THE INFLUENCE OF TEMPERATURE AND PRECIPITATION ON *PICEA MARIANA* AT TREELINE

by

Barbara Nocon

Submitted in Fulfillment of the
Requirements of Geography 4C6
for B.A.(Honours)

Department of Geography
McMaster University
Hamilton, Canada

1988

ABSTRACT

Statistical analyses between the relationship of tree-ring widths with variations in climate were used to examine the limiting climatic factors upon the growth rate of Picea mariana along the treeline and in hopes of reconstructing past climate. Tree-ring widths were used as a proxy measure of growth rates to establish the relationship of annual variances in temperature and precipitation on the growth rate of trees. Twelve tree cores were sampled from separate trees along the treeline northeast of Yellowknife, Northwest Territories. The trees, (with cores spanning 40 - 160 years per tree), were compared to monthly and seasonal variations of both temperature and precipitations. A stepwise regression model was used to examine the climate-growth response. No climatic variables were found to illicit a general response pattern. The growth rate of trees along the treeline, northeast of Yellowknife do not appear to be dependent upon variations in the regional climate. Therefore, no climatic reconstructions were possible.

ACKNOWLEDGEMENTS

Early in high school I had a fascination for trees. Now, ending university I have had the opportunity to study them in some depth. This would not have been possible had it not been for Dr. Glen MacDonald. I would like to thank him for suggesting this topic and giving me the opportunity to work with him. Thank you for all your invaluable guidance throughout the year. Particularly in the last stretch your patience and help was greatly appreciated.

I would like to thank the many people who helped me enjoy this year and get through all the preparation and hard work for my thesis:

To Chris, Julian, Katrina, Catherine - you've made this year bearable, and unforgettable by always keeping me in stitches.

As for Jim, "How are those tree rings?"! Thanks for your knowledge in this field and answering all my questions. Thank you for all your help.

To my sisters Liz and Ursula. When I fell off of my chair you always propped me back up. In a bind, you always helped me out. Thank you for your constant support.

To the rest of my fourth year geography classmates, all of whom are urban geographers, one last note...a tree is "a large, woody perennial plant with one main trunk and many branches" (Webster's New World Dictionary, 1973), HA! HA!

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CHAPTER 1

INTRODUCTION

Dendroclimatology, the use of tree-ring widths as climatic indicators, was first suggested in Europe in the eighteenth century. A narrowness in tree-ring widths was observed coinciding with the time of a 'severe' winter in the area in 1708-9. In North America it was not until 1833 that tree-rings were used by Twining for information leading to a paleoclimatic index (Studhalter, 1955).

A.E. Douglass, an American astronomer, is known to many people as "the father of tree-ring studies" for his intense study of tree-ring widths as climatic indicators (Fritts, 1976). Douglass used the ring width variations to provide himself with a long proxy record of the variations in rainfall which he required for his research for investigating a possible relationship between sunspot activity and rainfall (Bradley, 1985). He began his research using tree-rings in 1914 in the American Southwest. His research showed that one can extend information beyond living samples by matching dead tree samples to living ones (Stockton et al., 1985). The most significant advances in dendroclimatology have been developed in the last two decades. Much of this work has been carried out by H. C. Fritts and his associates at the Laboratory of Tree-Ring Research in the University of Arizona in Tucson (Bradley, 1985).

It is a function of this paper to examine *Picea mariana* trees at the treeline northeast of Yellowknife, Northwest Territories, To investigate the role of annual variances in temperature and precipitation upon their growth rate. The northern treeline of Canada is highly sensitive to fluctuations in climate (Jacoby and Ulan, 1981). Tree-ring width will be used as a proxy measure of growth rate. The objective of this research paper is to test if growth rates of trees at the northern treeline are strongly controlled by increases and decreases in monthly and seasonal temperatures and precipitations.

The research will provide ecological information on the relation of climate to growth rates of these northern tree populations. This research has important implications for short term paleoclimatological studies at the treeline. Temperature data for the treeline area around Yellowknife only extends to 1942. Trees, however, can live over one hundred years. If a relationship is established between treeline tree-rings and temperature, then tree-rings may be used to estimate what climatic conditions were like in the past for which time records are non-existent.

CHAPTER 2

LITERATURE REVIEW

The climate of the treeline fluctuates a great deal. A study by Jacoby and Ulan (1981) reveals that the treeline is an area sensitive to the climate due to fluctuations because treeline species are existing in a state of climatically induced stress. There are few records available for the climate of the Arctic. Some areas go back only a few decades. Therefore, past climatic reconstructions as well as investigating the possibility of climatic trends which could be used to investigate future climatic variations have become of increased interest.

Research carried out by Jacoby and Ulan (1981, 1982) indicate that moisture stress and temperature stress together play a role in influencing northern tree growth. Although moisture is important, they found that the limiting factor for this area was temperature.

Jacoby Jr. (1983) examined the forest-tundra ecotone in the Hudson Bay area. His study revealed that a positive correlation existed between ring width and July temperatures. However, in the month of August a positive correlation was found to exist between ring width and precipitation but this effect was strongest in sites where the trees were located on rocky soils and steep, well-drained, south facing slopes.

In a 1980 study prepared by Garfinkel and Brubaker in sub-Arctic Alaska, ring widths were used to define relationships between tree growth and climate. A direct relationship was found to exist between radial growth and temperature for the current summer and previous autumn months.

Jacoby and Cook, (in 1981), studied Picea glauca in the Yukon Territory, Canada. They obtained twenty seven cores from thirteen trees. They found the best relationship between tree growth and climate was between ring widths and June and July temperatures.

These studies show that seasonal temperatures and precipitation should be the controlling factor on the growth of trees along the tree line in the Yellowknife area.

CHAPTER 3

MATERIALS AND METHODS

3.1 Tree-Ring Morphology

A tree-ring is composed of alternating bands of light and dark xylem tissues. These are seasonal growth increments. The light bands (earlywood) are large, thin-walled cells and the darker bands (latewood) are thick-walled cells and are more densely packed. A couplet of earlywood and latewood make up an annual growth increment (Bradley, 1985).

The widths of tree-rings appear to be sensitive to variations in climate (Fritts, 1976; Bradley, 1985) because the climate limits various biochemical processes which directly affect the ring widths (Fritts, 1971). They therefore tend to be good climatic indicators. The tree's response to climate may be directly examined by analysis of the tree-ring width. The size of the cells within vary throughout the growing season. Under optimum growing conditions the cells are large in diameter. This illustrates rapid tree growth. However, climate may not be the only factor affecting tree-rings. Under competition the cell size tends to be narrow (Fritts, 1976).

When gathering tree samples where their ring widths will be used as a source of climatic information these trees are sampled in areas undergoing climatic stress. Therefore, they are sampled close to their ecological range (Bradley,1985). A study by Fritts in 1971 reveals that where there is no climatic stress upon the tree, the ring widths vary little. They are uniform in width. They therefore do not aid us by showing any variation in climate since climate is not a limiting factor in tree growth in these areas. The rings are termed complacent. Rings which vary greatly in width are termed sensitive. Sensitive rings occur in areas where climate is a limiting factor on tree growth. It is these trees which are best used in dendro-climatology.

Trees located near their latitudinal or altitudinal extremes have been found to have a direct relationship between their ring widths and summer temperatures (Fritts, 1976). This relationship tends to exist especially for trees in cool microclimates. The tree's growth relies upon biochemical processes such as respiration, and photosynthesis. In low temperature environments these processes are limited. Such environments may also effect tree growth (and thus ring width) by delaying the start of the growth period or ending the growing season before it is actually over (Fritts, 1976).

Precipitation also has a very strong direct relationship to tree ring widths. Its effect is most prominent in semi-arid sites. When a site has low precipitation this leads to a low soil moisture content which in turn leads to a low internal water stress. The physiological processes which are responsible for tree growth are limited by this moisture stress. The more precipitation an area receives, the greater the availability of moisture in the soil for the tree. This leads to an increase in the time period before moisture stress becomes the dominant factor affecting growth (Fritts, 1976).

3.2 Sampling Strategy

The examination of tree rings for dendrochronological studies is best done when complete cross-sections are being studied. However, this is rarely done since it involves the destruction of many healthy trees (Stockton et al., 1985). Therefore, research is undertaken by using cores from trees.

Stokes and Smiley (1968) suggest sampling the trees in the site radially using an increment borer. This instrument removes a core of wood approximately 4mm in diameter. The tree sampled is left unharmed and sap quickly seals the hole made.

Under optimum conditions between twenty to thirty trees are obtained with two to three samples extracted from each tree. However, it has been found that a sample of a minimum of ten trees is good for sites which are climatically sensitive (Stockton, et al., 198). Multiple sampling of a tree has been used by Fritts (1976). This helps to prevent any errors that may occur in dating by indentifying any missing rings. It is also believed that the best estimation of climate is produced by taking the average of multiple samples from a large data base of trees. When these averages are made, the variations in growth which are associated with the variations in the climate are common in all trees and therefore are retained. However, these trees sampled along the treeline were under great environmental stress. So as not to put any further stress upon them, only one core per tree was taken.

3.3 Tree-Core Preparation

In the lab each core is dried and mounted. They are then surfaced by slicing a thin layer from the surface using a razor blade. Widths are measured from the rings between the bark and the pith. The bark layer represents the current year. The rings near the pith represent the first years of growth. Counting and measuring of the cores is done under a stereomicroscope.

3.4 Field Site

Trees sampled are located approximately 200 km northeast of Yellowknife, Northwest Territories (62' 29" N, 114' 38" W), (Figure 3.1). Yellowknife is situated on the northern edge of Great Slave Lake. It is an area of rugged topography. The elevations range between 152.5m - 305m above sea level (Gage World Atlas, 1972). The coring was undertaken by Dr. Glen MacDonald in 1985.

(i) Climate

The Yellowknife tree site is located in the sub-arctic zone of Canada. The site is underlain by widespread permafrost. Little precipitation and low temperatures are characteristic of this area. The precipitation falls in either the form of rain or snow.

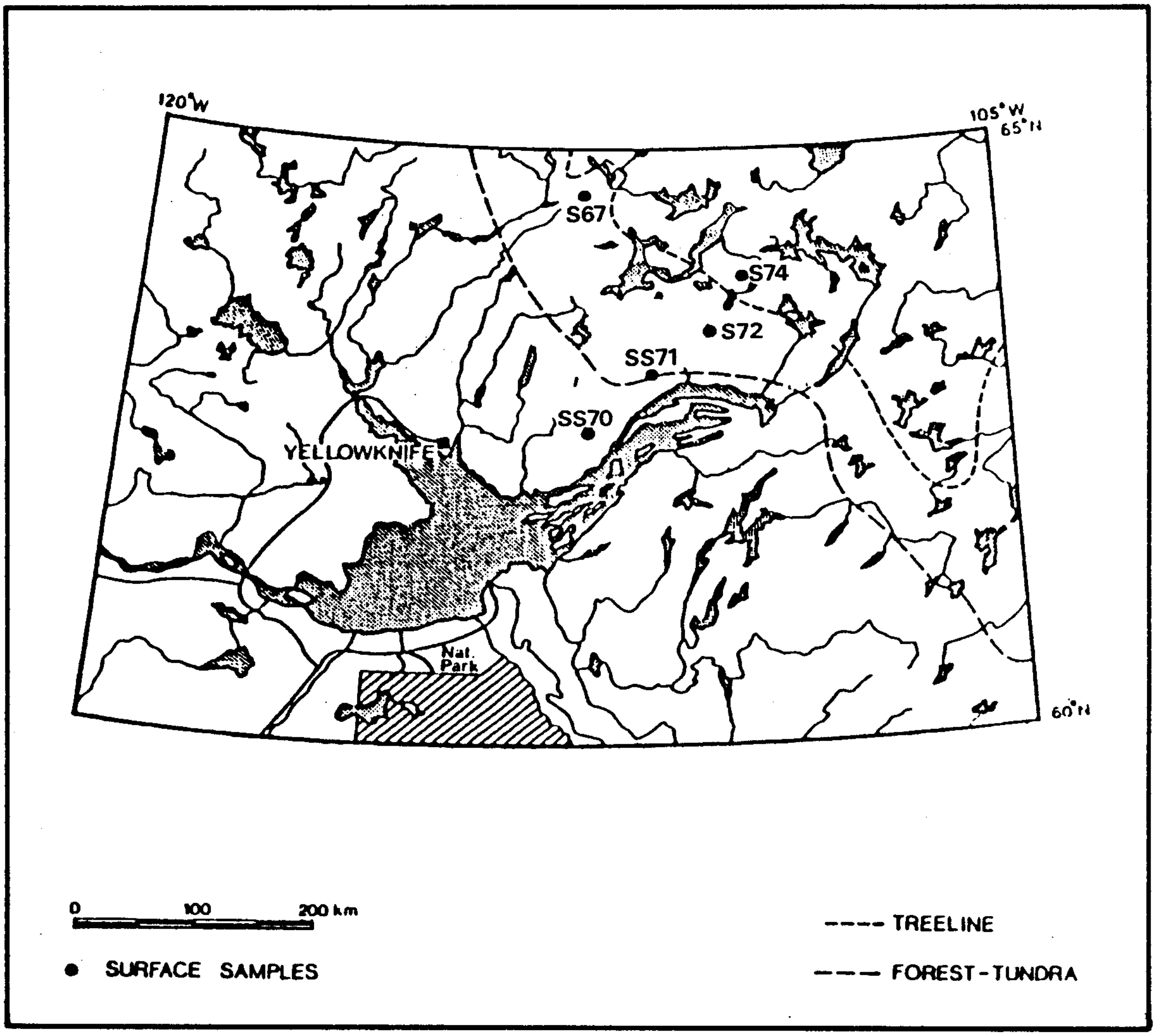
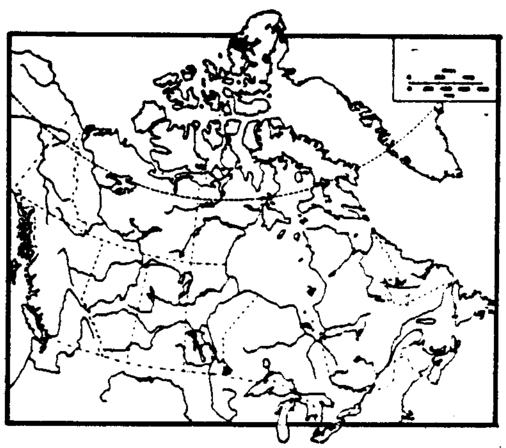


FIGURE 3.1 : Yellowknife Tree Sampling Sites.

Yellowknife ⟶



Rainfall ranges between zero and 30.5 cm annually whereas temperatures range from -35^{o}C (minimum low) in the winter season, to +20^{o}C (maximum high) in the summer season (National Atlas of Canada, 1974).

(ii) Bedrock and Soil Structure

The site is located on the Canadian Shield. This is a low-lying plateau composed of hard, ancient rocks. Overlying these rocks is a thin layer of podzolic soil. These soils are a result of the acidic needle litter deposited from coniferous trees and are therefore typical soil of forested areas (Pruitt Jr, 1978). Although the area receives little precipitation, the soil is only very slightly water deficient (International Society of Soil Science, 1979).

(iii) Vegetation

The sampling site is located in the forest-tundra zone of North America. This is the zone where the taiga (northern boreal coniferous forest) merges with the tundra (area whithout trees). It is a zone of scattered coniferous trees with sporadically growing shrubs. The dominant tree species located here are <u>Picea mariana</u>, <u>Picea glauca</u>, and <u>Picea banksiana</u> (Department of Environment, 1960).

CHAPTER 4

ANALYSIS

4.1 Data Collection

Picea mariana dominates the forest tundra zone around the Yellowknife tree sampling site. The trees are few and interspersed. They are also under extreme climatic stress. Therefore, only 12 healthy cores could be extracted from separate trees and only one core per tree.

Precipitation and Temperature data have been collected for the area since 1942 by the meteorological station located in Yellowknife. The climate data was extracted from the Atmospheric Environment Service for this area for the period 1942 - 1980.

4.2 Measurement

The tree cores were taken to McMaster University where they were prepared for analysis and then their ring widths counted under a stereomicroscope. The tree cores sampled span between a 40 - 160 year period per tree. The ring widths from each core were plotted on a graph using their ring widths as the Y-axis and years A.D. as the X-axis (Figures 4.1 - 4.12).

4.3 Standardization

In the early life stages of a tree, wider rings are often produced. The ring widths tend to decrease in size with increase

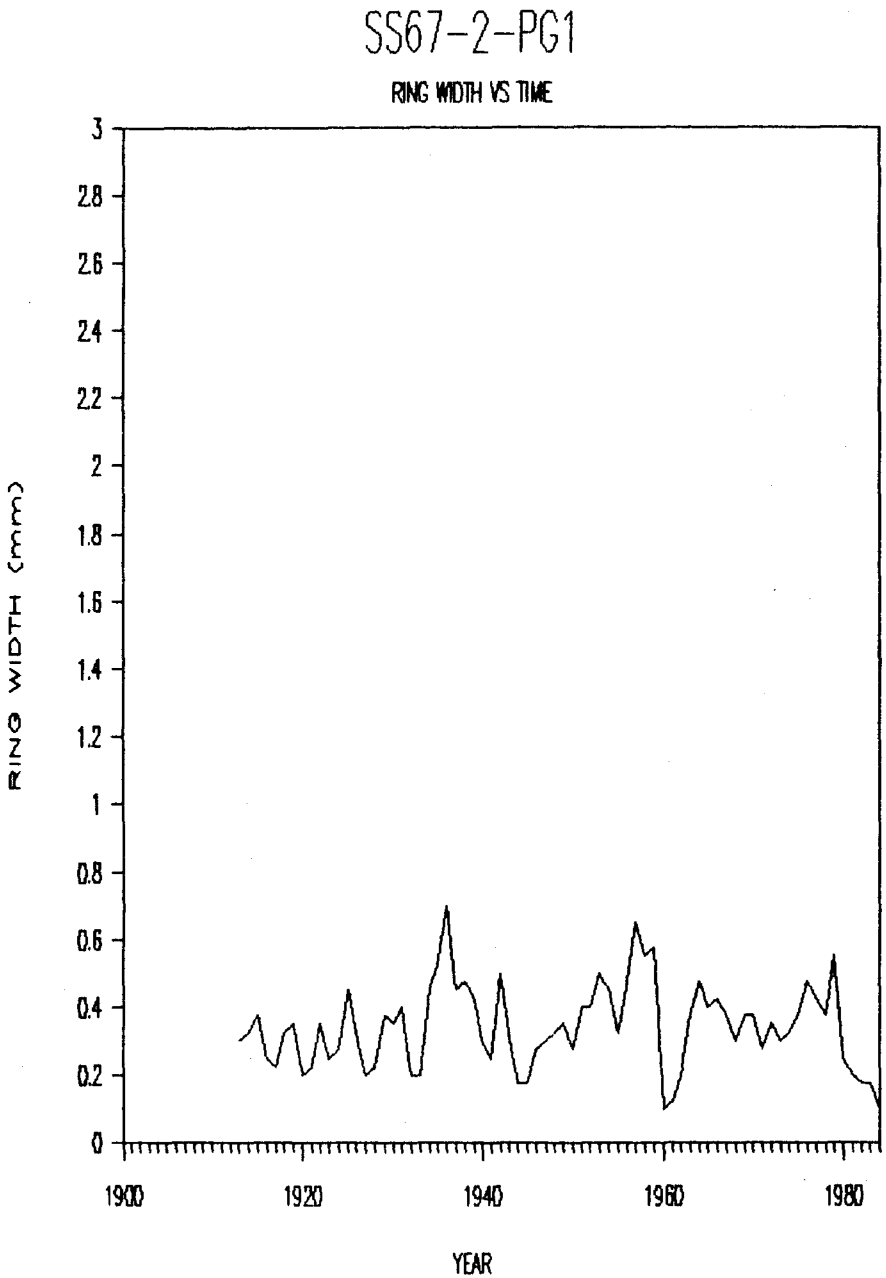


FIGURE 4.1

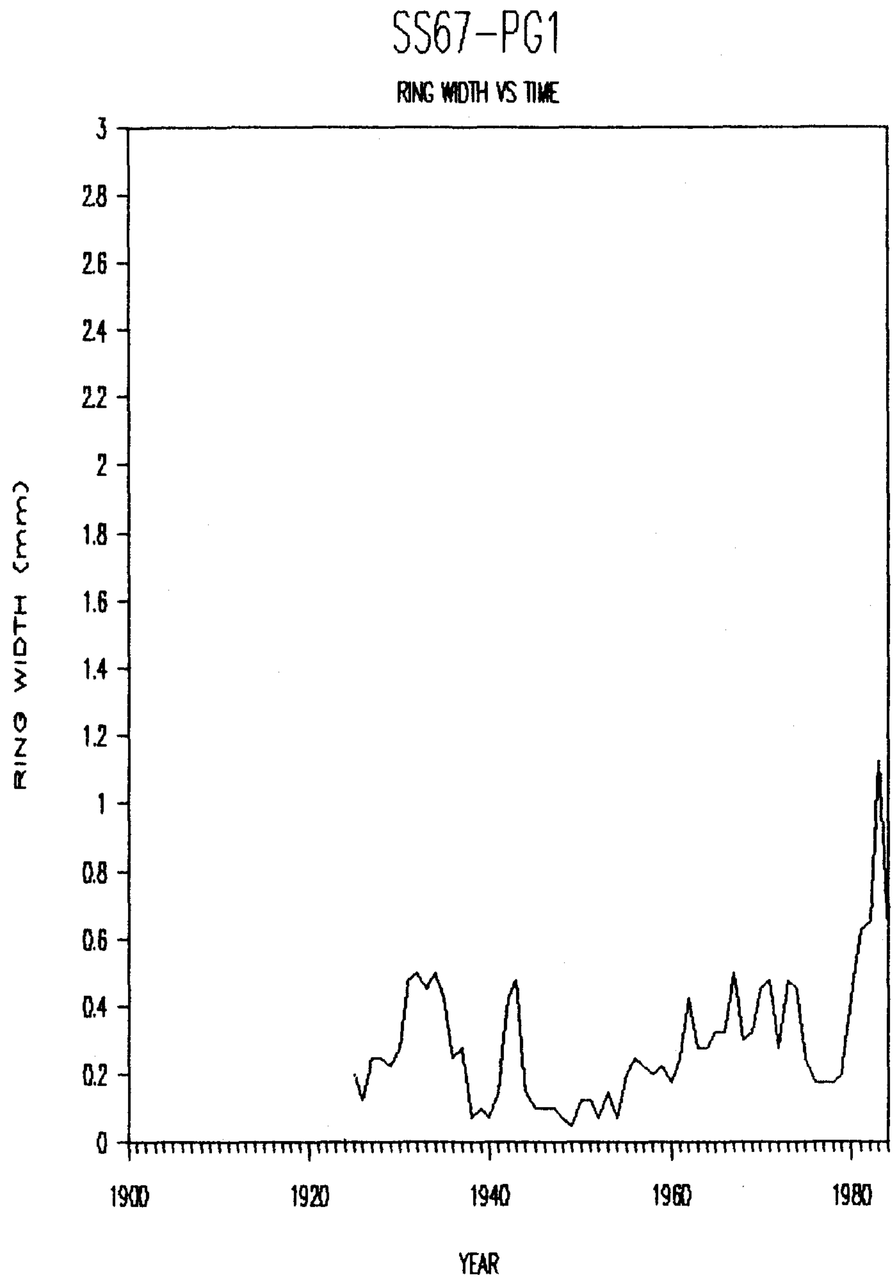


FIGURE 4.2

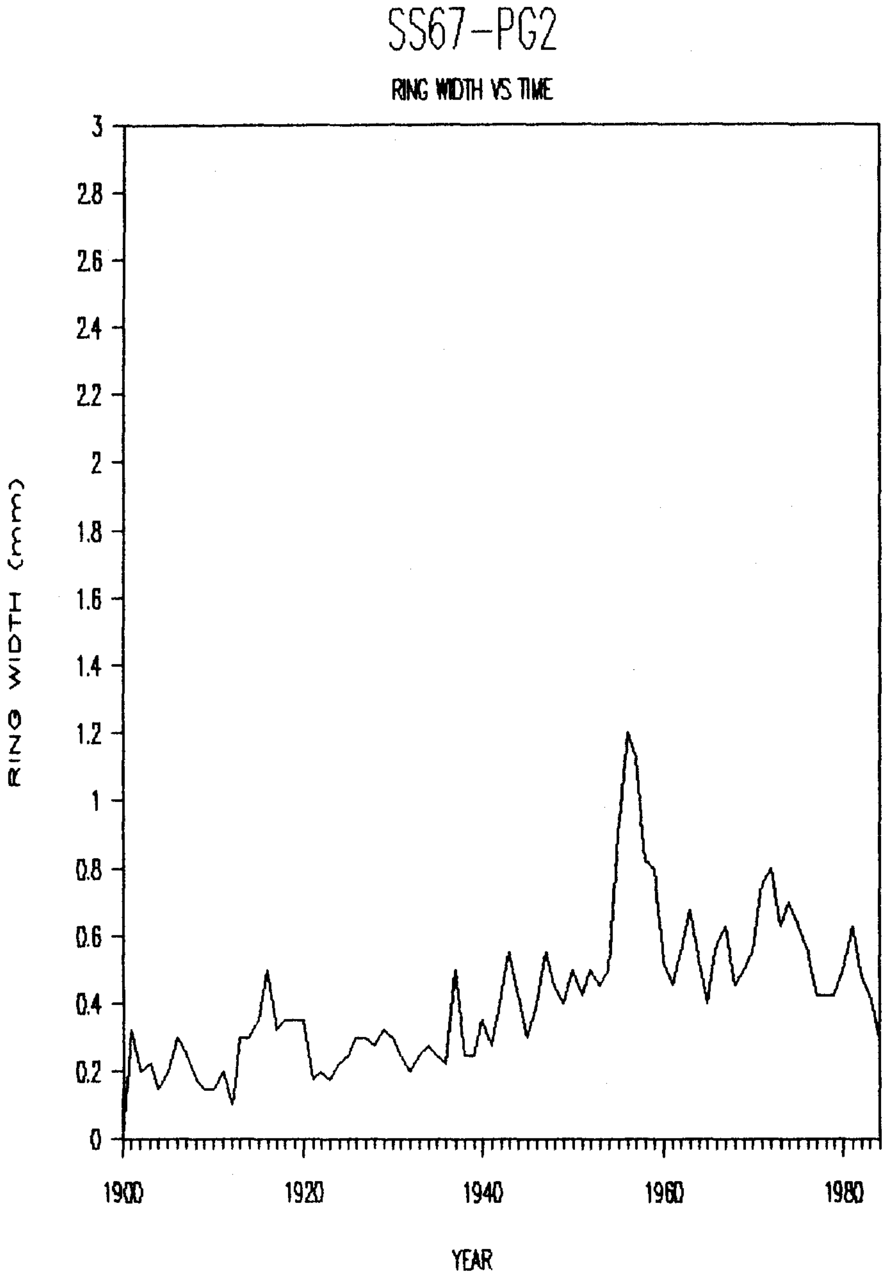
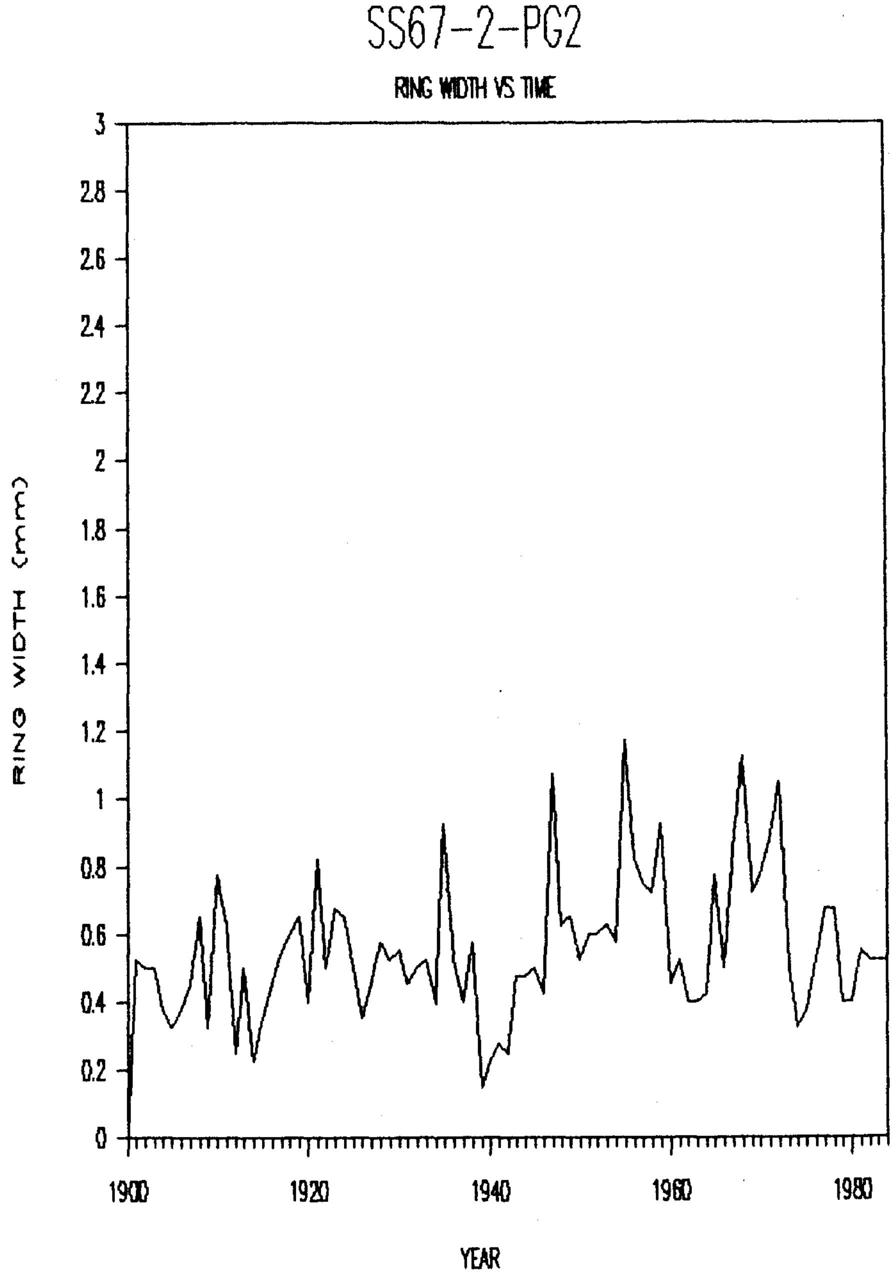


FIGURE 4.3



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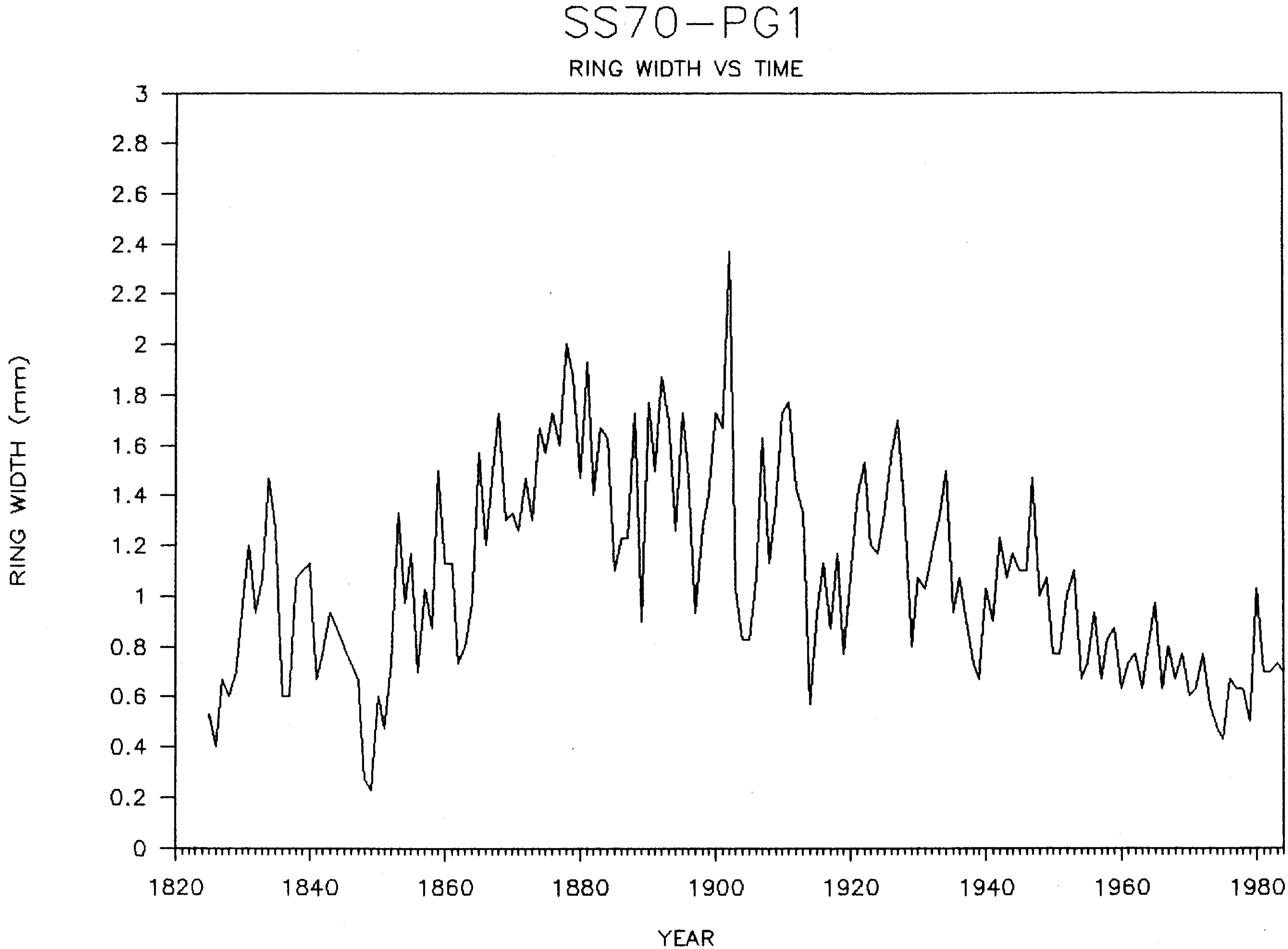

SS70-PG1
RING WIDTH VS TIME
RING WIDTH (mm)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1820
1840
1860
1880
1900
1920
1940
1960
1980
YEAR

FIGURE 4.5

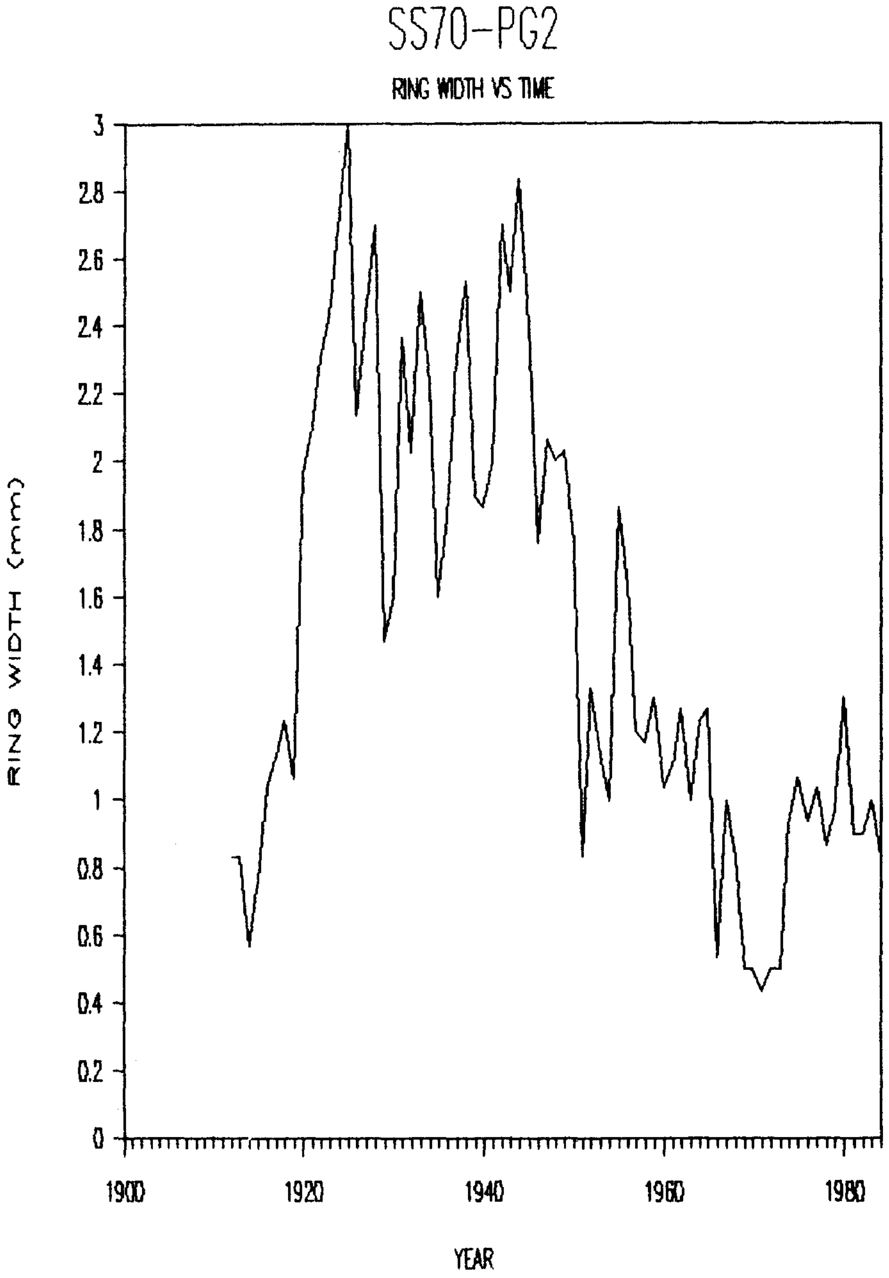


FIGURE 4.6

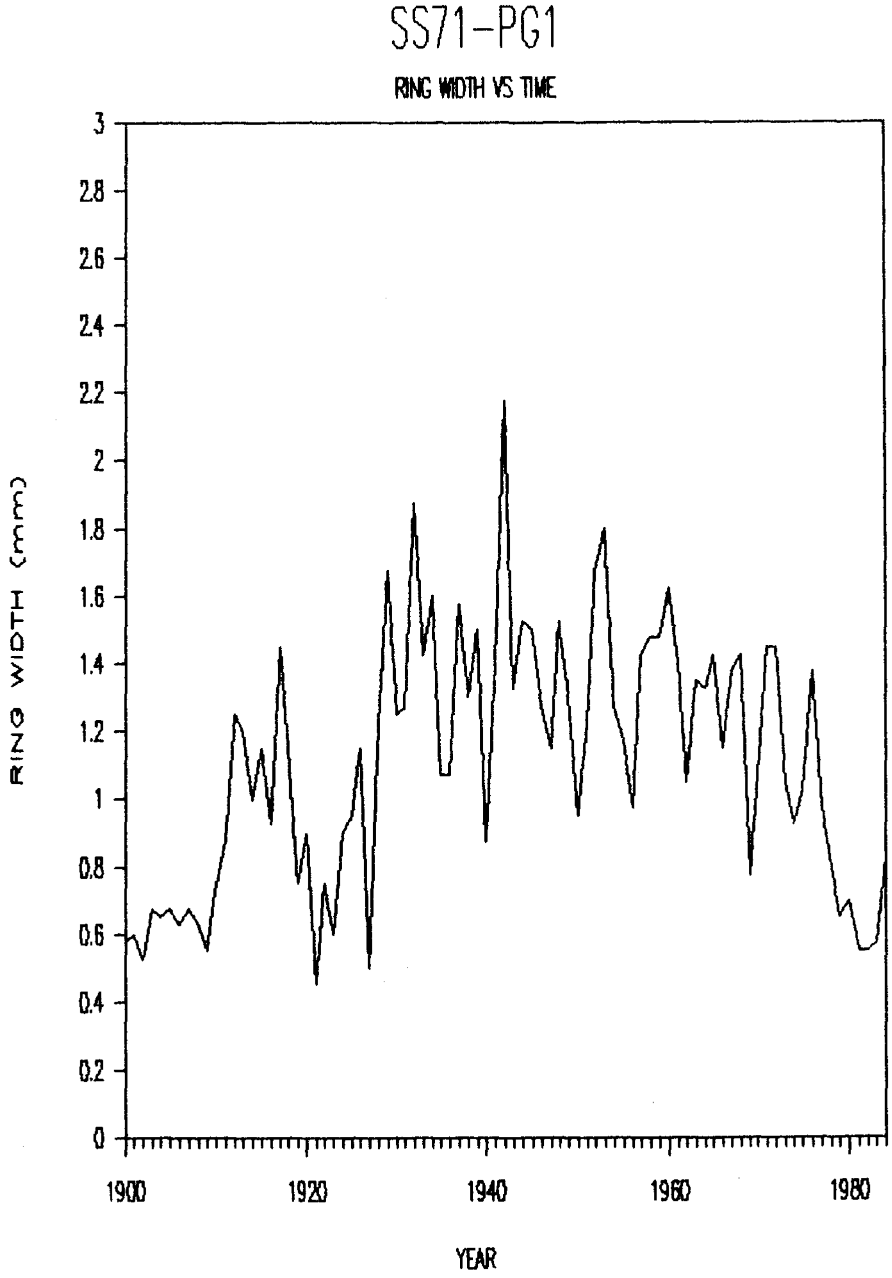


FIGURE 4.7

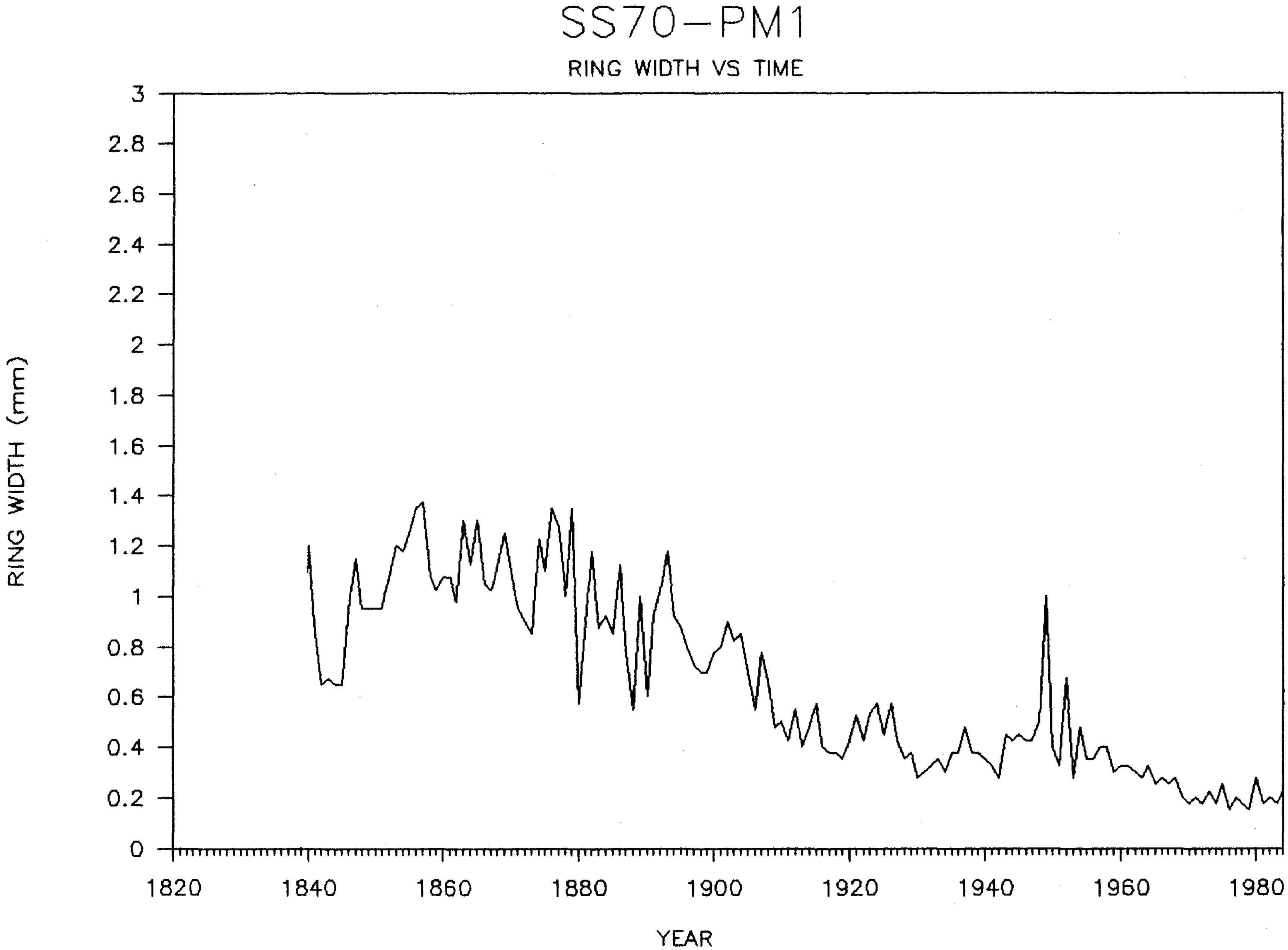

SS70-PM1
RING WIDTH VS TIME
RING WIDTH (mm)
YEAR
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3
1820
1840
1860
1880
1900
1920
1940
1960
1980

FIGURE 4.8

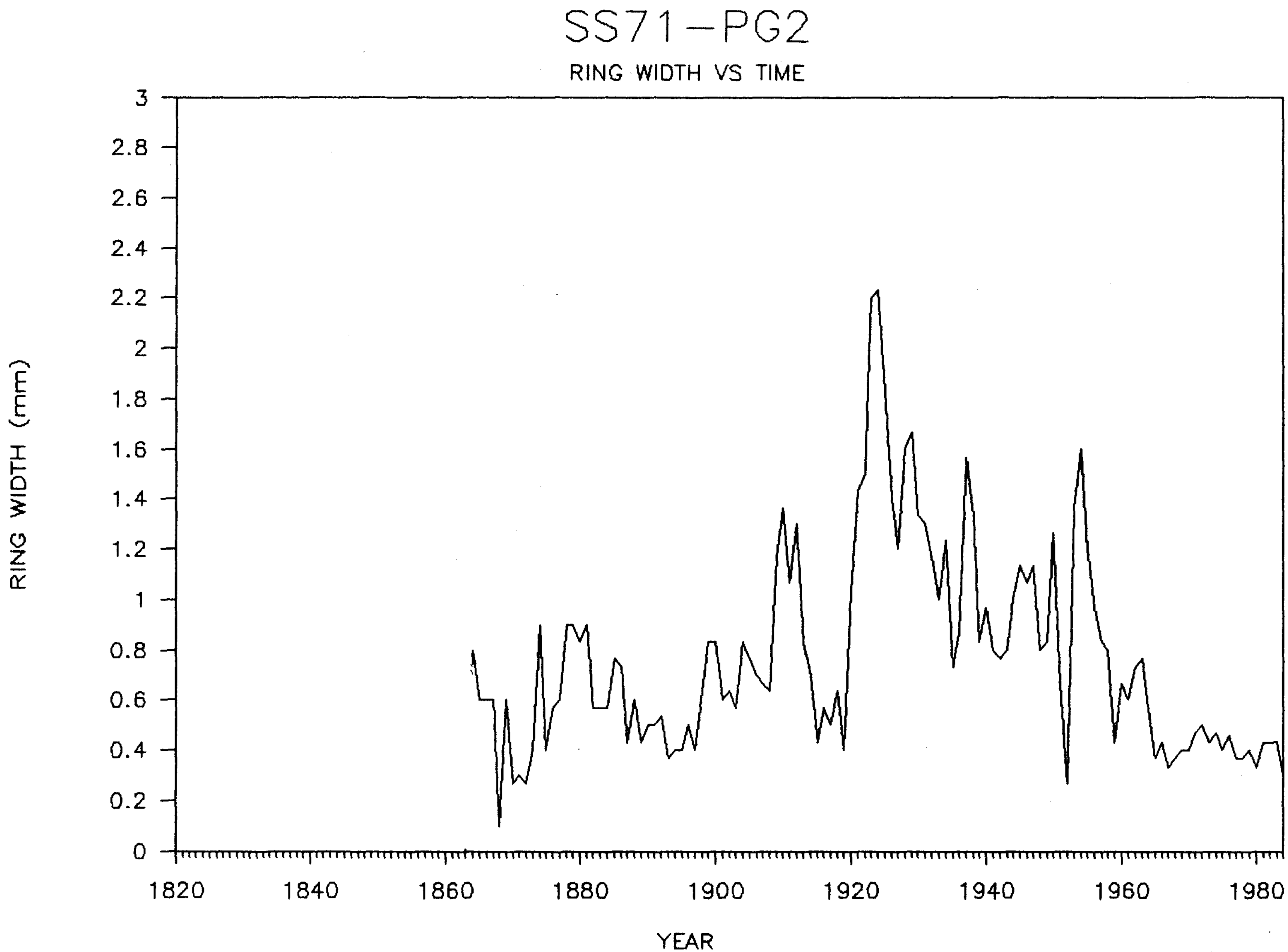
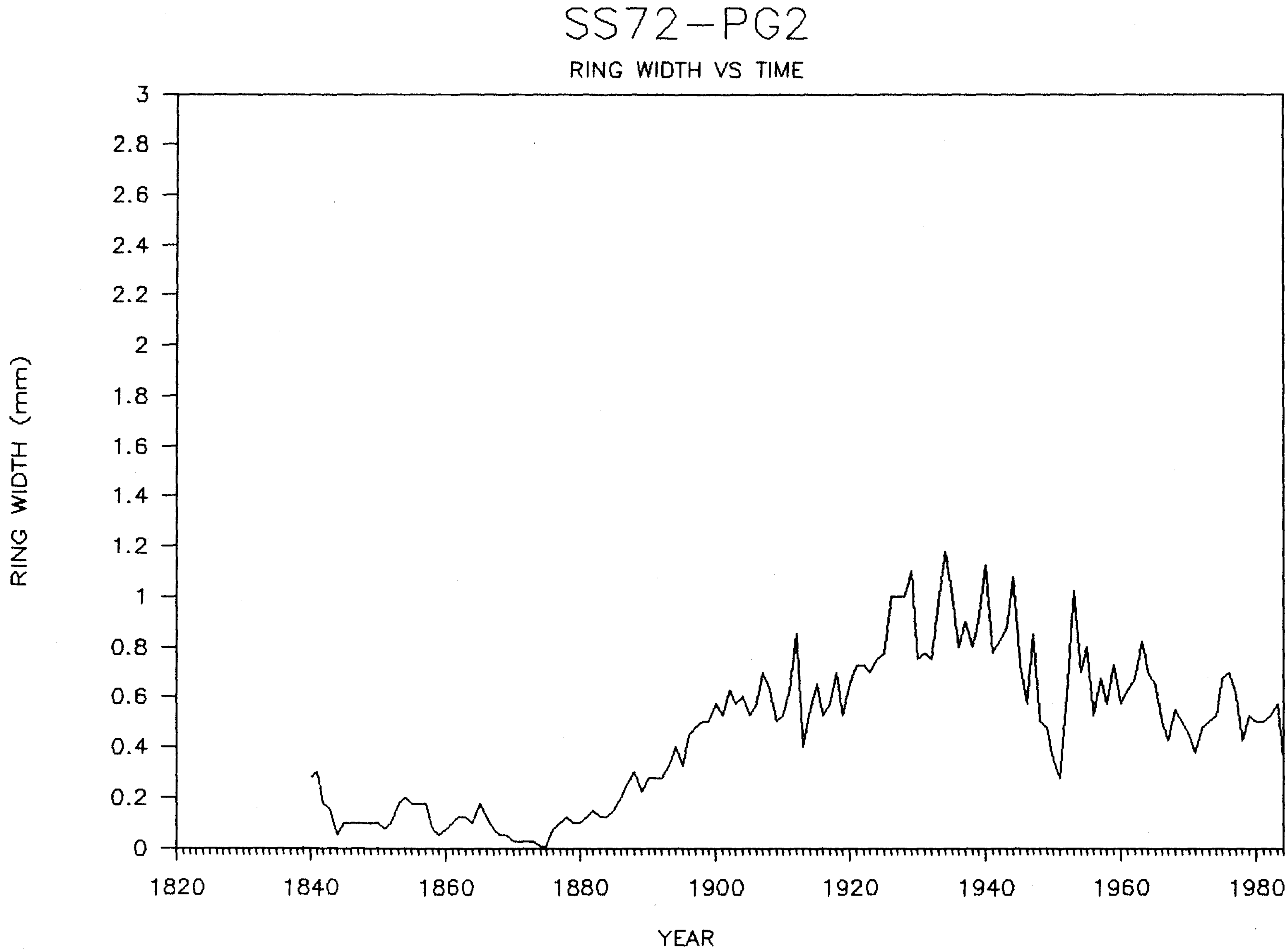

SS71-PG2
RING WIDTH VS TIME
RING WIDTH (mm)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1820
1840
1860
1880
1900
1920
1940
1960
1980
YEAR

FIGURE 4.9



SS72-PG2
RING WIDTH VS TIME
RING WIDTH (mm)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1820
1840
1860
1880
1900
1920
1940
1960
1980
YEAR

FIGURE 4.10

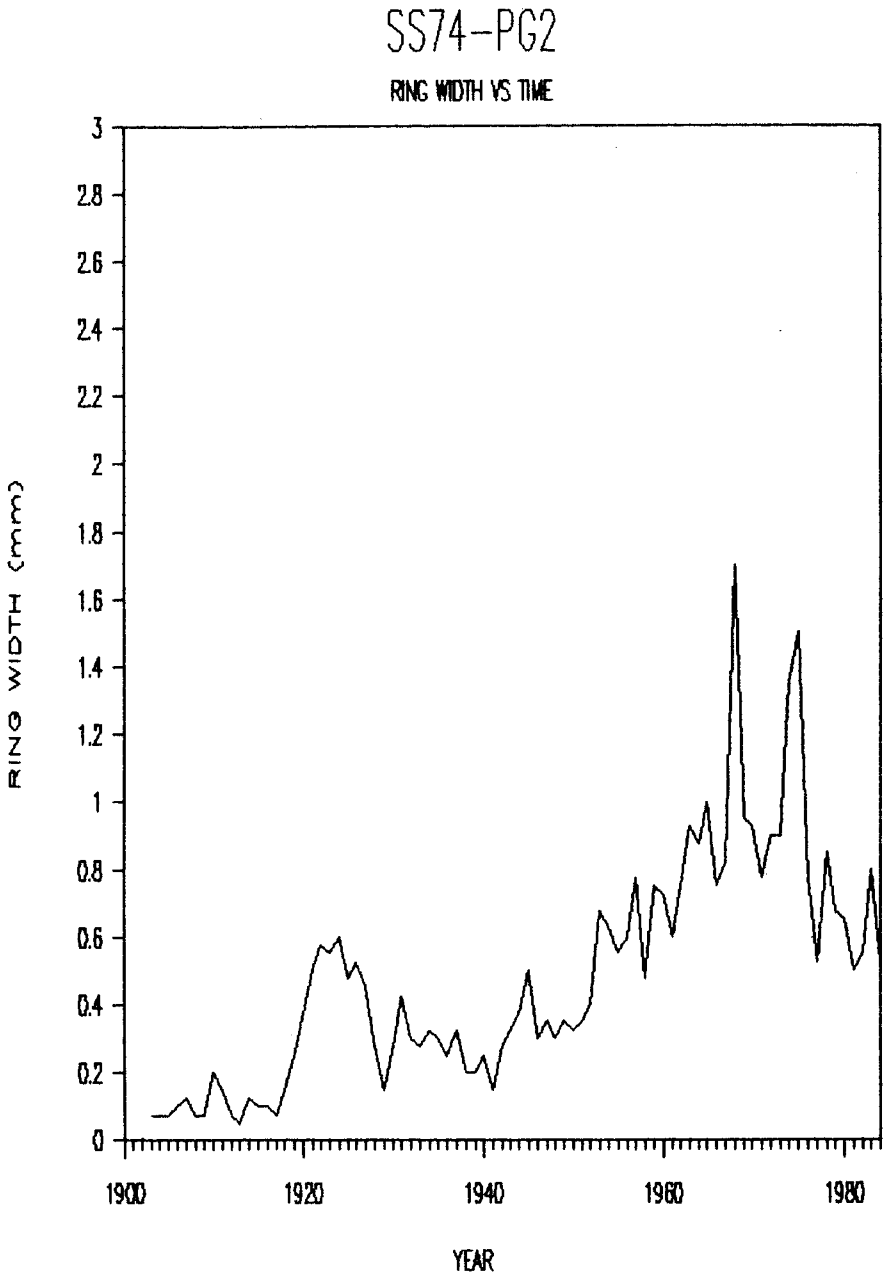


FIGURE 4.11

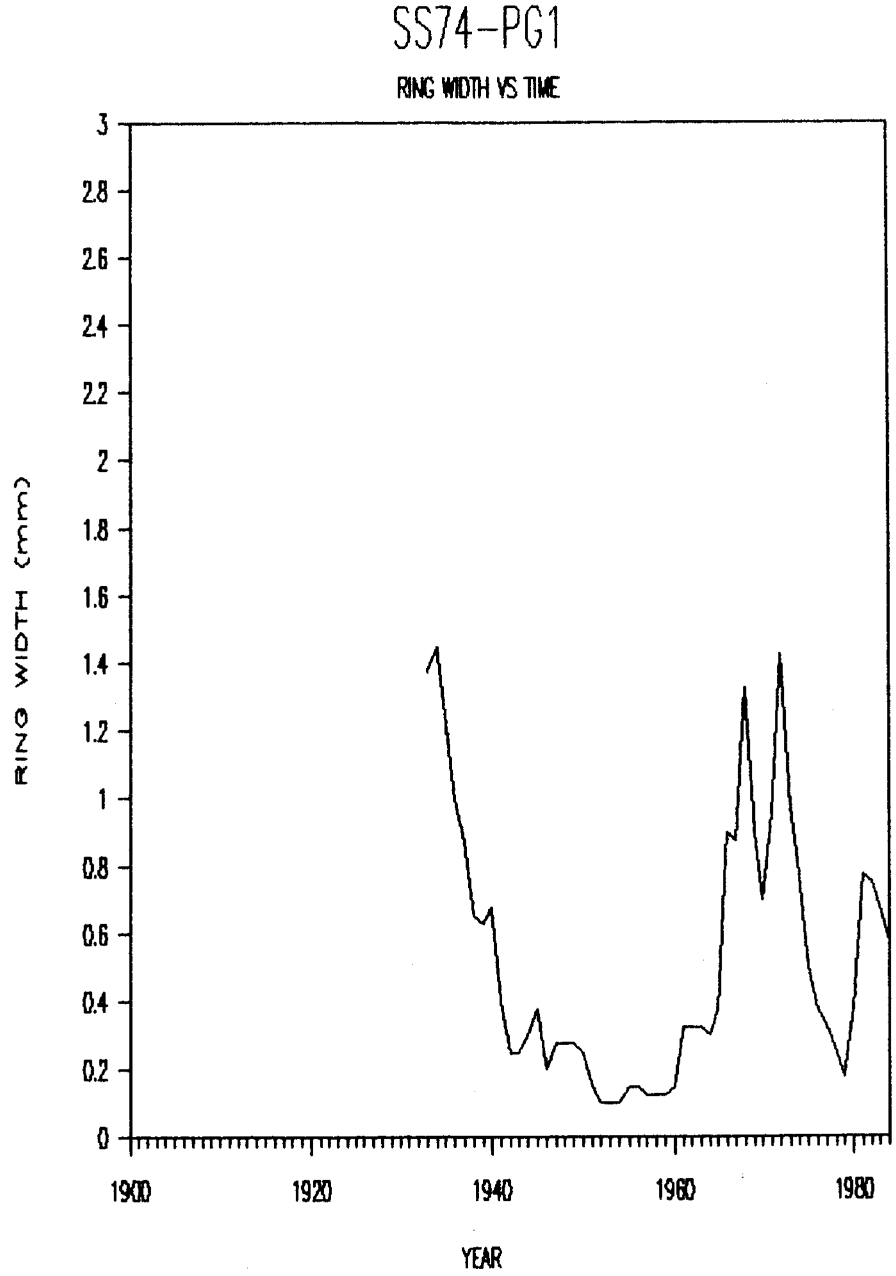


FIGURE 4.12

in age. This can be seen when the tree-ring widths are plotted against time (Figure 4.13). This growth function must be removed before any comparisons of ring widths are made between cores. The data is therefore standardized. An exponential or polynomial curve is fitted to the data and then the 'expected' value from the growth curve is divided into each individual ring width value (Stokes and Smiley, 1968; Fritts, 1971).

In the growth curves which have been plotted, no such 'growth response' was found (Figures 4.1 - 4.12). This may be a result of the trees being under climatic stress during their first years of growth. A variety of factors nay be controlling their growth such as low soil moisture. This would lead to a reduction in water absorption and a stunting of ring growth rate (Fritts, 1976). Since no growth response was present the data was not standardized and the raw data may be used thus losing no information as when standardization is done.

4.4 Calibration

The ring widths from each separate tree were plotted on a series of overlays to see if a similar pattern of tree-ring variation was present for all of the trees. Five tree core samples appeared to possess a similar pattern which suggests a climatic signal is present. An accurate relationship cannot be determined by solely using overlays. Therefore, this data is then calibrated. This is the comparison of variations found in the ring widths to other trees and to variations in the climatic

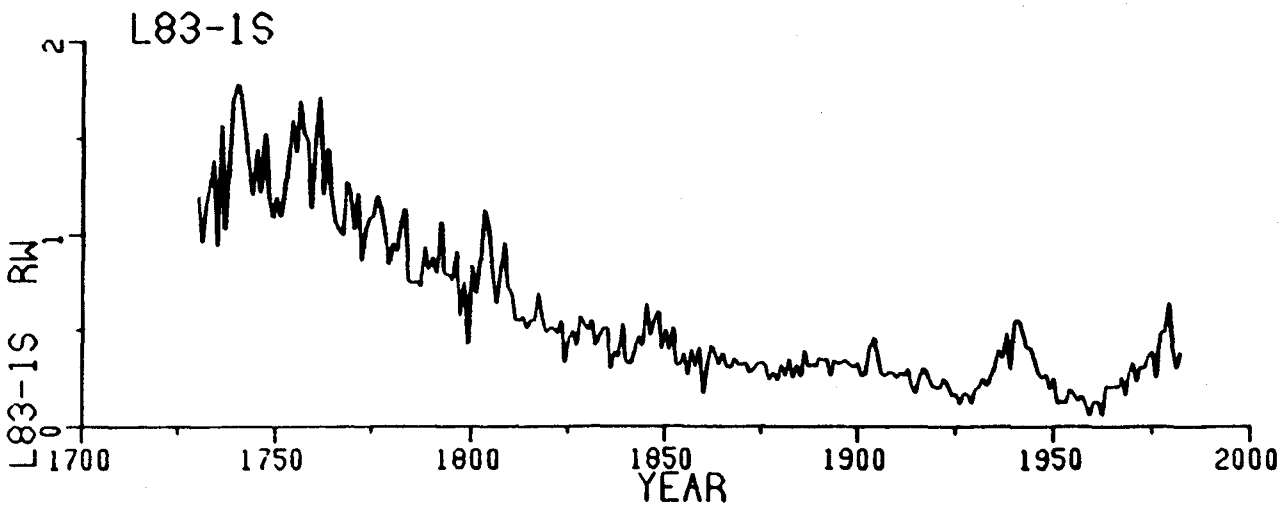


FIGURE 4.13: Exponential Ring Width Pattern for L83-1S (from Hamilton, 1984).

data. Table 4.1 illustrates the relationship of one tree to another for their annual ring widths.

For calibration, a stepwise multiple regression model was undertaken with climate as the independent variable and ring width as the dependent variable. Although most research shows evidence of one main variable, (that being temperature) responsible for the variance in tree-ring growth (Cropper and Fritts, 1981; Jacoby and Cook, 1981), some studies have also showed precipitation having an influence on ring width growth (Jacoby and Ulan, 1981,1982; Jacoby Jr., 1983). Therefore, a stepwise regression model with monthly mean temperature and monthly precipitation as the independent variables will be used. In addition, at these stresed sites accumulated seasonal temperature or moisture variation may be more important than monthly variations. Therefore, fall, winter, spring, summer seasonal temperature and precipitation variables were also used in a multiple regression analysis.

4.5 Statistical Analysis Technique

Variances in ring width are not a reflection of a single factor limiting the tree's growth. More than one factor may be limiting the growth. Also, one factor may have greater importance upon the growth rate and, this factor may have a varying degree of importance during the year. If a tree is located on a semi-arid site and receives equal amounts of high precipitation during a winter season and a summer season, the tree's growth rate will be affected in different ways. Environmental conditions which

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12
T12												X (-ve)
T11											X	X (-ve)
T10										X		X (-ve)
T9									X	X	X (-ve)	X (-ve)
T8								X	X (+ve)		X (-ve)	X (-ve)
T7							X	X (+ve)	X (+ve)	X (+ve)		
T6						X		X (+ve)	X (+ve)	X (+ve)	X (-ve)	X (-ve)
T5					X	X (+ve)	X (+ve)	X (+ve)	X (+ve)	X (+ve)	X (-ve)	X (-ve)
T4				X								
T3			X	X (+ve)								
T2		X			X (-ve)	X (-ve)	X (-ve)	X (-ve)	X (-ve)			X (+ve)
T1	X	X (-ve)	X (+ve)									

T1	=	SS 67-2 PG1	=	74 years old
T2	=	SS 67 PG1	=	60 years old
T3	=	SS 67 PG2	=	84 years old
T4	=	SS 67-2 PG2	=	84 years old
T5	=	SS 70 PG1	=	161 years old
T6	=	SS 70 PG2	=	74 years old
T7	=	SS 71 PG1	=	85 years old
T8	=	SS 70 PM1	=	145 years old
T9	=	SS 71 PG2	=	121 years old
T10	=	SS 72 PG2	=	145 years old
T11	=	SS 74 PG2	=	82 years old
T12	=	SS 74 PG1	=	53 yearsold

Table 4.1 Correlations Between Trees

limit growth rate vary between seasons and therefore, the processes which are controlling their growth will be different (Fritts, 1976).

A climatic factor found to be a significant variable in tree growth may be under the effect of another variable. This is often the case where precipitation becomes the significant variable. Precipitation is directly dependant upon temperature. The temperature of the atmosphere controls whether the outcome of precipitation is either snow or rain and the amount of moisture stress. To overcome this process, a number of different climatic variables should be used to test a relationship. A statistical technique should be undertaken where a host of variables may be used (Fritts, 1976).

The use of a simple correlation analysis is not suggested since most climatic variables are intercorrelated. If the climatic data yields a positive intercorrelation, using this method may exaggerate measures of significance for variables which are truly insignificant. Whereas negative intercorrelations will drastically reduce the significance of variables which do have a causal effect on growth. This intercorrelation between variables is not a problem when using a multiple regrssion model (Fritts, 1976).

A linear relationship is assumed to exist between some variables of growth and some climatic variables in multiple regression models. The resulting equation from this analysis represents what effect exists between a variable and growth. It is expressed as follows from Fritts (1976, p.341):

$$y_t = b_o + b_1x_{1t} + b_2x_{2t} \cdots b_mx_{mt}$$

where: y = the estimate of the predictand [growth] which varies each year (t), depending upon the values of the predictors [the climatic variables].

$b_1 - b_m$ = regression coefficients, associated with each of the 'm' predictor variables x_1 through x_m

b_o = scales the equation to the mean of the predictand.

Multiple regression techniques are most common for dendro-climatological analyses. However, the technique often requires many assumptions to be made before the analysis. Stepwise multiple regression analysis requires fewer of these assumptions. This model is used to select a small number of significant variables from the mass of variables (Fritts, 1976).

The technique involves the calculation of the correlations for all the variables, the calculation of the intercorrelations for the climate variables and the calculation between the growth and the climate variable, to examine if any correlation exists. The climatic variable which correlates best with growth is placed first into the regression equation and correlations for the other variables are recalculated. The climatic variable with the next highest correlation is then added into the equation. A new equation is obtained from this. Variables continue to be added into the equation until no more are found to have significance. (Fritts, 1976; Younger, 1985).

4.6 Variables

The growth of trees located on stressed sites vary greatly in their annual ring widths. These fluctuations in growth rates may be the result of climatic conditions not only of the current year but also of the prior year (Garfinkel and Brubaker, 1980). Therefore, a large set of variables which may have an effect on growth rate are used.

The climatic variables examined are for precipitation and temperature over a 15-month period, reflecting the possible influence of climate for the prior year and current year upon growth rates. A positive correlation value would reveal a direct relationship between the variable and growth rate whereas a negative correlation value would reflect the existence of an inverse relationship (Garfinkel and Brubaker, 1980).

The climatic variables being examined may be reduced by amalgamating the various months into seasons (Table 4.2). The seasons must be related to either prior or present effects influencing growth rates. The climatic variables for the seasonal responses are recorded separately for precipitation and for temperature to examine their separate effects on growth rate (Guiot et al., 1982).

MONTHLY VARIABLES		SEASONAL VARIABLES
JUNE JULY AUGUST	PRIOR	SUMMER - PRIOR
SEPTEMBER OCTOBER NOVEMBER	PRIOR	AUTUMN - PRIOR
DECEMBER JANUARY FEBRUARY		WINTER
MARCH APRIL MAY	CURRENT	SPRING - CURRENT
JUNE JULY AUGUST	CURRENT	SUMMER - CURRENT

Table 4.2 The Amalgamation of Monthly Climate Variables

CHAPTER 5

RESULTS

5.1 INTRODUCTION

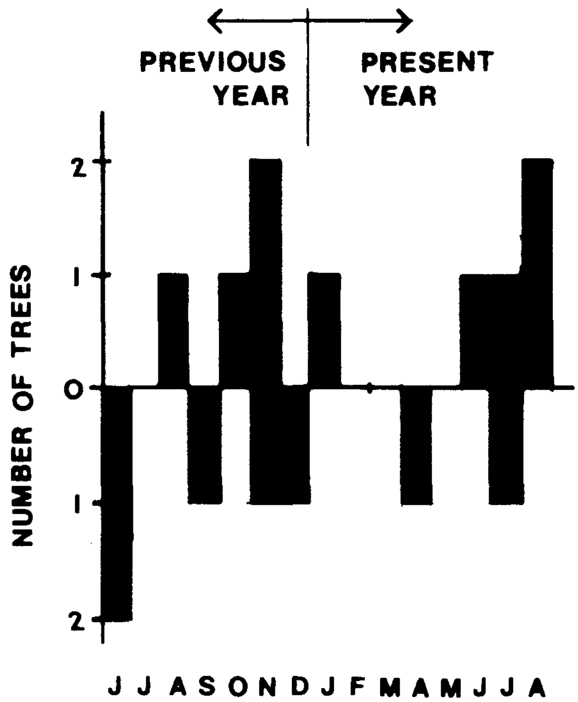
The results from the stepwise multiple regression comparison of monthly and seasonal temperature and precipitation with tree-ring widths are presented in Figures 5.1, 5.2, 5.3, 5.4. Temperature and precipitation variables are graphed separately. The number of trees having a significance of 95% or better with each variable is graphed. Trees possessing positive correlations with climate variables appear above the 'zero' line whereas trees possessing negative correlations with the climate variables appear below it.

5.2 TEMPERATURE

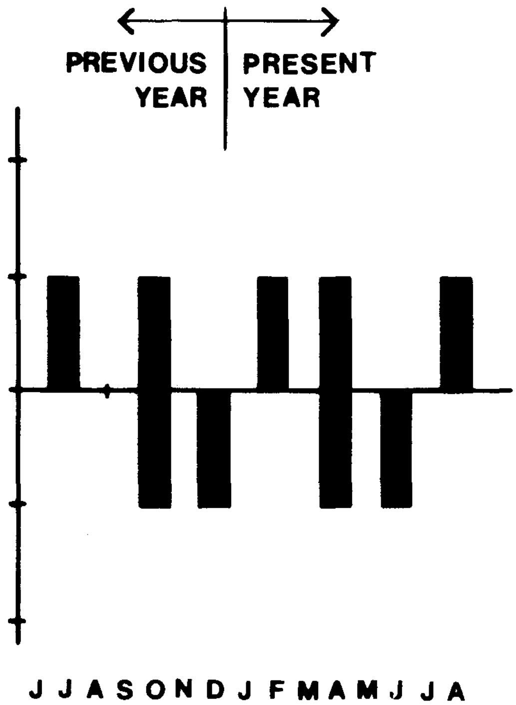
There appears to be a wide variation in the relationship between monthly temperature and growth rate (Figure 5.1). Except for July of the previous year and February, March and May of the present, the climate variables are each significantly correlated with the ring widths of one or two trees. November and July both have a negative and positive relationship with the ring width of different trees. The only climate variables significantly correlated with ring widths of two trees are June and November temperatures of the previous year and August temperature of the current year.

TEMPERATURE | PRECIPITATION

MONTHLY

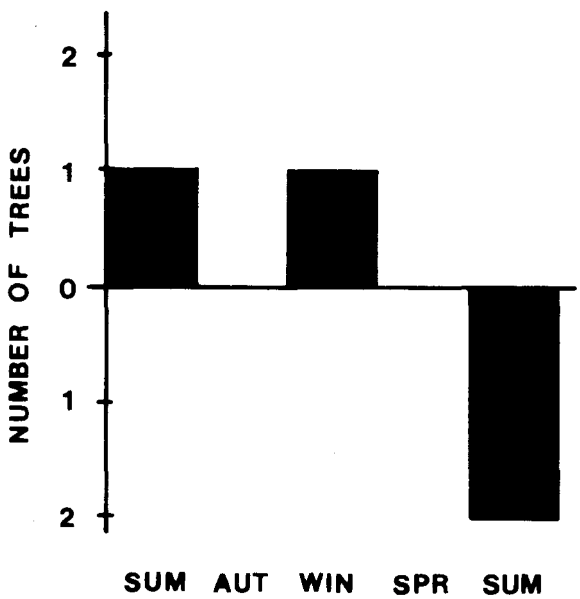


(FIG. 5.1)

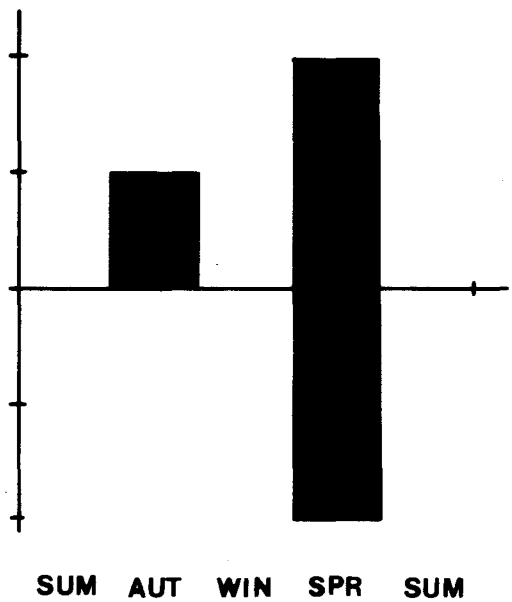


(FIG. 5.2)

SEASONAL



(FIG. 5.3)



(FIG. 5.4)

The amalgamation of monthly variables to create seasonal variables does not exhibit any clearer relationship between climate and ring width (Figure 5.3). No single season appears to be the dominant factor controlling growth. The previous summer and winter seasons each have a positive correlation whereas the summer of the current growing season consists of two negatively correlated responses.

5.3 Precipitation

The relationship of monthly precipitation on ring width is very irregular (Figure 5.2). Only seven of the months; July, October, December of the prior year and February, April, June and August of the current year, possess a significant relationship with ring widths of any trees. Each month is only significantly correlated for a single tree.

Figure 5.4 illustrates that seasonal precipitation also has a poor general relationship with ring width. Autumn of the prior year has a single tree responding positively with it and spring of the current year possesses negative and positive correlations of two trees each.

CHAPTER 6

FINDINGS AND CONCLUSIONS

6.1 Findings

The results presented here provide no clear indication of a relationship between neither temperature nor precipitation to the growth of *Picea mariana* at the treeline northeast of Yellowknife. However, significant correlations between certain climate factors and ring width were found for some trees. I will discuss the likely cause of these correlations. I will then discuss why in general the correlations were so poor.

High summer temperatures of the previous year along with high winter temperatures reveal that one tree benefits from this climate by having an increased growth rate the following year. High summer temperatures in the prior year will have a positive effect on growth rate by storing away carbohydrates and photosynthates. These nutrients may be stored within the tree and not used during that season for late radial growth but rather utilized the next year, therefore increasing nutrient availability for the following year and thus increasing the growth rate (Garfinkel and Brubaker,1980).

One tree responds positively to high winter temperatures. The development of reaction wood is common in permafrost areas and may result in an unclear climatic response (Jacoby and Ulan, 1981). High winter temperatures would result in the thinning of the permafrost layer at an earlier time. Growth may begin earlier in the season. The length of growing season would therefore be increased and this would reflect in a thicker ring width.

Within these sites two trees show a negative correlation between ring width growth and temperature. This reveals that the two trees react to high summer temperatures in the current growing season by growing small rings; their growth has been stunted. This could be a combined reaction where the trees are also dependent upon precipitation. Low precipitation rates would increase moisture stress upon the tree. With the accompaniment of high temperatures, the evapotranspiration rate of the soils would be increased and the soil moisture stress accentuated. High temperatures may also cause an increase in the rate by which nutrients are utilized (Fritts, 1976).

The effects of precipitation are often dependent on temperature. It is difficult therefore to monitor what effect precipitation has on its own (Garfinkel and Brubaker, 1980). One tree is positively correlated with autumn precipitation. High precipitation in the autumn season and current spring may lead to increased growth rates in the following summer. This is emphasized in areas where the growing season is short such as at the treeline (Bradley,1985). High autumn precipitation may fall as snow if the temperatures are high enough. This would insulate the soil and root system of the tree against any moisture stress (Fritts, 1976).

A very weak relationship also exists in two trees between spring precipitation and ring width. High precipitation in the current spring also alleviates soil moisture stress and internal water stress. These processes are necessary for rapid and healthy growth of the tree in a short growing season (Fritts, 1976).

High precipitations may also be negatively correlated with ring width as is for two of these trees. This is a primary concern for areas underlain by permafrost (Jacoby and Ulan, 1981). Permafrost inhibits adequate drainage and this excessive moisture drowns the roots and decreases the oxygen in the soil which results in low growth rates (Fritts, 1976).

A consistent pattern between tree-ring width and climate does not exist. Relationships between ring width and the monthly climate variables is widespread and poor as is the relationship between ring width and the seasonal climatic variables. The trees appear to be responding to various variables. Examination of the correlation between trees (Table 4.1) reveals that not all trees are correlated with one another. In the 57% which are, fifty percent have a negative correlation and fifty percent have a positive correlation. The samples are not responding in a general pattern but rather individually. This suggests that the site to site variations in microhabitats have a stronger influence on tree growth as measured by ring width than the variations in regional climate.

The trees may each be responding to various nonclimatic factors (noise). If the samples were collected from trees located on disimilar sites such as north and south-facing slopes, or in both wet and dry areas, these contrasting environments would distort of lose the climatic 'signal' (Fritts, 1982).

By increasing the number of trees sampled and the number of cores extracted from each tree, these variations between the individual habitats may possibly be overcome. The 'noise' may be balanced and may allow the climatic 'signal' to be increased. A climatic response to regional climate may then possibly be established (Fritts, 1982).

6.2 Conclusion

Each tree is an individual and therefore often reacts to environmental conditions differently. This appears to be occurring with Picea mariana sampled along the treeline northeast of Yellowknife. No single climatic variable; monthly or seasonal, temperature or precipitation, possessed any strong or general correlation with the rate of tree growth as represented by ring width. Microhabitat variations within each site appear to be stronger factors limiting tree growth than the variations in regional climate thus limiting the climatic response, and making climatic reconstruction of the area not possible.

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