.68	.68	.68	.68	.68
13	1870 1994	.65	.62	.62	.62	.62	.62	.62
14	1865 1994	.63	.60	.60	.60	.60	.60	.60
15	1919 1994	.53	.63	.63	.63	.63	.63	.63
16	1871 1994	.53	.62	.62	.62	.62	.62	.62
17	1838 1994	.58	.71	.71	.71	.71	.71	.71
18	1873 1994	.63	.53	.53	.53	.53	.53	.53
19	1867 1994	.49	.54	.54	.54	.54	.54	.54
20	1861 1994	.49	.54	.54	.54	.54	.54	.54
21	1870 1994	.48	.54	.54	.54	.54	.54	.54
22	1870 1994	.30	.40	.40	.40	.40	.40	.40
23	1899 1944	.56	.54	.54	.54	.54	.54	.54
24	1960 1994	.66	.66	.66	.66	.66	.66	.66
25	1903 1994	.74	.74	.74	.74	.74	.74	.74
26	1920 1994	.63	.63	.63	.63	.63	.63	.63
27	1803 1994	.41	.40	.40	.40	.40	.40	.40
28	1805 1994	.67	.48	.48	.48	.48	.48	.48
29	1844 1994	.59	.53	.53	.53	.53	.53	.53
30	1923 1994	.39	.49	.49	.49	.49	.49	.49
31	1868 1994	.39	.49	.49	.49	.49	.49	.49
32	1876 1994	.40	.60	.60	.60	.60	.60	.60
33	1891 1948	.36	.44	.44	.44	.44	.44	.44
34	1960 1994	.72	.72	.72	.72	.72	.72	.72
35	1872 1994	.75	.69	.69	.69	.69	.69	.69
36	1870 1994	.52	.38	.38	.38	.38	.38	.38
37	1871 1994	.67	.59	.59	.59	.59	.59	.59
38	1843 1994	.65	.67	.67	.67	.67	.67	.67
39	1858 1994	.75	.63	.63	.63	.63	.63	.63
40	1864 1994	.44	.50	.50	.50	.50	.50	.50
41	1865 1994	.57	.67	.67	.67	.67	.67	.67
42	1873 1994	.62	.58	.58	.58	.58	.58	.58
43	1868 1994	.63	.71	.71	.71	.71	.71	.71

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

[A] Correlations with master dating series of lagged 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

Series	Year	Correlation	Effect	Year-to-year change	Outliers
Series 1	MM0960W	1923 to 1994	72 years	[B] Entire series, effect on correlation (.652) is:	Lower 1993 -.023 1932 -.022 1949 -.012
				[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year	1899 +3.2 SD; 1966 +3.2 SD
Series 2	MM0941E	1899 to 1994	96 years	[B] Entire series, effect on correlation (.510) is:	Lower 1972 -.030 1911 -.021 1966 -.020
				[E] Outliers 2 3.0 SD above or -4.5 SD below mean for year	1899 +3.2 SD; 1966 +3.2 SD
Series 3	MM0947E	1878 to 1994	117 years	[B] Entire series, effect on correlation (.650) is:	Lower 1913 -.028 1918 -.016 1936 -.012
				[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year	1914 +3.2 SD
Series 4	MM0943	1901 to 1994	94 years	[B] Entire series, effect on correlation (.705) is:	Lower 1934 -.012 1914 -.012 1915 -.012
				[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year	1914 +3.2 SD
Series 5	MM0953	1913 to 1994	82 years	[B] Entire series, effect on correlation (.671) is:	Lower 1968 -.031 1925 -.014 1933 -.013
				[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year	1968 +4.2 SD
Series 6	MM0942W	1918 to 1994	77 years	[B] Entire series, effect on correlation (.682) is:	Lower 1935 -.046 1922 -.016 1919 -.012
				[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year	1887 +3.5 SD
Series 7	MM0959W	1873 to 1994	122 years	[B] Entire series, effect on correlation (.658) is:	Lower 1923 -.028 1953 -.017 1930 -.011
				[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year	1887 +3.5 SD
Series 8	MM0943W	1877 to 1994	118 years	[B] Entire series, effect on correlation (.726) is:	Lower 1898 -.014 1897 -.010 1899 -.009
				[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year	1917 +3.0 SD

Series 9	MMQ955N	1814 to 1994	181 years	[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
Series 10	MMQ945W	1868 to 1989	122 years	[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	
Series 11	MMQ943E	1875 to 1994	120 years	[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	
Series 12	MMQ949W	1884 to 1994	111 years	[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
Series 13	MMQ947M	1870 to 1994	125 years	[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	
Series 14	MMQ952N	1865 to 1994	130 years	[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
Series 15	MMQ941W	1919 to 1994	76 years	[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	
Series 16	MMQ959E	1871 to 1994	124 years	[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
Series 17	MMQ950W	1838 to 1994	157 years	[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
Series 18	MMQ945E	1873 to 1994	122 years	[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	

Series 19	MMQ959	1867 to 1994	128 years	[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
Series 20	MMQ950E	1861 to 1994	134 years	[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	[E] Outliers 1 3.0 SD above or -4.5 SD below mean for year 1911 +3.6 SD
Series 21	MMQ946W	1870 to 1994	125 years	[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
Series 22	MMQ951	1870 to 1994	125 years	[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 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 Lower 1902 -.035 1915 -.032 1904 -.031 1909 -.022 Higher 1895 .096 1881 .031 1918 .028 1889 .021	
Series 23	MMQ958E	1899 to 1944	46 years	[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	
Series 24	MMQ958E	1960 to 1994	35 years	[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	
Series 25	MMQ947	1903 to 1994	92 years	[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	
Series 26	MMQ940E	1920 to 1994	75 years	[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
Series 27	MMQ955N	1803 to 1994	192 years	[*] 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

Series 28	MMQ955S	1805 to 1994	190 years	[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
Series 29	MMQ956S	1844 to 1994	151 years	[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	
Series 30	MMQ940W	1923 to 1994	72 years	[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	
Series 31	MMQ952S	1868 to 1994	127 years	[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	
Series 32	MMQ953S	1876 to 1994	119 years	[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
Series 33	MMQ958W	1891 to 1948	58 years	[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
Series 34	MMQ958M	1960 to 1994	35 years	[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	
Series 35	MMQ947	1872 to 1994	123 years	[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	
Series 36	MMQ956N	1870 to 1994	125 years	[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	
Series 37	MMQ953N	1871 to 1994	124 years	[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

MMQ948M 1843 to 1994 152 years

[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

[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 1895 .010

MMQ951N 1864 to 1994 131 years

[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

[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

[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

[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

MMQ948M 1843 to 1994 152 years

[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

[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 1895 .010

MMQ951N 1864 to 1994 131 years

[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

[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

[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

[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

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: BSAUPR.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
- 2 Segments examined are
- 3 Autoregressive model applied
- 4 Series transformed to logarithms
- 5 Critical correlation, 99% confidence level .3281
- 6 Master dating series saved
- 7 Listing of ring measurements in Part 6
- 8 Parts printed
- 9 Absent rings included in master series

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

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	Ident	Seq	Year	End	Yrs
.	BS0935M	1	1865	1994	130
.	BS0929E	2	1921	1994	74
.	BS0938M	3	1876	1994	119
.	BS0928M	4	1903	1994	92
.	BS0925SM	5	1915	1994	80
.	BS0937S	6	1885	1980	96
.	BS0931S	7	1915	1994	80
.	CLIFF2	8	1915	1994	80
.	BS0923NM	9	1905	1994	90
.	BS0932NE	10	1844	1994	151
.	BS0921	11	1920	1994	75
.	BS0927M	12	1899	1994	96
.	BS0921NM	13	1914	1994	81
.	BS0921SE	14	1897	1994	98
.	BS0934NE	15	1922	1964	43
.	BS0925	16	1912	1994	83
.	BS0936	17	1845	1937	93
.	BS0936	18	1950	1994	45
.	BS0929M	19	1934	1994	61
.	BS0935	20	1874	1994	121
.	BS0928E	21	1905	1994	90
.	BS0922NM	22	1907	1994	88
.	BS0927E	23	1900	1994	95
.	BS0939M	24	1880	1919	40
.	BS0939M	25	1946	1994	49
.	BS0934SM	26	1924	1994	71
.	BS0933NE	27	1841	1919	79
.	BS0933NE	28	1942	1994	53
.	BS0922SE	29	1905	1994	90
.	BS0931N	30	1915	1994	80
.	BS0935E	31	1873	1994	122
.	BS0924SE	32	1918	1994	77
.	BS0930S	33	1900	1994	95
.	BS0926NM	34	1914	1994	81
.	BS0936E	35	1841	1994	154
.	BS0924NM	36	1915	1994	80
.	BS0926SE	37	1908	1994	87
.	BS0932SM	38	1845	1993	149
.	BS0938E	39	1876	1994	119
.	BS0923SE	40	1904	1994	91
.	CLIFF1	41	1918	1994	77
.	BS0930N	42	1872	1994	123
.	BS0936M	43	1843	1994	152
.	BS0939E	44	1886	1919	34
.	BS0939E	45	1956	1994	39
.	BS0925NE	46	1920	1994	75

Year	Value	No	Ab	Year	Value	No	Ab
1850	.842	6		1900	.494	19	
1851	.617	6		1901	.051	19	
1852	-1.880	6		1902	1.208	19	
1853	1.144	6		1903	.859	20	
1854	.679	6		1904	1.515	21	
1855	.360	6		1905	.359	24	
1856	-.905	6		1906	-.175	24	
1857	.677	7		1907	-.626	25	
1858	-.295	7		1908	.300	26	
1859	1.808	7		1909	-.579	26	
1860	.250	6		1910	-.816	26	
1861	-.498	6		1911	-1.588	26	
1862	.444	6		1912	-.855	27	
1863	1.039	6		1913	-.722	27	
1864	-.904	6		1914	.457	29	
1865	-.445	7		1915	.212	34	
1866	-.860	7		1916	.991	34	
1867	.677	7		1917	.612	34	
1868	-.295	7		1918	-.930	36	
1869	1.808	7		1919	-.313	36	
1870	.045	7		1920	1.803	35	
1871	-.683	7		1921	1.494	36	
1872	-1.044	8		1922	1.308	37	
1873	-2.372	9		1923	-1.409	37	
1874	1.070	10		1924	.037	38	
1875	-.850	10		1925	.292	38	
1876	-1.263	12		1926	-.530	38	
1877	-.710	12		1927	.127	38	
1878	.756	12		1928	.093	38	
1879	1.388	12		1929	-.620	38	
1880	.864	13		1930	-.627	38	
1881	1.970	13		1931	-.681	38	
1882	-.032	13		1932	.616	38	
1883	-.439	13		1933	-1.647	38	
1884	.089	13		1934	-.544	39	
1885	-.410	14		1935	.668	39	
1886	.501	15		1936	.078	39	
1887	.603	15		1937	1.871	39	
1888	-.549	15		1938	1.480	38	
1889	.959	15		1939	.932	38	
1890	-.786	15		1940	-.204	38	
1891	.336	15		1941	.163	38	
1892	1.151	15		1942	-.076	39	
1893	-1.184	15		1943	-.703	39	
1894	-1.363	15		1944	-.673	39	
1895	-1.785	15		1945	-1.313	39	
1896	-.822	15		1946	.548	40	
1897	-.442	16		1947	1.605	40	
1898	-.657	16		1948	-.526	40	
1899	-.152	17		1949	-2.116	40	
1841	.463	2		1990	.720	40	
1842	1.449	2		1991	.663	40	
1843	-.772	3		1992	1.099	40	
1844	.814	4		1993	-.747	40	
1845	-1.575	6		1994	.270	39	
1846	1.050	6					
1847	.665	6					
1848	1.182	6					
1849	-3.543	6					

154 values in series

Year	Rel value	Year	Rel value	Year	Rel value	Year	Rel value	Year	Rel value
1850	-c	1900	-b	1950	-a	1850	-c	1900	-b
1851	-b	1901	-a	1951	-b	1851	-b	1901	-a
1852	-b	1911	-c	1961	-d	1852	-b	1911	-c
1853	-d	1912	-c	1962	-b	1853	-d	1912	-c
1854	-d	1913	-c	1963	-b	1854	-d	1913	-c
1855	-a	1914	-b	1964	-f	1855	-a	1914	-b
1856	-d	1915	-a	1965	-e	1856	-d	1915	-a
1857	-c	1916	-d	1966	-d	1857	-c	1916	-d
1858	-a	1917	-b	1967	-d	1858	-a	1917	-b
1859	-a	1918	-d	1968	-i	1859	-a	1918	-d
1860	-c	1919	-a	1969	-a	1860	-c	1919	-a
1861	-b	1920	-g	1970	-b	1861	-b	1920	-g
1862	-b	1921	-c	1971	-d	1862	-b	1921	-c
1863	-d	1922	-e	1972	-c	1863	-d	1922	-e
1864	-d	1923	-f	1973	-b	1864	-d	1923	-f
1865	-c	1924	-d	1974	-d	1865	-c	1924	-d
1866	-e	1925	-a	1975	-g	1866	-e	1925	-a
1867	-c	1926	-b	1976	-e	1867	-c	1926	-b
1868	-a	1927	-a	1977	-d	1868	-a	1927	-a
1869	-a	1928	-c	1978	-d	1869	-a	1928	-c
1870	-a	1929	-b	1979	-a	1870	-a	1929	-b
1871	-c	1930	-c	1980	-d	1871	-c	1930	-c
1872	-d	1931	-c	1981	-d	1872	-d	1931	-c
1873	-d	1932	-b	1982	-d	1873	-d	1932	-b
1874	-d	1933	-g	1983	-d	1874	-d	1933	-g
1875	-c	1934	-b	1984	-b	1875	-c	1934	-b
1876	-e	1935	-c	1985	-c	1876	-e	1935	-c
1877	-c	1936	-a	1986	-a	1877	-c	1936	-a
1878	-c	1937	-g	1987	-a	1878	-c	1937	-g
1879	-b	1938	-f	1988	-d	1879	-b	1938	-f
1880	-c	1939	-d	1989	-b	1880	-c	1939	-d
1881	-c	1940	-a	1990	-c	1881	-c	1940	-a
1882	-d	1941	-a	1991	-c	1882	-d	1941	-a
1883	-b	1942	-e	1992	-c	1883	-b	1942	-e
1884	-d	1943	-c	1993	-c	1884	-d	1943	-c
1885	-b	1944	-c	1994	-a	1885	-b	1944	-c
1886	-b	1945	-e			1886	-b	1945	-e
1887	-b	1946	-c			1887	-b	1946	-c
1888	-b	1947	-f			1888	-b	1947	-f
1889	-b	1948	-b			1889	-b	1948	-b
1890	-c	1949	-h			1890	-c	1949	-h

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
1	BSQ935M	1865	1994	.56	.60	.59	.64
2	BSQ929E	1921	1994	.56	.56	.51	.49
3	BSQ938M	1876	1994	.56	.73	.73	.73
4	BSQ928M	1903	1994	.73	.73	.79	.86
5	BSQ925SM	1915	1994	.53	.53	.71	.86
6	BSQ937S	1885	1980	.41	.41	.50	.53
7	BSQ931S	1915	1994	.50	.50	.65	.75
8	CLIFF2	1915	1994	.50	.50	.67	.75
9	BSQ923NM	1905	1994	.60	.60	.76	.86
10	BSQ932NE	1844	1994	.79	.71	.59	.44
11	BSQ921	1920	1994	.65	.65	.61	.71
12	BSQ927M	1899	1994	.42	.42	.44	.61
13	BSQ921NM	1914	1994	.58	.58	.64	.65
14	BSQ921SE	1897	1994	.58	.58	.64	.69
15	BSQ934NE	1922	1964	.57	.57	.57	.57
16	BSQ925	1912	1994	.55	.55	.61	.69
17	BSQ936	1845	1937	.73	.64	.57	.49
18	BSQ936	1950	1994	.81	.73	.64	.57
19	BSQ929M	1934	1994	.68	.68	.51	.49
20	BSQ935	1874	1994	.68	.68	.64	.60
21	BSQ928E	1905	1994	.58	.58	.65	.75
22	BSQ922NM	1907	1994	.64	.64	.76	.77
23	BSQ927E	1900	1994	.41	.41	.49	.57
24	BSQ939M	1880	1919	.36	.36	.36	.36
25	BSQ939M	1946	1994	.37	.37	.37	.37
26	BSQ934SM	1924	1994	.38	.38	.36	.61
27	BSQ933NE	1841	1919	.42	.38	.36	.61
28	BSQ933NE	1942	1994	.55	.55	.57	.57
29	BSQ922SE	1905	1994	.61	.57	.57	.57
30	BSQ931N	1915	1994	.65	.65	.71	.66
31	BSQ935E	1873	1994	.41	.41	.50	.68
32	BSQ924SE	1918	1994	.71	.71	.70	.77
33	BSQ930S	1900	1994	.56	.56	.83	.83
34	BSQ926NM	1914	1994	.67	.67	.83	.83
35	BSQ936E	1841	1994	.71	.67	.50	.39
36	BSQ924NM	1915	1994	.76	.76	.75	.75
37	BSQ926SE	1908	1994	.67	.73	.72	.72
38	BSQ932SM	1845	1993	.51	.63	.47	.56
39	BSQ938E	1876	1994	.38	.38	.58	.75
40	BSQ923SE	1904	1994	.58	.58	.64	.75
41	CLIFF1	1918	1994	.70	.70	.69	.78
42	BSQ930N	1872	1994	.46	.46	.49	.78
43	BSQ936M	1843	1994	.69	.68	.64	.53
44	BSQ939E	1886	1919	.62	.62	.55	.53
45	BSQ939E	1956	1994	.56	.56	.56	.56
46	BSQ925NE	1920	1994	.78	.78	.76	.79

Series 9	BSQ23NW	1905 to 1994	90 years	[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
Series 10	BSQ32NE	1844 to 1994	151 years	[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	
Series 11	BSQ921	1920 to 1994	75 years	[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	
Series 12	BSQ927W	1899 to 1994	96 years	[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	
Series 13	BSQ921NW	1914 to 1994	81 years	[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	
Series 14	BSQ921SE	1897 to 1994	98 years	[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	
Series 15	BSQ934NE	1922 to 1964	43 years	[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	
Series 16	BSQ925	1912 to 1994	83 years	[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	
Series 17	BSQ936	1845 to 1937	93 years	[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	
Series 18	BSQ936	1950 to 1994	45 years	[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	
Series 19	BSQ929W	1934 to 1994	61 years	[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	

Series 20	BS0935	1874 to 1994	121 years	[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
Series 21	BS0928E	1905 to 1994	90 years	[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
Series 22	BS0922NW	1907 to 1994	88 years	[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
Series 23	BS0927E	1900 to 1994	95 years	[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
Series 24	BS0939W	1880 to 1919	40 years	[A] Segment High 1880 1919 -2 -05 -08 .02 .12 -.17 -.07 -.01 -.01 .36 .02 .36 .20 -.24 -.16 -.06 .00 -.03 -.52 -.12 .05 -.07 [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
Series 25	BS0939W	1946 to 1994	49 years	[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
Series 26	BS0934SW	1924 to 1994	71 years	[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
Series 27	BS0933NE	1841 to 1919	79 years	[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
Series 28	BS0933NE	1942 to 1994	53 years	[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
Series 29	BS0922SE	1905 to 1994	90 years	[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

Series 30	BS0931N-	1915 to 1994	80 years	[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
					Lower 1948	-.021	1993	-.019	1964	-.015	1920	-.013	Higher	1949	.020	1965	.016	1981	.014	1933	.014
					[E] Outliers	1	3.0 SD above or	-4.5 SD below	mean for year	1885	+3.2 SD										
Series 31	BS0935E	1873 to 1994	122 years	[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
					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										
Series 32	BS0924SE	1918 to 1994	77 years	[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
					Lower 1957	-.014	1940	-.014	1932	-.010	1927	-.010	Higher	1965	.014	1937	.012	1968	.011	1920	.011
					[E] Outliers	1	3.0 SD above or	-4.5 SD below	mean for year	1885	+3.2 SD										
Series 33	BS0930S	1900 to 1994	95 years	[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
					Lower 1904	-.023	1928	-.023	1943	-.014	1913	-.013	Higher	1981	.049	1968	.013	1933	.013	1965	.011
					[E] Outliers	1	3.0 SD above or	-4.5 SD below	mean for year	1954	+3.6 SD										
Series 35	BS0936E	1841 to 1994	154 years	[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
					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										
Series 36	BS0924NW	1915 to 1994	80 years	[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
					Lower 1993	-.017	1985	-.017	1961	-.013	1942	-.013	Higher	1923	.015	1965	.010	1920	.010	1937	.010
					[E] Outliers	1	3.0 SD above or	-4.5 SD below	mean for year	1992	+3.0 SD										
Series 37	BS0926SE	1908 to 1994	87 years	[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
					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										
Series 38	BS0932SW	1845 to 1993	149 years	[B] Entire series, effect on correlation (.571) is:	Lower 1922	-.027	1988	-.016	1923	-.014	1980	-.012	Higher	1981	.034	1849	.028	1949	.014	1873	.013
					Lower 1922	-.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										
Series 39	BS0938E	1876 to 1994	119 years	[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
					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										

Appendix B

***** 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

**** 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\1978.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

**** Input file names ****
Site : C:\GAP3\BRF.LOC
Soil : C:\GAP3\BR-NOSTR.SOL
Climate : C:\GAP3\BR1979.CLI
Plant 1 : C:\GAP3\BR-OAK.PLT
Save : C:\GAP3\MONTHLY.SAV
File not found
File not found

**** Output file names ****
Summary : C:\GAP3\1979.SUM
Model : C:\GAP3\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

**** 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\1979.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

**** Input file names ****

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

**** 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

**** 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

**** 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

**** 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

**** 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_FTP)
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

**** 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

**** 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\1983.SUM
Model : C:\GAPS3\1983S.DET

**** Simulation procedures *****

Soil temperature : not simulated
Evapo-transpiration : Priestley-Taylor (Priestley-Taylor-FTP)
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

```

**** 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_RTP)
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



**** 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\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 : 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

***** 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-FTP)
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

**** 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\1985.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

**** Input file names ****

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

**** 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

**** 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_FTP)
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

**** 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

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

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

**** 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

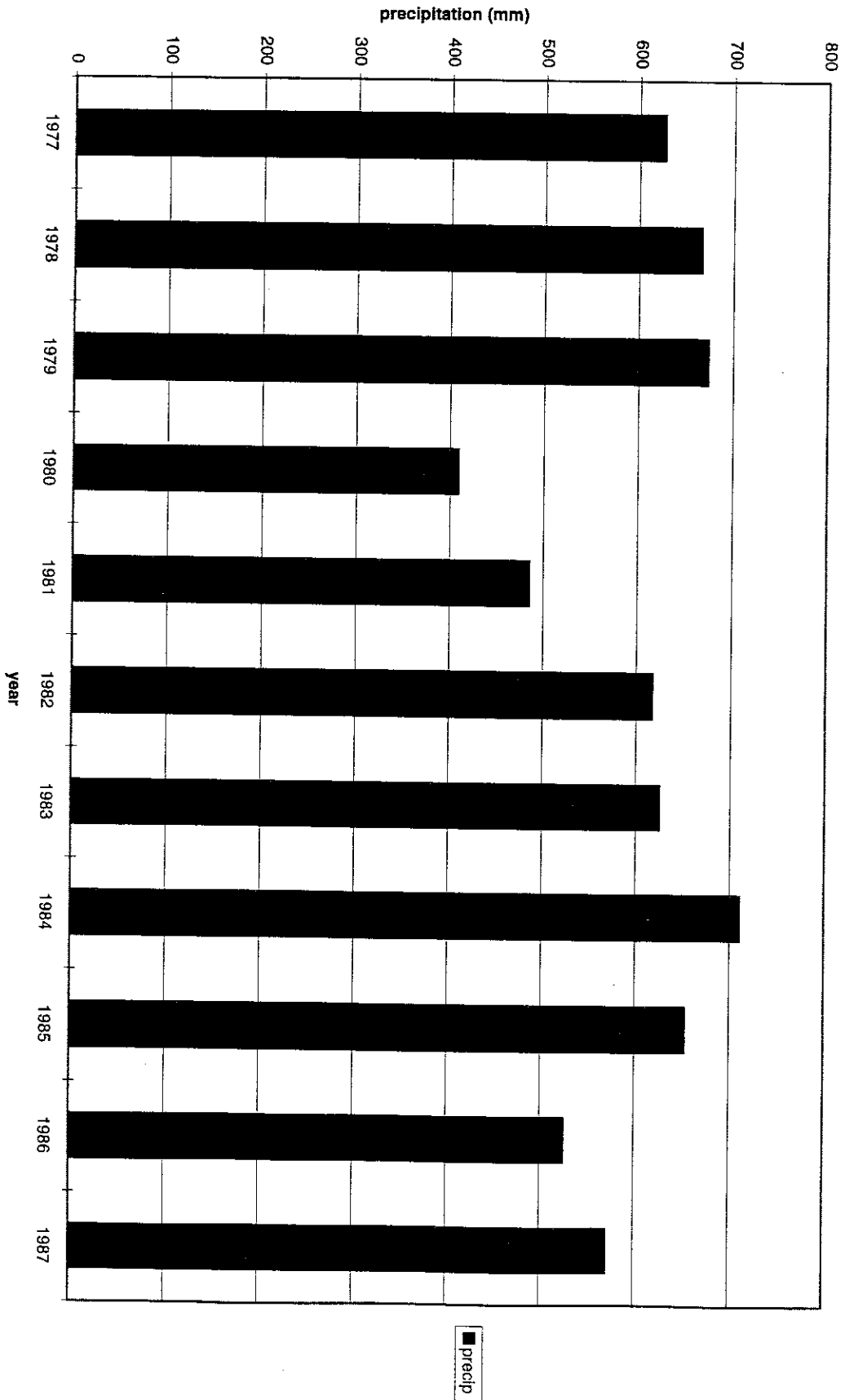
**** summary water budget (kg/m2 or mm) ****

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



Year	April	May	June	July	August	September	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