
Radial growth analysis of Acer Saccharum existing in the same area within the Big Woods forest of Minnesota

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ABSTRACT:

The purpose of this study was to examine the radial growth patterns of fifteen *Acer saccharum* growing in a 1000 m^2 area of Cannon Valley Wilderness Park within the Big Woods forest of Minnesota. Each tree was cored on the east side, 12 inches from its base, and diameter was taken at breast height. Individual rings were counted to determine age, and each core was measured in centimeters using twenty year intervals. Regression analysis and ANOVA tests were utilized to determine whether there was any relationship between the diameter and the age of each tree, and whether trees showed any periods of growth outburst or decline. The P value examining diameter as a function of age was .4819 suggesting that there was no relationship between age and diameter, although, the slope was .213 suggesting a general trend of increased diameter with increased age. The P value analyzing twenty year growth intervals was .3798 suggesting there were no outstanding growth differences throughout each individual's life span. Apparently the individual suppression- release cycles overlap enough to create a consistent overall growth rate giving *Acer saccharum* the necessary flexibility to continue to remain a climax component of temperate forests. There was, however, a slight decline in radial growth since 1935. This may be a result of natural forest patterns, or an outcome of increased gaseous, atmospheric pollution.

INTRODUCTION:

Forests cover approximately one third of the world's land surface. It is estimated that prior to human development, over half of the earth's land surface was covered by forest (Duffey, 1980). The ever enlarging human population has continued to increase the demand on the land, and subsequent destruction of forests. In addition to land development, air pollutants such as excess carbon dioxide, sulfur dioxides and nitrogen fixation may threaten forest health. For obvious reasons forest decline and pollution are serious matters requiring a need for information on the forest's original state in order to examine the differences caused by these factors.

Temperate deciduous forests (see figures 1-2), are rich in maple, yellow birch, black cherry, beech, ash and basswood.

Different concentrations and combinations of these dominant species make up the different strands of temperate forests. Indicated by its name, maple-basswood forests are generally dominated by *Acer saccharum* and *Tilia americana* species. Maple-basswood forests surveyed in north central Minnesota indicated that *Acer saccharum* were the dominant species (Bray, 1956). Sugar maple is considered to be a climax component in deciduous forests (Fowells, 1965), making it an excellent candidate for study since it appears to maintain successful regeneration rates.

Seeds are the principal agents of regeneration of many species (Schopmeyer, 1974) therefore, colonization and ensuing forest patterns may result largely from patterns of seed dispersal and establishment (Hughes and Fahey, 1988). The regeneration strategy of sugar maples is to form a bank of seedlings that remain suppressed until a disturbance creates an opening allowing more light, nutrients, and water to be available (Houle, 1990). Studies have indicated that sugar maples do not grow well under dense canopies where there is little light; they enter a period of suppression where little energy is expended toward growth (Curtis, 1956). Saplings growing under closed canopies showed significantly narrower ring widths suggesting slower radial growth rates (Canham, 1984). In 1985, Canham also showed that sugar maples growing in unlogged stands underwent between one to five suppression periods before reaching the canopy. The average length of suppression was between 22-28 years, the longest exceeding 100 years.

Once a disturbance occurs and light availability increases, during the first five years of growth sugar maple seedlings exhibit apical dominance, a period of growth where height increases rapidly with little lateral branching in order to reach the canopy level more quickly (Bonser, Aarssen 1994). After initial apical dominance, during periods of release, both lateral growth and height increase with increased light availability (LaRocque, 1983). Sugar maple's suppression and release system in response to light availability gives it the flexibility necessary to successfully reach the canopy and consequently, be a dominant species.

The growing season for *Acer saccharum* begins in spring, and concludes during the onset of winter. Hett (1970) reported that *Acer saccharum* growing on the north shore of Lake Superior grew for a period of 116-156 days. Growing seasons are analyzed by reading core samples taken from tree trunks. Early in the growing season, the vascular cambium of the xylem forms a lighter colored wood called the secondary tissue which increases the tree's diameter. As winter approaches and the growing season comes to an end, the growth darkens forming a conspicuous dark ring evident of one complete growth season (Stokes, 1968). Rings may then be counted to determine individual tree age.

In this study, fifteen cores were taken from the trunks of *Acer saccharum* growing in the same area in order to determine individual ages. Individual ages were compared with each tree's diameter at breast height (DBH) in order to determine growth rates and to outline suppression- release cycles characteristic of *Acer saccharum*. Also, lateral growth in centimeters was measured for twenty year intervals of each tree to determine whether *Acer saccharum* underwent growth lags or spurts throughout their life span. Actual year to year suppression-release cycles were not recorded, but overall diameter compared with age gave a good estimate of growth rate differences between trees in the same area. The following null hypothesis was tested: *Acer saccharum* growing in the same area will have similar suppression-release cycles and therefore, have similar growth rates.

MATERIALS AND METHODS:

Study site

The Cannon Valley Wilderness Park, located 8.5 miles north of Fairbault, Minnesota is a deciduous forested area considered to be part of the Big Woods forest, originally covering over 3100 square miles (Milbert, 1994). In 1936, Daubenmire performed an in-depth study on the forest composition of the Big Woods finding it was, for the most part, a homogenous climax deciduous forest dominated by sugar maple and basswood. The study site was on the far southern edge of the Park, on the crest of a large hill approximately 1000 m^2.

Methods

Fifteen *Acer saccharum* were selected (DBH > 10 cm) within the study site using random sampling techniques. Samples were taken using an increment boring tool which extracted a core 5 mm in diameter. The length of the sample was determined by the diameter of each individual tree. Care was taken to bore past an estimated half way mark in order to attain each tree's complete life history. Cores were taken on the east side of the tree approximately twelve inches from the base. Diameter at breast height was recorded using a diameter tape.

Cores were stored in plastic straws for 2-3 days to allow samples to dry. Fifteen long ridges or waves were cut into a 1 x 6 piece of wood, and cores were glued into the ridges (using carpenter's glue) making sure to align samples with the cambium on the outside of the board, and the phloem and xylem reaching to the inside of the board. The glue was allowed to dry for 1-2 days, and then a power sander was used to sand off the top 1/3 of the each sample in order to examine the tree rings. In some cases, fine sanding was needed, and 220 sandpaper was used. Samples were wiped with a damp cloth to enhance the visual clarity of the rings and then were examined under a dissecting microscope. Pin pricks were used to mark off every ten years of growth to allow for easier reading. Also, starting from the outer cambium, every twenty years of radial growth was measured in centimeters for each individual.

Analysis

Regression analysis was performed to determine if there was a linear relationship between age and DBH of *Acer saccharum*. ANOVA was used to analyze the radial growth rates of the four, different age intervals (1975-1995, 1955-1975, 1935-1955, 1915-1935) in order to determine whether any of these age intervals experienced increased or decreased radial growth rates.

RESULTS:

Regression analysis showing the radial growth at breast height as a function of age was shown in Figure 1. The P value was .4819, a value far greater than .05 suggesting that there was absolutely no relationship between DBH and the age of *Acer saccharum.* However, the slope was slightly positive with a value of .213 suggesting that *Acer saccharum* displayed a general trend of increased DBH with increased age.

Centimeters of radial growth were examined as a function of tree age. These were analyzed in four, twenty year intervals using ANOVA, as shown in Figure ~~four~~. The results of ANOVA gave a P value of .3798. Clearly, this value shows that there was no difference in radial growth rates between different age intervals. Overall, however, the results revealed a slight decline in radial growth since 1935. The radial growth for age intervals 1935-1955, 1955-1975, 1975-1995 were 3.125, 3.004, and 2.486 respectively.

DISCUSSION:

The premise of this paper suggested that *Acer saccharum* growing in the same area would experience similar radial growth rates due to similar suppression-release cycles caused by light availability of similar climate and weather conditions. This hypothesis was tested by counting the total number of tree rings found on each individual core sample and comparing it with its diameter at breast height. Results from this experiment suggested that *Acer saccharum* growing in the same area did not display similar suppression -release cycles. The graph in Figure 3 visually displays the lack of association between the two variables, and confirms this with a P value of .4819. It is interesting to note, however, that there is a general trend of increased diameter with increased age as shown by the positive slope of .213.

These results show that diameter and age are independent of one another suggesting that suppression- release cycles vary significantly between individual trees growing in the same area. Bonser and Aarssen (1994) reported that there was a proportional relationship between light availability and lateral growth for *Acer saccharum*. The results of this experiment concur with Bonser and Aarssen, but add that light availability must be dependent on direct rays mediated by canopy space or shade, rather than longitudinal forest placement determined by different climates as shown in Figures 1-2.

In 1985, Canham studied the growth of *Acer saccharum* in a logged area, and in an unlogged area. He found that in the unlogged area, 100% of the trees experienced between one to five suppressions varying between 22- 100+ years. Only 20% of the trees in the logged area showed suppression -release cycles. He also found that a small, single tree gap was enough to significantly effect the growth rates of surrounding saplings. He found that not only trees directly under a gap, but also trees adjacent to the gap were strongly influenced by increased penetration of light. Canham's data gives proficient evidence supporting why *Acer saccharum* growing in the same area, of similar ages, grow at such different rates.

This data is interesting when compared with data from Figure 4, and 4a. These figures show the mean radial growth rates for twenty year age intervals. Thirteen sugar maple were 20 years or older, twelve of these were 40 years or older, ten of these were 60 years or older, and 7 of the thirteen were 80 years or older. The four different twenty year age intervals ranging from 1915-1995 showed no mean difference in growth rates. Their means of lateral growth in centimeters were 2.486, 3.004, 3.125, and 3.041 cm respectively with a P value of .3798 suggesting that there was no change in lateral growth between the four, different, twenty year age intervals. Therefore, although there was no relationship between total age and DBH (as shown in Figure 3), there appears to be some consistency in lateral growth rates throughout the tree's life. At no time does the tree take off into an unusual growth spurt, or lag. It appears that the suppression -release cycles are synchronized and overlap enough to show consistent lateral growth rate differing only between 2.486 and 3.125 cm over twenty year intervals. Canham (1985) found that the average suppression of *Acer saccharum* in an unlogged area lasted between 22-28 years; this data conflicts with the results found in this experiment. This experiment showed that *Acer saccharum* grew at relatively equal rates when measured in 20 year intervals. The difference in results could be due to the study area. The forest is part of the original Big Woods suggesting it has never been logged, and the diverse DBH as a function of age verifies this notion, however, the area was predominantly adult sugar maple with few other adult species; a characteristic unique to the crest of the hill. Surrounding forest on the side of the hill and in the valley showed much greater diversity. I am also unclear as to the amount of available sunlight the trees experienced in their seedling and sapling stages. It is probable that there were more canopy disturbances allowing for greater sunlight availablility, and consequentally quicker suppression -release cycles occuring within 20 year time frames allowing for similar growth rates when measured at this interval. More research needs to be done in this area examining individual radial growth in 10, or even 5 year increments in order to see if these intervals show growth rate differences.

Although the P value suggests that there was no major difference in growth rate as seen in the bar graph in Figure 4, there has been a slight decline in lateral growth over the last 60 years. It is important to realize that this could be part of a natural cycle, however, it is also important to be aware that this decrease in lateral growth could be a result of other factors such as pollution.

Dendroecological investigations have shown a synchronous decrease in radial growth of Red spruce since the 1960s in forested areas of the United States (Adams et al. 1985, McLaughlin et al. 1987, Raynal et al. 1988). Decline of sugar maples have been reported in 1910, 1930, 1960 and 1970. The sugar maple decline in the northeastern United States and Canada have been linked to increased acid deposition, although no specific cause and effect evidence has been reported (McLaughlin et al. 1985). The problem lies in the unknown. The life span of a forest is much longer than a human life span, therefore, normal patterns may be perceived by humans as the result of increased pollution, when in reality they may be routine changes. On the other hand, increased gases in the atmosphere seems a likely candidate for the decrease in sugar maples and other forest populations. Atmospheric carbon dioxide has increased from 280 to 355 microliters/L since 1800, and there is more human induced nitrogen fixation than fixation via natural pathways (Vitousek, 1995). Pollution may be causing long-term, deadly effects on forests that two year or even twenty year studies are unable to detect. Whatever the reason may be, forest decline and decreased radial growth are documented facts.

In conclusion, the sugar maples examined in Cannon Valley Wilderness Park showed no significant relationship between age and diameter. This was most likely a result of the individual suppression -release cycles specific for each tree. Each individual release was a direct result of small disturbances in the canopy allowing greater light availability for *Acer saccharum* directly beneath or adjacent to its openings. Also, there was no interval of growth where sugar maples grew more rapidly or slowly over a 80 year period of time. This suggests that although each tree has specific suppression -release cycles dependent on light availability; overall, sugar maple growth was consistent. In order to better understand long-term forest patterns, more research needs to be done on forest compositions over long periods of time so that future comparisons may be made. Unfortunately, few records such as this exist, as a result, there is nothing with which to compare current forest density and growth results. Studies such as this need to be continued to use as a resource bank for later years. Perhaps the small decline in radial growth seen in *Acer saccharum* is a natural cycle, perhaps not.

REFERENCES

Adams, H.S., et al. 1985. Growth-trend declines of spruce and fir in mid-Appalachian sub alpine forests. *Environmental and Experimental Botany*. 25: 315-325.

Bray, Roger. 1956. Gap phase replacement in a maple-basswood forest. *Ecology*. 37: 598-600.

Bonser, Stephen, Lonnie Aarssen. 1994. Plastic allometry in youn sugar maple: adaptive responses to light availability. *American Journal of Botany*. 81: 400-406.

Canham, Charles. 1984. Canopy recuitment in shade tolerant tree species: The response of *Acer saccharum* and *Fagus granifolia* to canopy openings. Ph.D Thesis, Cornell University.

Canham, Charles. 1985. Supression and release during canopy recruitment in *Acer saccharum*. *Bulletin of the Torrey Botanical Club*. 112: 134-145.

Curtis, J.T. 1959. The vegetation of Wisconsin. University of Wisconsin Press, Madison.

Daubenmire, R. 1936. The "Big Woods" of Minnesota: Its structure, and relation to climate, fire, and soils. *Ecological Monog*. 6: 235-268.

Duffey, Eric. 1980. The Forest World. A&W Publishers, Inc. : New York.

Fowells, H.A. 1965. Silvics of the forest trees of the United States. Handbook No. 271. U.S. Department of Agriculture, Washington DC.

Hett, Joan, O. Loucks. 1970. *Acer saccharum* seedling mortality. *Ecology*. 51: 255-264.

Houle, Gilles. 1990. Growth patterns of sugar maple seedlings and mature trees in healthy and in declining hardwood stands. *Canadian Journal of Forestry Research*. 20: 894-901.

Hughes J., Timothy Fahey. 1988. Seed dispersal and colonization in a disturbed northern hardwood forest. *Bulletin of the Torrey Botanical Club*. 115: 89-99.

McLaughlin, S.B. 1985. Effects of air pollution on forests. A critical review. *J. Air Pollut. Control. Assoc*. 35: 512-534.

McLaughlin et at. 1987. An analysis of climate and competition as contributors of decline of red spruce in high elevation Appalachian forests of the eastern United States. *Oecologia.* 72: 487-501.

Milbert, Dan. 1994. Managing Landscapes in the Big Woods Ecosystem. MN -DNR.

Raynal et al. 1988. Historical growth patterns of red spruce and balsam fir at Whiteface Mountain, New York. *In* effects of atmospheric pollution on spruce and fir forests in the eastern United States and the Federal Republic of Germany. United States Forest Service, Washigton, DC.

Schopmeyer, C.S. 1974. Seeds of woody plants in the United States. Handbook 450. U.S. Government Printing Office. Washington, DC.

Stokes, Marvin A. 1968. An Introduction to Tree Ring Dating. University of Chicago Press: Chicago.

Vitousek, Peter, M. 1994. Beyond global warming: ecology and global change. *Ecology*. 75: 1861-1876.

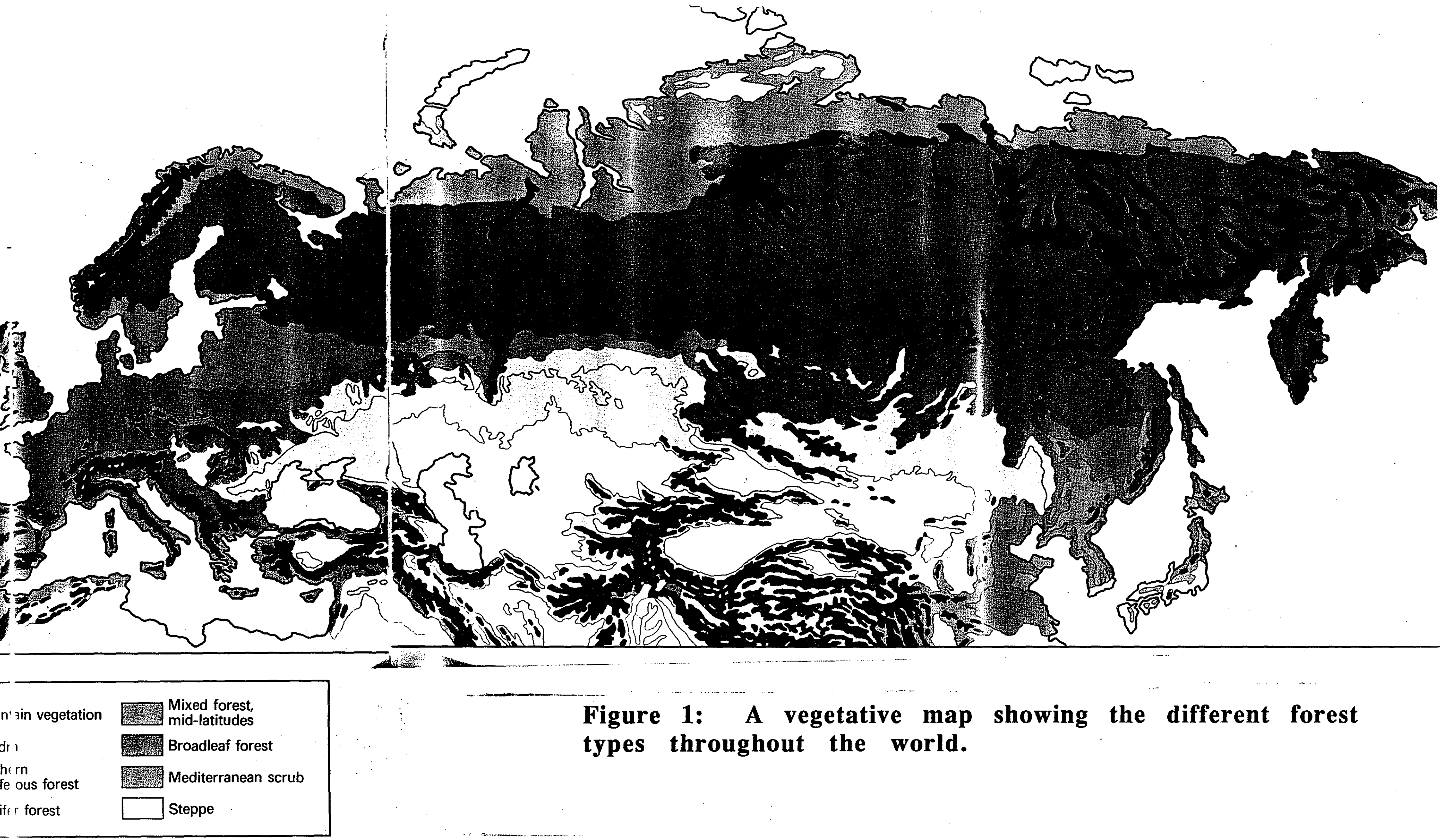
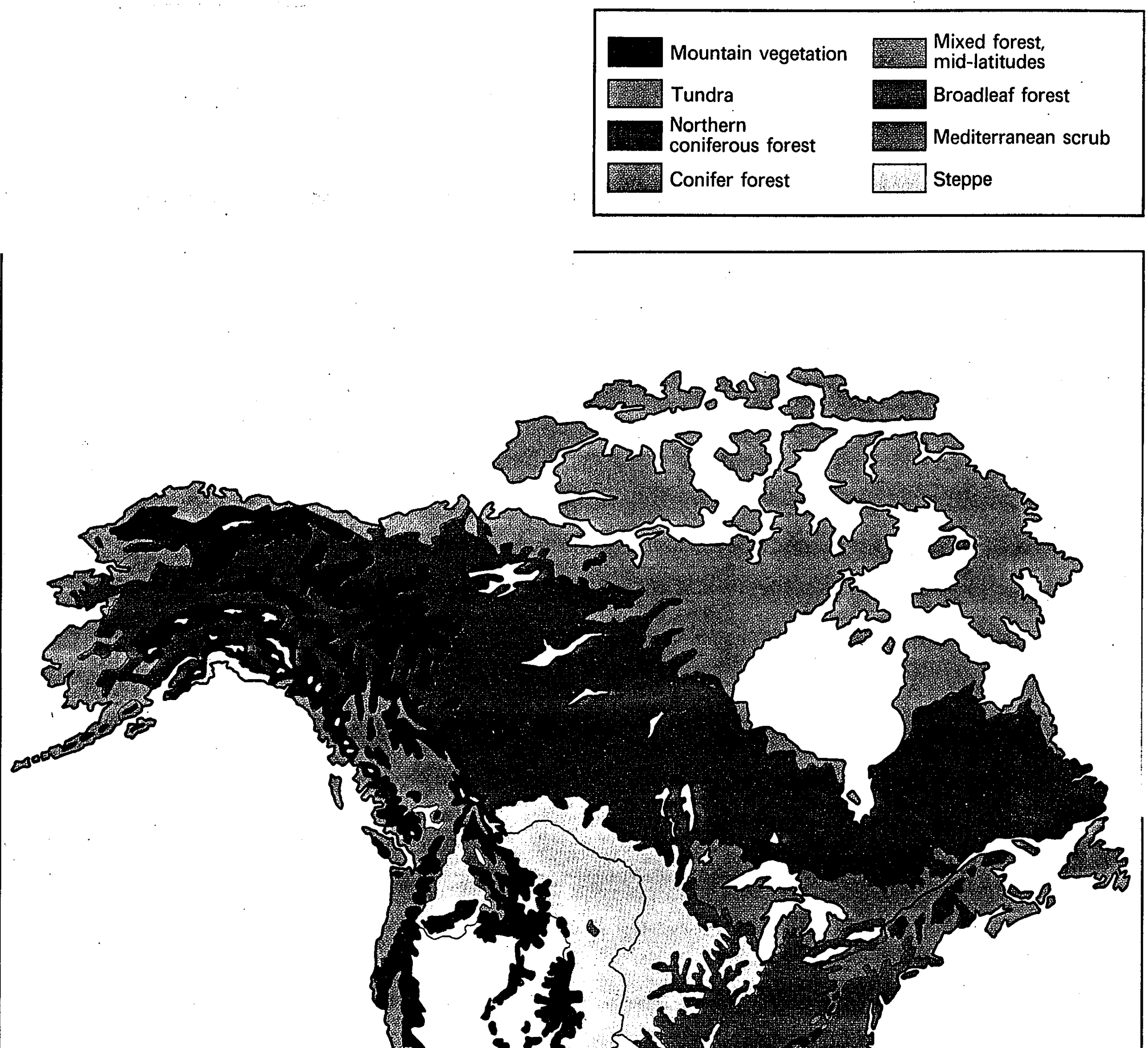
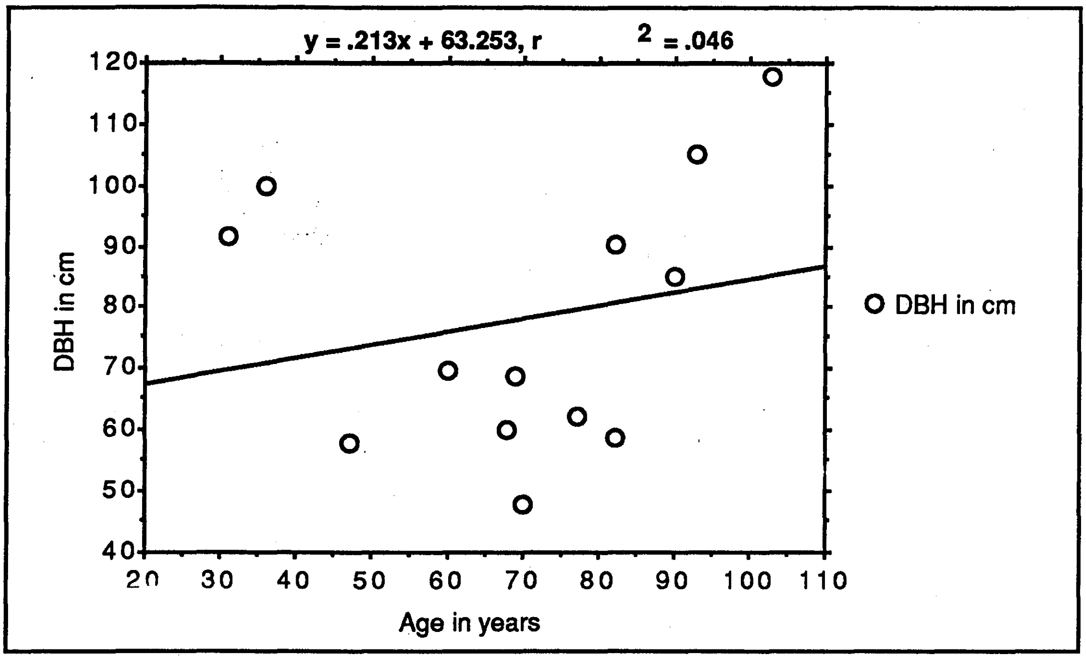


Figure 1: A vegetative map showing the different forest types throughout the world.

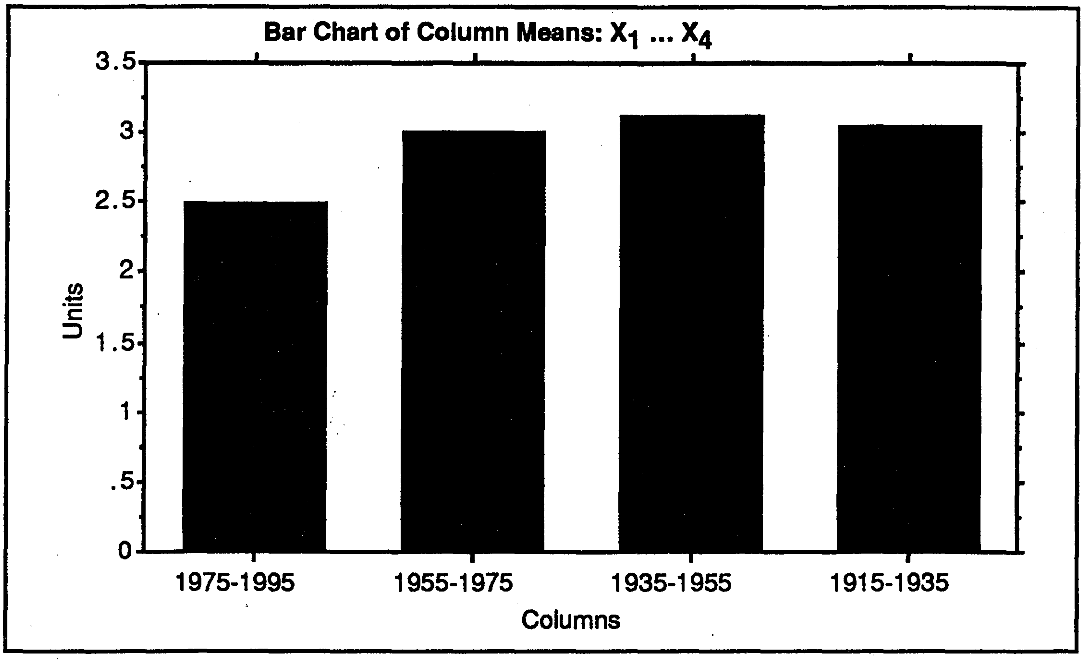
Figure 2: A vegetative map showing the different forest types throughout the United States of America.





P value = .4819

Figure 3: Regression analysis showing the radial growth rate in centimeters as a function of age in years.



P value = .3798

Figure 4: A bar graph showing the mean radial growth rate of four, 20 year *Acer saccharum* age intervals.

Figure 4a: A table showing the mean radial growth rates measured in centimeters over periods of 20 years.

Age interval	Count	Mean
1975-1995	13	2.486 cm
1955-1975	12	3.004 cm
1935-1955	10	3.125 cm
1915-1935	7	3.041 cm