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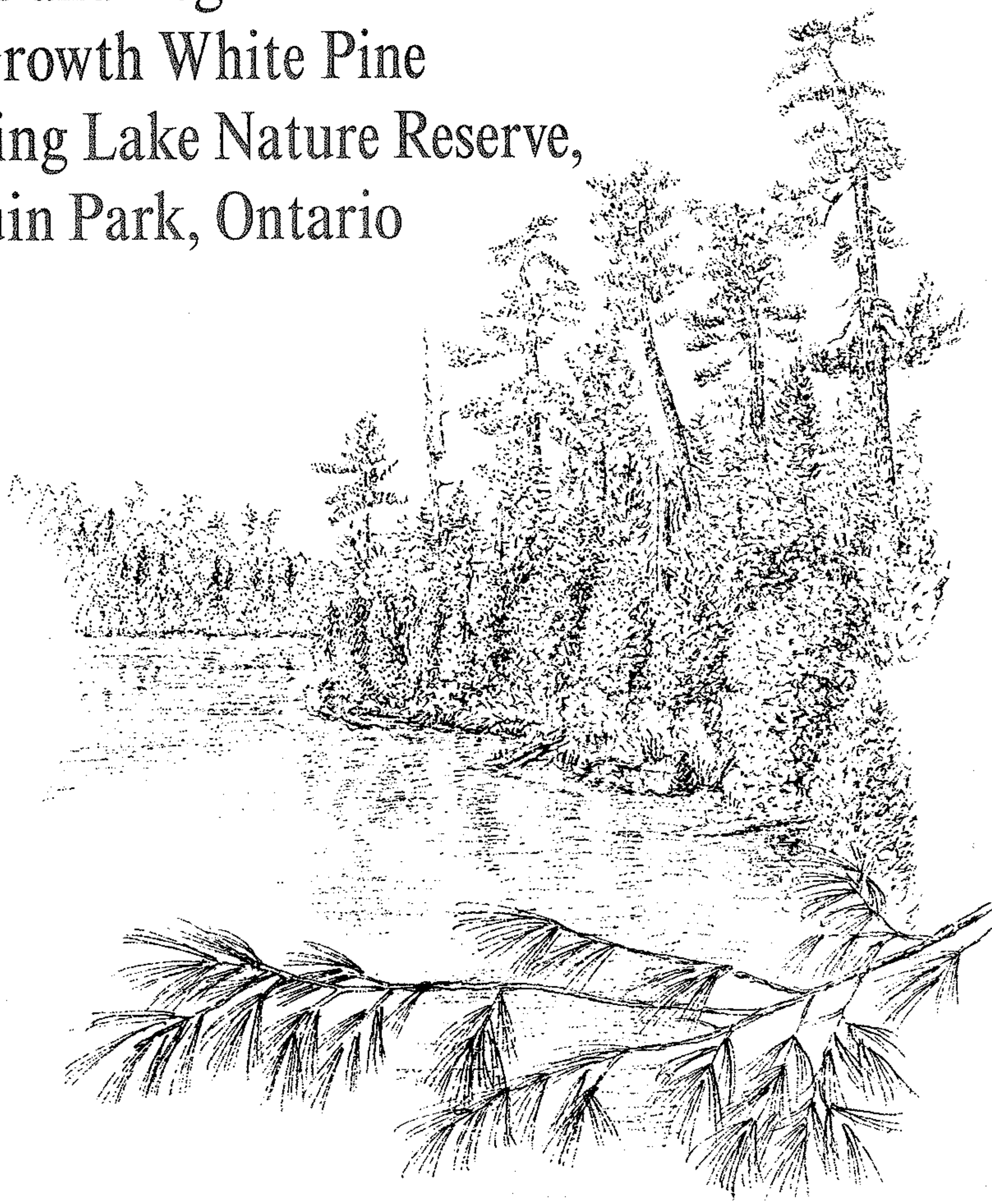
Age, Size and Regeneration of Old Growth White Pine at Dividing Lake Nature Reserve, Algonquin Park, Ontario



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Age, Size and Regeneration of Old Growth White Pine at Dividing Lake Nature Reserve Algonquin Park, Ontario

by

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Abstract

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The age, mode of regeneration and diameter growth of white pine were determined in an old growth stand near Dividing Lake, Algonquin Provincial Park. The white pine ranged in age from 267 to 486 years. There was no significant relationship between white pine age and diameter (DBH). The distribution of tree ages indicated that the white pine component in this mixed pine-hardwood stand was multi- or all-aged. Most of the pine sampled regenerated during 2 periods (circa 1650 and 1710). However, some pine regeneration occurred throughout the period from 1507 to 1726. Cycles of relatively minor stand disturbances by surface fires or windthrow, with less frequent major disturbances by more intense fires, may have led to the development of this multi-aged pine forest. The most common form of white pine regeneration was advanced reproduction. Ring width series have been developed for the Dividing Lake white pine.

Keywords: white pine, old growth, regeneration, disturbance, age, dendrochronology

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Introduction

The Ontario provincial government has taken steps to preserve the remnant old growth white and red pine forests on Crown land. In 1992, the Ontario Ministry of Natural Resources (OMNR) developed the Old Growth Conservation Initiative and created an Old Growth Policy Advisory Committee to formulate a strategy for conserving old growth forests in Ontario. In February 1995, the Minister reserved from development another 2,402 ha of white and red pine old growth located in Shelburne and Delhi Townships of the Obabika Lake area. To date, the OMNR has designated 32,781 ha of old growth white and red pine reserves, and additional areas are being considered for protection. Although much attention has been given to protecting these old growth ecosystems, we know little about their structure and function or about the natural disturbance processes that formed them.

The Old Growth Forests Policy Advisory Committee recommended the development of a set of indices for identifying, evaluating and monitoring old growth forests (OMNR 1994). The committee stated that the indices should address such old growth features as age, natural disturbance history, and species and structural diversity. It recognized that to develop old growth conservation strategies, we must understand how natural disturbances like fire affect forest regeneration. The committee realized that fire is an important natural disturbance factor in old growth pine ecosystems and that fire suppression has altered natural successional processes. It emphasized the need to learn more about the role of fire in old growth forests as well as the structure and function of these unique ecosystems.

The Great Lakes-St. Lawrence Silviculture Program at the Ontario Forest Research Institute is evaluating the role of fire in hardwood-pine forests in central Ontario. The fire history in these forests will be reconstructed by sampling the relic old growth white and red pine stumps that exist in the understories of the current forests.

In the summer of 1994, pine stumps from 3 sites in Algonquin Provincial Park and 1 site in the Bracebridge area were sampled. A master ring width chronology is being developed for white and red pine, and it will be used to date any fire scars that are observed in the samples of relic white and red pine stumps. In the summer and fall of 1994, live old growth white and red pine from Hobbs Township (North Bay District) and Dividing Lake (Algonquin Provincial Park) were sampled, and these samples will be used to construct the master ring width chronologies. This Research Report gives preliminary results from the old growth white pine stand at Dividing Lake.

Methods

Two increment cores were taken at a bole height of 1.4 m from each of 28 dominant white pine in an old growth stand near Dividing Lake, Algonquin Provincial Park. For each tree, bole diameter (at 1.4 m), slope and aspect were also recorded. Cores were mounted, and using 600-grit paper, were sanded to a final surface. Annual rings were cross-dated and measured. Germination dates were estimated by adding 10 years to the pith dates found on the cores. When pith dates could not be read directly from the cores due to heart-rot, the number of missing rings was estimated by multiplying the length of the missing radius times the estimated growth rate for the inner 20-year period.

The mode of regeneration was determined for each white pine sampled by analyzing the temporal pattern and rate of change of ring widths from increment cores that were sound to the pith. Three processes were considered as reasonable alternatives for the regeneration of white pine: (1) new seedlings that develop in a large canopy opening, (2) new seedlings that develop in a small canopy opening and (3) advanced reproduction (i.e., white pine seedlings that established under a mature canopy) that develops when an opening forms in the main canopy. Individual pines were assigned to specific regeneration classes based on the following criteria:

Regeneration Class L – new seedlings that establish in large canopy openings:

1. gradually increasing ring widths the first 5 to 10 years,
2. followed by 30 to 50 years of relatively large diameter increments,
3. with subsequent decreases in diameter growth.

Regeneration Class I – new seedlings that establish in small canopy openings:

1. relatively narrow ring widths initially,
2. followed by gradual increases in ring widths for extended periods.

Regeneration Class A – advanced reproduction:

1. narrow ring widths for long periods,
2. followed by an abrupt increase in ring widths.

Results and Discussion

White pine age and diameter relationship

Although much discussion has focused on what to include in a definition of old growth, there is no commonly accepted, detailed definition for old growth white pine stands in Ontario (Hunter 1989, Duchesne 1994, OMNR 1994). Obviously, the age of white pine is a characteristic common to all definitions. In this study, dominant white pine were from 267 to 486 years old (Tables 1 and 2). This age range is comparable to ages reported for old growth white pine in the Lake States (Graham 1941, Stearns 1950, Wells et al. 1983). Some researchers have used diameter as an indicator of white pine age (e.g., Quinby 1991); however, in the dominant white pine sampled at Dividing Lake, there was no significant correlation between the age and diameter (DBH) (Figure 1, Table 3). The second oldest tree (457 years) had the smallest DBH, while the oldest tree (486 years) was one of the largest pines (117 cm).

The age of white pine was negatively correlated with growth rate (Table 3), suggesting that older trees have relatively slow growth rates (Figure 2). The diameter of white pine was positively correlated with growth rate (Table 3), indicating that larger pines grow faster than smaller trees (Figure 3).

These results highlight the lack of relationship between the age and DBH of dominant, old growth white pines: Larger trees grow faster than smaller trees, but larger trees are not necessarily the oldest trees. Therefore, estimating age based on a tree's diameter is not recommended for characterizing the age structure of old growth white pine stands.

White pine age structure

Although canopy dominance and tree size suggest an even-aged white pine component in these mixed pine-hardwood stands at Dividing Lake, tree ages varied by at least 200 years (Table 1). White pine older than 400 years made up 20% of the dominant trees sampled, while 52% were 300 to 400 years, and 28% were from 250 to 299 years old. A frequency distribution of age class for white pine approximates a reverse J-curve, indicating an all-aged or multi-aged forest (Figure 4). Quinby (1991) reported that old growth white pine forests in the Temagami area were at least partially uneven-aged; however, he based his analysis on tree

Table 1. Age and growth data for dominant, old growth white pines sampled at Dividing Lake, Algonquin Provincial Park, Ontario. The errors in the age estimates are a function of the increment core quality and the number of missing rings (hollow trees) within some trees. Radial growth rates are presented as an average of the entire increment core and for the innermost 20 growth rings on each core.

Germination year	Age (years)	Error in age estimate (± years)	DBH (cm)	Radial growth rate	
				Entire core	Inner 20 rings
				-------(mm/radii/year)-------	
1507	486	23	117	0.82	1.85
1537	457	3	53	0.63	0.50
1562	431	18	89	0.71	1.17
1576	417	162	62	0.89	0.67
1584	409	15	69	0.63	0.87
1607	386	3	109	1.11	2.22
1612	381	71	78	0.91	1.15
1631	362	39	67	1.18	0.32
1637	357	4	---	0.65	1.00
1640	353	35	96	1.01	1.75
1645	348	2	77	0.79	1.40
1648	345	5	75	0.83	1.30
1651	342	8	108	1.36	1.70
1651	342	54	83	0.87	1.86
1656	338	22	85	1.08	2.50
1665	329	23	92	1.10	1.80
1687	306	26	98	1.48	2.12
1688	305	3	72	1.18	1.57
1698	295	14	84	1.16	1.77
1699	294	29	125	1.67	3.62
1707	286	30	118	1.68	2.43
1710	283	4	70	0.99	1.25
1721	273	3	82	1.25	2.35
1721	273	3	67	1.18	0.63
1726	267	43	57	1.10	0.82

Table 2. Age and growth statistics for dominant, old growth white pine sampled at Dividing Lake, Algonquin Provincial Park, Ontario. The growth rate is the average ring width calculated from the increment cores. The growth rate 20 is the average ring width per year for the innermost 20 rings.

Variable	N	Mean	Std. dev.	Min.	Max.
Age (years)	25	347	60	267	486
Pith date (years)	25	1647	60	1507	1727
Growth rate (mm/yr.)	28	1.03	0.28	0.63	1.68
Diameter (cm)	25	84.7	19.8	53.0	125.0
Growth rate 20 (mm/yr.)	28	1.50	0.73	0.32	3.62

Table 3. Correlation coefficients between diameter (DBH), tree age, growth rate and growth rate 20 for dominant white pine sampled at Dividing Lake, Algonquin Provincial Park, Ontario. The growth rate is the average ring width (mm/year) calculated from all growth rings sampled. The growth rate 20 is the average ring width (mm/year) for the innermost 20 rings. Note that there is no significant correlation between age and size.

Correlation analysis			
	Age	Growth rate	DBH
	-0.02	0.56	
DBH	0.902	0.001	------
	24	24	
	-0.32	0.63	0.81
Growth rate 20	0.1100	0.0003	0.0001
	25	28	24
		-0.66	-0.025
Age	------	0.0003	0.9071
		25	24

diameter rather than on actual measures of tree age. Multi-aged old growth white and red pine stands have been documented in Itasca State Park (Spurr 1954, Frissell 1973), northern Wisconsin (Maissurow 1941), Michigan (Whitney 1986) and Algonquin Park, Ontario (Cwynar 1977). Other authors have reported that the pine in mixed-species or pure old growth stands in the Great Lakes-St. Lawrence region were even-aged (Maissurow 1935, Duchesne 1994). Age analysis of relic red pine stumps from a site near Basin Lake, Algonquin Provincial Park, indicated that the previous old growth red pine forest was even-aged and originated between 1670 and 1680 (R. Guyette, University of Missouri, Columbia, MO, unpublished data).

Heinselman (1981) suggested that there are essentially 2 types of white and red pine ecosystems: (1) those that result from frequent light fires every 5 to 50 years, with severe fires occurring at longer intervals (typical of xeric, pyrogenic sites); and (2) those that result from stand-replacing fires that occur at intervals of 150 to 300 years, with some seedling establishment following minor stand disturbances between severe fires (typical of more mesic ecosystems or sites protected from fire). The former disturbance regime may lead to white and red pine forests that tend to be even-aged, while the latter regime may produce multi-aged white pine forests.

White pine regeneration

For dominant trees that were cored near the pith, advanced reproduction was the most frequent mode of regeneration (Table 4). This reproduction may have recruited into the overstorey as a result of periodic disturbances (e.g., light surface fire or windthrow) that caused canopy openings. However, a frequency distribution of estimated germination dates indicates that there were periods (circa 1650 and 1710) of more frequent recruitment (Figure 5).

Table 4. Regeneration data for old growth white pine at Dividing Lake, Algonquin Provincial Park, Ontario.

Pith date (ground level)	Date of first growth release	Age at release	Total tree age	DBH (cm)	Growth rate (mm/year)	Regeneration Class[a]
1688	1746	57	305	72	1.18	A
1537	1692	155	457	53	---	A
1721	1796	75	273	67	1.18	A
1656	1710	54	338	85	1.08	I
1631	1868	236	362	67	1.18	A
1687	1709	21	306	98	1.48	A
1576	1865	288	417	62	0.89	A
1699	---	---	294	125	1.67	L
1707	1762	54	286	118	1.68	A
1637	---	---	357	---	0.65	L

[a] Regeneration classes: A = advanced reproduction, I = new seedlings in small canopy gaps, L = new seedlings in large canopy gaps.

Many researchers have documented the occurrence of multi-aged white and red pine forests that resulted from light surface fires about every 30 to 45 years, with more severe fires occurring at intervals from 130 to 200 years (Spurr 1954; Frissell 1973; Heinselman 1973, 1981; Swain 1978; Whitney 1986; Frelich 1992; Stearns 1992). In many of these studies, most white pine reproduction occurred in years of severe fires. However, some regeneration occurred in the absence of catastrophic disturbances. This cycle of regeneration pulses followed by low levels of recruitment best explains the frequency distribution of germination dates observed at Dividing Lake.

White pine seedlings can establish and develop in the understorey of mature forests where light levels are as low as 20 to 25% of full sunlight (Horton and Bedell 1960, Stiell 1978, Wendel and Smith 1990). Maximum height growth occurs when light levels are near 45% of full sunlight (Logan 1966). Therefore, white pine is well-suited to regeneration by gap phase replacement. Disturbances that cause small openings in the overstorey canopy, such as light surface fires or windthrow, may favour the recruitment of white pine into the overstorey.

However, regeneration by gap phase replacement can maintain only low levels of white pine in the overstorey. Overstorey mortality due to non-catastrophic windthrow is about 10% every 70 years (Frelich 1992). Catastrophic windthrow in hardwoods throughout the white pine range occurs at intervals of 1,000 to 2,000 years, well beyond the maximum life expectancy of white pine (Lorimer 1977, Canham and Loucks 1984, Whitney 1986, Frelich and Lorimer 1991). Mass regeneration of white pine following extensive windthrow is rare (Frelich 1992). Thus, the historically extensive white and red pine forests in the Great Lakes-St. Lawrence region were probably not solely the result of wind disturbances (Frissell 1973, Frelich 1992).

White pine can maintain its overstorey dominance for many centuries under a regime of relatively short-term, periodic disturbances of moderate intensity and less frequent major disturbances (Cwynar 1978, Quinby 1991, Frelich 1992). In particular, major fires every 150 to 300 years favour white pine dominance (Heinselman 1973, Frelich 1992). When major fires occur every 100 to 150 years, red pine becomes more prominent in the overstorey. Major fire cycles shorter than 100 years promote the development of jack pine, red oak, aspen and white birch forests.

Frequent light surface fires (e.g., every 30 to 50 years) contribute to pine regeneration by providing suitable seedbeds, by releasing advanced reproduction and by reducing understorey competition. Windthrow also promotes pine regeneration by providing suitable seedbeds and by releasing advanced reproduction.

The survival of an individual pine after fire is influenced by its ability to tolerate being burned and correlates with increasing age and size. Young white pine seedlings and saplings are not able to survive fires; they must have enough time to develop fire-resistant characteristics (i.e., thick bark and tall, clear boles). According to Stearns (1992), 30- to 40-year-old white pines can survive surface fires. However, McConkey and Gedney (1951), Van Wagner (1970, 1978) and Cwynar (1977) reported that pines less than 50 years old are susceptible to fire. Pines older than 80 years and taller than 18 m are tolerant of surface fires (Van Wagner and Methven 1978, Wright and Bailey 1982). Mature, overstorey pines can withstand up to 50% crown scorch with only minor mortality (<10%). When fire intervals are short, pines have less time to grow and to develop fire resistant characteristics. The frequent fires (e.g., every 5-15 years) that followed the pine loggers (circa 1850 to 1920) eliminated much of the pine reproduction and favoured the regeneration of hardwoods such as aspen and white birch (Howe and White 1913).

The survival of pine after fire also depends on the probability that the area around the tree will burn, which depends on such factors as weather; topography; fuel type, continuity and structure; fire intensity and behaviour; and the presence of streams and lakes. Fire effects can vary greatly, and unburned areas often exist within the fire perimeter. Pines in these unburned areas are more likely to survive the fire even if they are young or small. The likelihood that a given area will burn during a specified period of time increases with the fire frequency.

Ring width variation

Ring width series have been developed for the white pine sampled at Dividing Lake (Figure 6). Interestingly, more than half of the white pine cores had missing rings (some as many as 9) during a 10-year period of extremely slow diameter growth around 1840. Similar observations have been made on old growth white pine cores taken in Hobbs Township, North Bay District, OMNR (R. Guyette, Univ. Missouri, Columbia, MO, unpublished data). This period of very low diameter growth is unique during the last 300 years, and its cause is unknown.

Summary

Increment cores from old growth white pine near Dividing Lake, Algonquin Provincial Park, were used to characterize tree age, diameter growth and mode of regeneration. There was no significant relationship between pine DBH and age. The ages of these dominant white pine ranged from 267 to 486 years. The age structure of the overstorey pine approximated a reverse J-curve distribution, suggesting an all-aged or multi-aged pine component in this mixed pine-hardwood stand. There were 2 periods (circa 1650 and 1710) of significant pine regeneration. Lower levels of pine regeneration occurred from 1507 to 1726. Dominant white pine regenerated most often through advanced reproduction. Cycles of relatively frequent minor stand disturbances by surface fires or windthrow, with less frequent major disturbances by more intense fires, may have led to the development of this multi-aged pine forest.

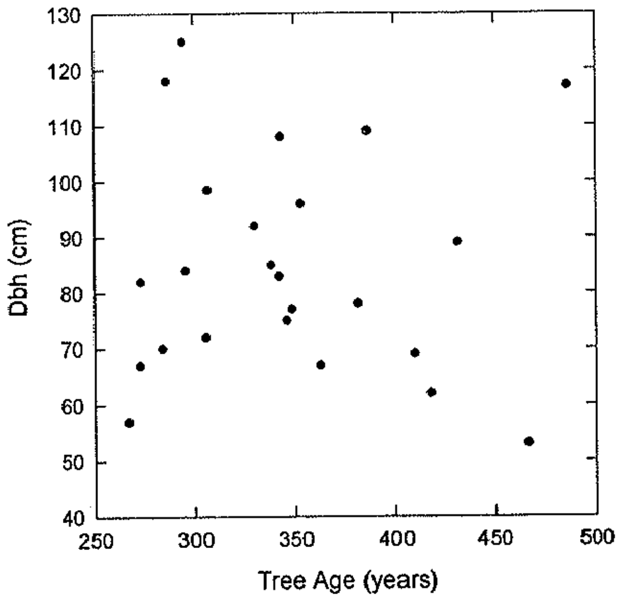

Figure 1. Age of dominant old growth white pine in relation to DBH.

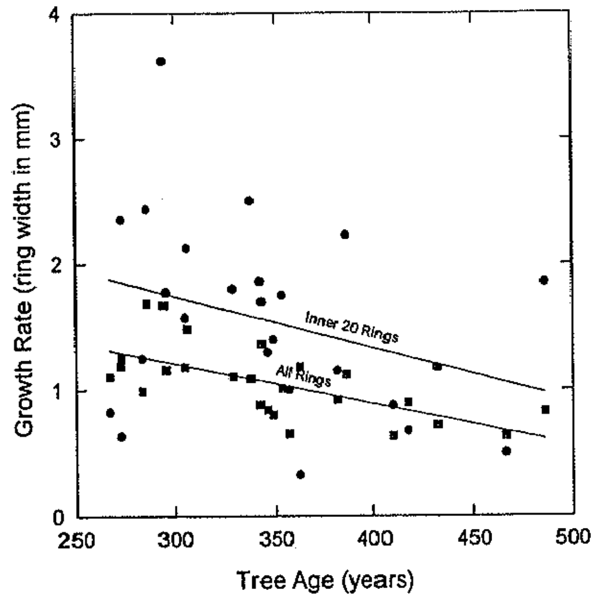

Figure 2. Age of dominant old growth white pine in relation to diameter growth rate. Growth rates are shown for the inner 20 rings (closed circles) and all rings (closed squares).

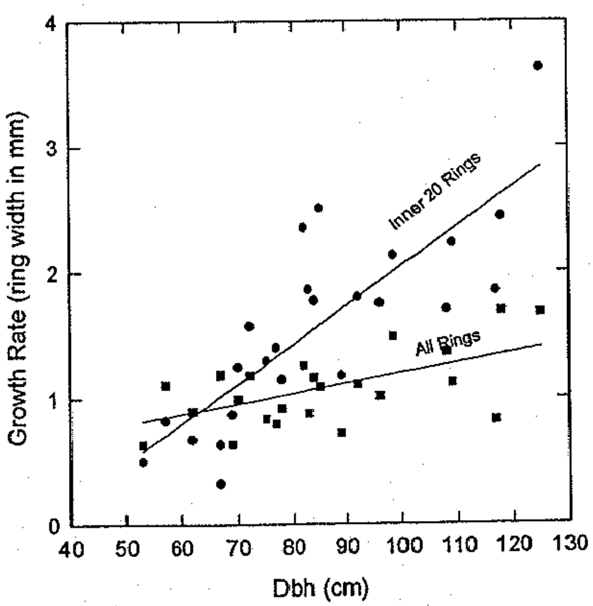

Figure 3. DBH of dominant old growth white pine in relation to diameter growth rate. Growth rates are shown for the inner 20 rings (closed circles) and all rings (closed squares).

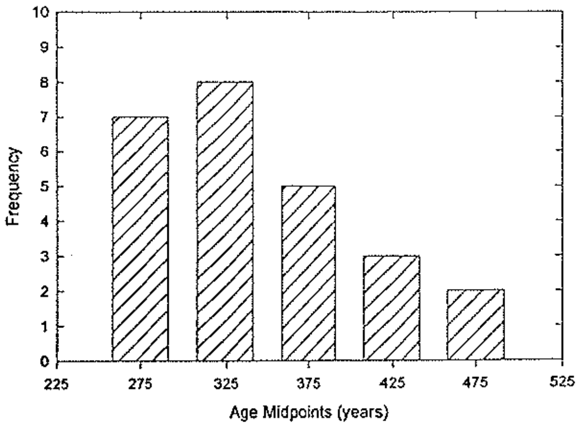

Figure 4. A frequency distribution by age class for dominant old growth pine at Dividing Lake.

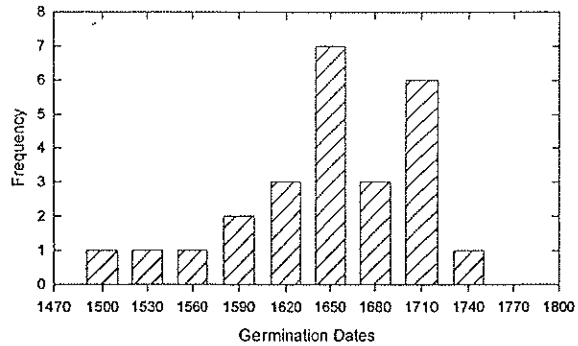

Figure 5. A frequency distribution by germination dates for dominant old growth white pine at Dividing Lake.

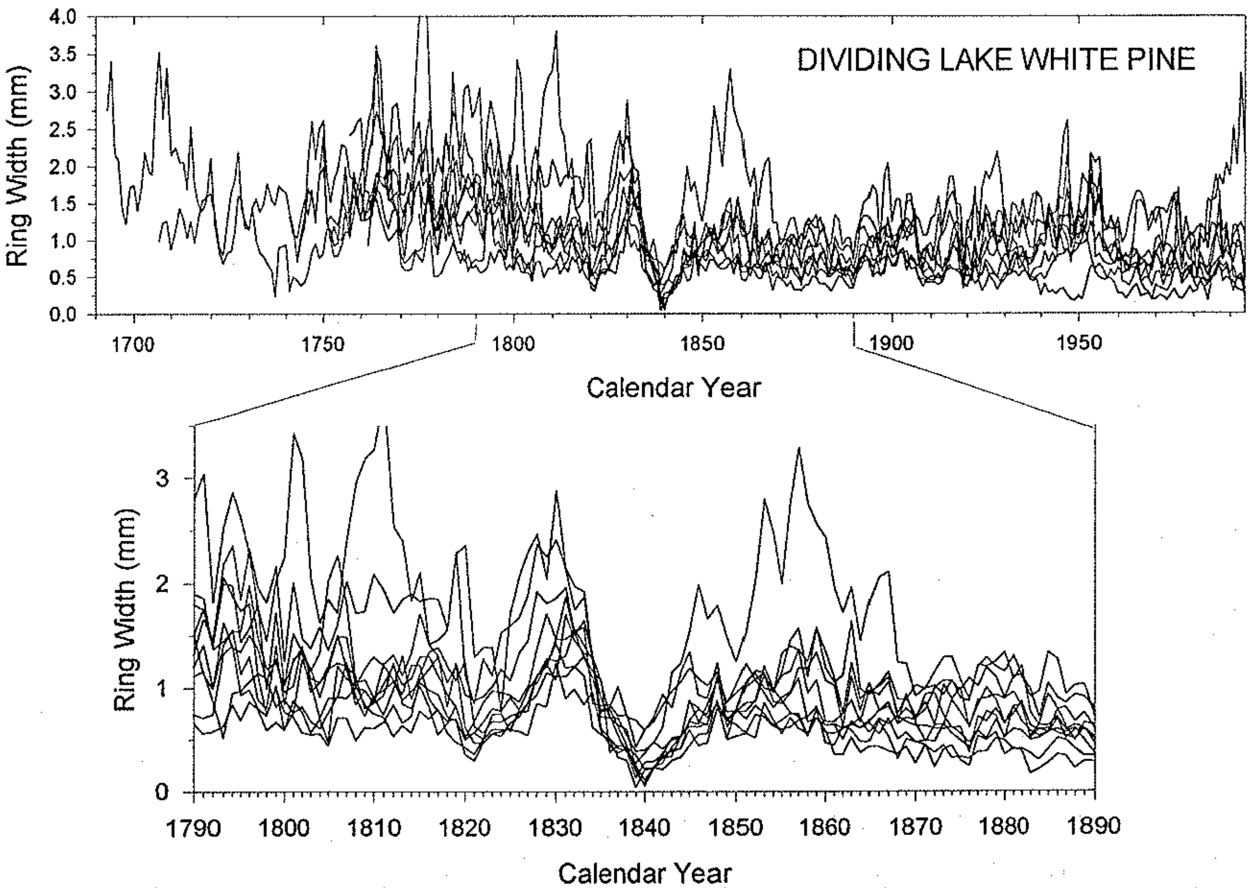

Figure 6. A ring width series for dominant old growth white pine sampled at Dividing Lake. A 10-year period of extremely slow diameter growth occurred around 1840.

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