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TITLE:

IS RECENT CLIMATE CHANGE INCREASING OR DECREASING GROWTH OF TREELINE TREES AT DENALI NATIONAL PARK?

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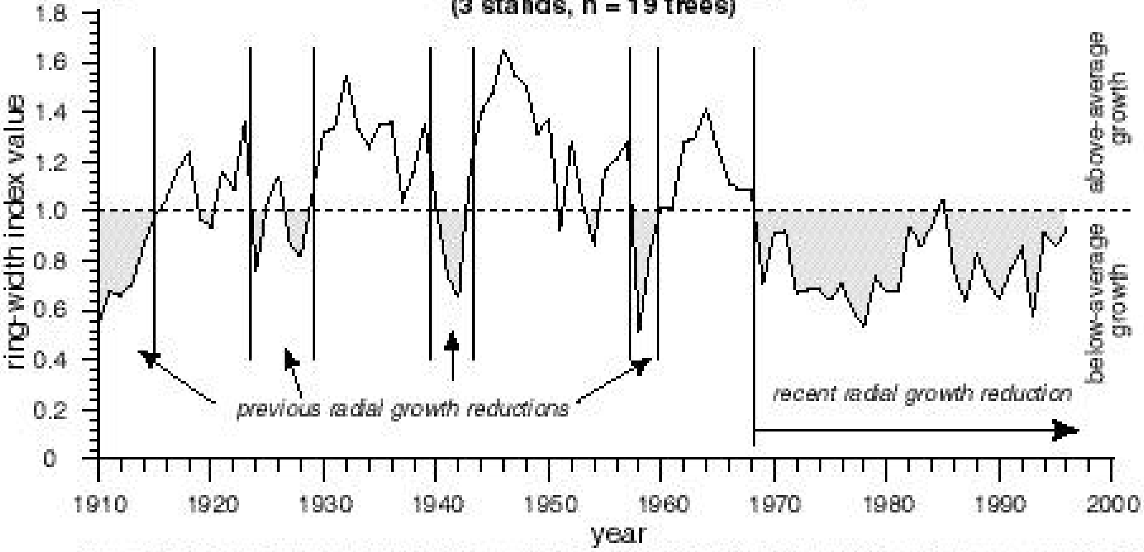
IS RECENT CLIMATE CHANGE INCREASING OR DECREASING GROWTH OF TREELINE TREES AT DENALI NATIONAL PARK?

BACKGROUND

Tree-rings contain a wealth of information about climatic conditions affecting the growth and health of trees (Fritts 1976). Previous studies have found that radial growth of white spruce near treeline in central and northwest Alaska is positively correlated with summer temperature (Jacoby et al. 1985), and in general with northern hemisphere annual temperature (Jacoby and D'Arrigo 1989). These trees, growing at the northern or elevational tree limit, were assumed to be limited almost exclusively by cold temperatures. An increased growth rate of these trees is taken to represent a pure temperature warming "signal." Tree-ring analysis of subarctic trees was one of the main forms of paleoclimatic evidence demonstrating that the arctic has experienced significant climate warming in the last two centuries (Overpeck et al. 1997).

Global climate models predict high magnitude of warming in the Arctic in response to increased greenhouse gas build-up in the atmosphere (Houghton 1996). Recent tree-ring analysis in Alaska has highlighted the sensitivity of tree growth to the ***drying*** effects of climate warming in the interior and northern Alaska regions (Juday et al. 1998). White spruce radial growth since 1976 on the most productive upland forest sites in the Fairbanks region (Figure 1) is the poorest of the 20th century (Juday and Marler 1997), and forest yield and sustainability have been affected (Jacoby et al. 1997).

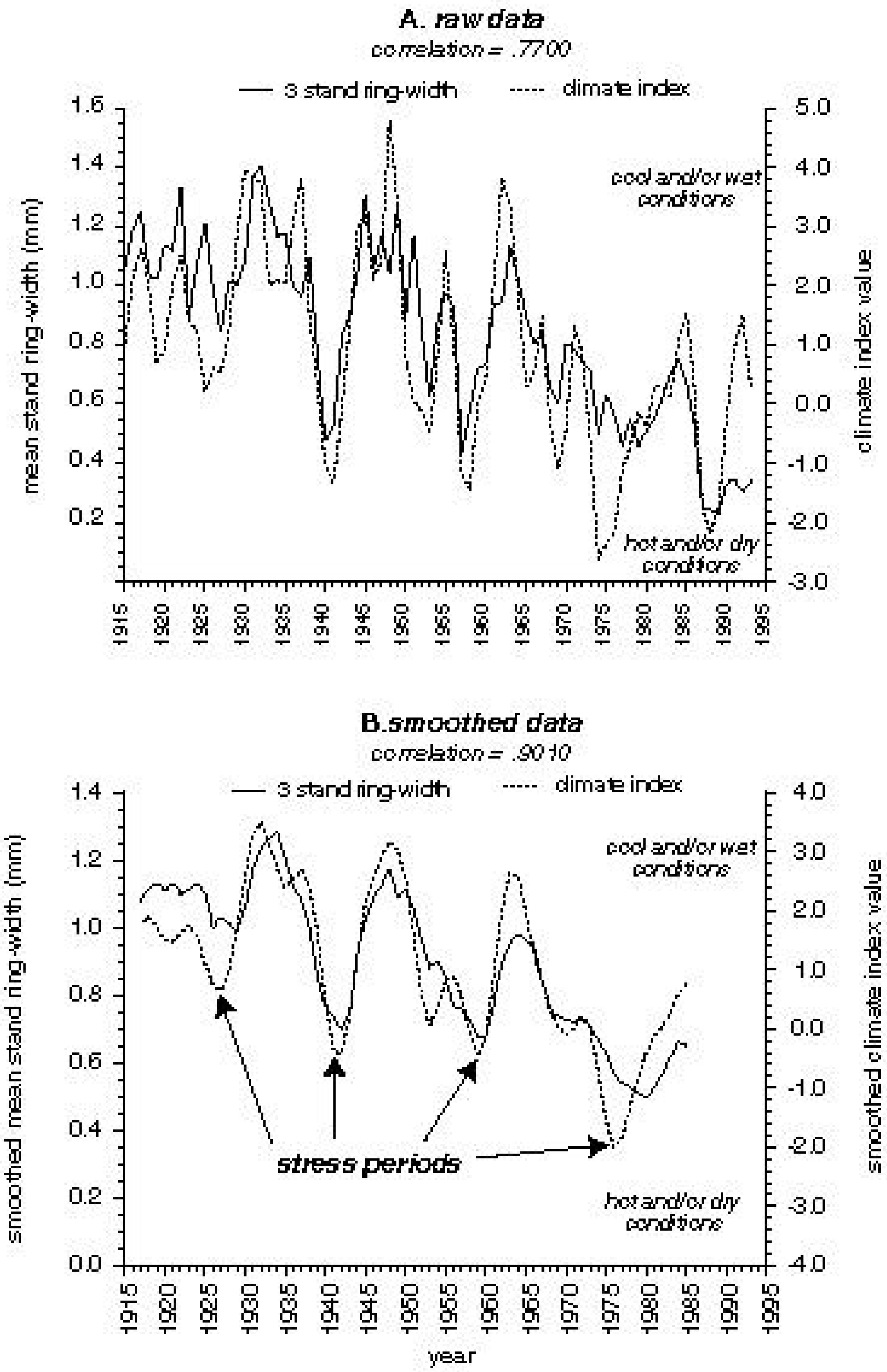
Figure 1. Standard chronology of white spruce radial growth, Lower Chena River (3 stands, n = 19 trees)



Ring-width index values were developed from a straight line fit of individual tree radial growth curves, normalized to dimensionless values with mean scaled to 1.0, and the arithmetic mean of all trees computed by year.

The principal cause of the recent reduction in white spruce growth on productive low-elevation sites appears to be heat and drought stress, which has increased to extreme levels in the late 20th century (Barber and Juday 1997, Barber et al. 1997, Juday et al. 1998). Unlike previous periods of stress that were short and sharp, the recent warming and drying is both extreme and long-lasting (Figure 2).

Figure 2. Relationship of mean radial growth of 3 white spruce stands (n = 39 trees) at Bonanza Creek LTER and multiyear Fairbanks climate index



These results challenge simple assumptions typically made in ecological models that increased warmth at high latitudes will cause increased growth of the current or potentially new forest and tundra ecosystems (e.g. Oechel and Vourlitis 1994). The general process of climate change that includes a considerable component of warming causes a variety of ecological changes which may include decreased plant growth for some parts of the ecosystem as well as increased growth.

Increasing or decreasing growth at Denali?
A fundamental issue for arctic tree-ring research now is to determine the direction and magnitude of growth responses to recent climate changes, especially in places that are sensitive to change, such as treeline sites (Szeicz and Szeicz 1994). Jacoby and D'Arrigo (1995) have detected a *decline* in the responsiveness of white spruce radial growth to late 20th century warming at treeline that may be related to increasing moisture stress. On the other hand, Myneni et al. (1997) have measured an overall plant growth *increase* in tundra and forest/tundra edge (based on satellite measurements) in recent warm years, not a decline. Resolving the question of the growth response of trees at treeline to the recent warming climate is an important issue for arctic global change studies, because of the implications for carbon balance, vegetation change, and secondary effects on animal species in the ecosystem.

Denali National Park (DNP) is an ideal location to do an initial evaluation of climate sensitivity of high-elevation trees in central Alaska. DNP includes extensive mid-elevation and treeline transitions on the north side of the Alaska Range in a dry continental climate accessible by road. Mid-elevation and treeline transitions on the south side of the Alaska Range in DNP represent a transitional continental/martitime climate. The history of previous environmental research in DNP provides the opportunity to relate insights gained from tree-ring research (such as times of major cold or warm intervals) to a variety of responses in important park resources. The recent concentration of research in the Rock Creek watershed provides the opportunity to develop insights into important processes in the watershed that extend back in time well before monitoring efforts began.

Spruce bark beetles and tree growth
The spruce bark beetle (*Dendroctonus rufipennis*) outbreak currently underway in southcentral Alaska has resulted in tree death over 3.2 million acres in the last 10 years (Matthews et al. 1997). In heavily affected stands all spruce greater than 10 cm have been killed. It is one is one of the largest areas of insect-caused tree mortality ever recorded in North America (Werner 1996). The USGS BRD Alaska office (Steve Matsuoka) is conducting a study of the effect of beetle-caused mortality on wildlife habitat in the Copper River Basin. As part of the BRD study cores tree cores have been collected from 228 trees; 123 live and 105 dead located in four 36 ha study plots located in the upper Tonsina River drainage along the Richardson Highway. Tree cores collected from 18 vegetation plots located in a systematic random fashion. In each 20 m x 20 m vegetation plot vegetation plot, cores were collected from two dominant live spruce trees and two dominant beetle-killed trees (when available). Trees were cored at breast height and from the uphill side of the tree when on a slope. Each core is stored in a straw and labeled with the study plot, location, core number for that location (1-4), date of collection, dbh, species (white, black, or unknown spruce), and whether the tree was alive or dead.

OBJECTIVES

Copper Basin bark beetle study

1. Determine the total age and date of death of the BRD Matsuoka Copper Basin spruce core sample.
2. Determine whether acceleration or decline of recent (last 20 to 30 years) radial growth of the sample is related to bark beetle mortality .

Denali treeline study

1. Measure a tree-ring sample that is balanced by tree size class so that it represents the overall, aggregate growth of a forest at the Denali National Park Headquarters and middle and upper Rock Creek Watershed sites over the last 150 years. Include trees likely to be
2. Determine whether radial growth of the sample has been accelerating or decreasing overall in the last 2 to 3 decades.
3. Determine the climate factors that best correlate with the radial growth of the sample during the 20th century.
4. Determine whether the environmental or climate factors that best correlate with the stand-level growth are different in the first part of the 20th century compared to the later portion, especially since a major shift in climate in Alaska in 1976 - 77.

WORK STATEMENT

1. The existing collection of Copper Basin tree cores will be processed and analyzed. New tree cores will be collected from white spruce at the following Denali National Park sites:

Site	# cores	Est. technician work weeks
Headquarters	20 to 30	4
Rock Ck.	60 to 80	9

2. Tree cores will be glued to tulip poplar mounting sticks for permanent storage and handling. Sample identification data will be transferred to the mounting sticks. Water soluble glue will be used so that removal of core sections for other forms of analysis would be possible in the future.

3. Cores will be oriented for viewing a transverse cut surface to obtain maximum ring boundary definition. Twisted cores will present sections with tangential cut surfaces, and supplemental preparation on the lateral surface of those sections will be undertaken.

4. Fragmented, rotten, or deformed cores that cannot be accurately measured will be mounted if continuous ring sequences can be obtained, but unusable cores will be discarded.

5. Core sections will be sanded with successively finer grit sandpaper. Ordinary ring sections will be sanded to the level of 360-grit. Core sections with rings narrower than .05 mm will be sanded to 600-grit.

6. Cores will be physically marked at even decade intervals (e.g. 1980, 1970, 1960 etc.) throughout the length of the core. Ordinary ring sections will be marked with graphite pencil

markings and date labels. Core sections with rings narrower than .05 mm will be marked with triangular indentations formed by the tip of a surgical scalpel.

7. Ring-widths will be measured on a VELMEX laser traveling stage plate system. Ring-widths will be measured to micron-level precision (thousandths of mm).

8. Digital files of the ring-with measurement data will be developed in both the “decadal” format that is the standard of the International Tree-Ring Database, and in column format.

Climate data
I will obtain monthly temperature and precipitation data for the Denali National Park Headquarters, Healy, and Fairbanks. The Denali Park record is recoverable from 1925 to 1986 or 1987, Healy from 1943 to present, and Fairbanks from 1906 to present. I will test radial growth responsiveness primarily against the Denali Park data but I will also see if other stations are significant as well.

Analysis
For the Denali sample I propose to use accepted dendroclimatological techniques (Cook and Kairiukstis 1990, Wigley et al. 1983) involving standardization and de-trending of composite tree-ring series and tests of climatic sensitivity. Growth anomalies that may be climatically related (missing ring boundaries from early frosts, consistent narrow rings, coherent stand-wide acceleration of growth) will be used to establish cross-dating and a narrative summary of climate response history will be developed from these observations.

I will compare radial growth responses in the tree-rings with the Denali climate record. If both data arrays (chronology and climate) exhibit normal distribution I will apply a Pearson correlation to determine the maximum sensitivity to climatic factors, otherwise a Spearman rank correlation approach will be used. Correlation coefficients will be calculated between the tree-ring chronology and the monthly climate values. I will combine the selected climate factors scoring the strongest correlation (positive or negative) into a normalized index.

I will perform sensitivity analysis to determine factors limiting tree growth in the early compared to more recent portions of the record. I will focus on the detection of unique threshold effects of the current climate.

BUDGET

	hours	direct	indirect	subtotal
Salary				
Faculty (Glenn Juday)	80	$4,158	$2,133	$6,291
Technician (Robert Solomon)	780	$17,328	$8,889	$26,217

Supplies (sandpaper,wood mounting sticks,

hand lenses)	$200	$103	$303
Travel (3 round-trips Fairbanks-Denali)	$600	$308	$908
Subtotal	**$22,286**	**$11,433**	
TOTAL			**$33,719**

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CURRICULUM VITAE - Glenn Patrick Juday
Education: Purdue University, 1972, B.S. Suma cum Laude, Forest Management
Oregon State University, 1976, Ph.D., Forest Ecology (Botany Department)
Postdoctoral experience: Oregon State University, 1976-77, Rockefeller Foundation Post-doctoral Fellowship in Environmental Affairs; Federal-State Land Use Planning Commission for Alaska, 1977-78, Research Natural Areas Coordinator; USDA Forest Service Pacific Northwest Research Station, 1978-81, Ecologist; University of Alaska, 1981-87, Visiting Associate Professor.
Current Position: Associate Professor of Forest Ecology (11-month appointment, tenured); Forest Sciences Department, School of Agriculture and Land Resources Management, University of Alaska Fairbanks, Fairbanks, AK.
National/International Science Contributions: Chair, Society of American Foresters Forest Ecology Working Group 1997-98; President, Natural Areas Association, 1985-89; Special Issue Editor, Natural Areas Journal, old-growth forest issues 1988-89; Co-convenor, National Climate Forum, November 1997; Chair, LTER working group on climate change and its ecological consequences, 1997; Invited Speaker, U.S. Global Change Research Program Congressional Seminar, Dec. 1997; Contributing author, U.S. regional workshops on climate change, Alaska region, June 1997, and New England region, September 1997; Consultant to The Nature Conservancy National Headquarters, Science Programs Office, special assignment, Jan. - March 1988; Member, expert review panel, Tongass National Forest Land Management Plan, 1995; Chair, School of Agriculture and Land Resources Management Strategic Plan Committee, University of Alaska Fairbanks, 1994; Science Consultant to Exxon Valdez Oil Spill Restoration Program (1993-present); Alaska Ecological Reserves Coordinator, 1977-present; Coordinator, Rosie Creek Fire Research Project 1983-89; Chairman, Oregon Natural Area Preserves Advisory Committee, 1973-77, Executive Chairman 1976-77; Science Steering Board, Center for Global Change and Arctic System Science, UAF 1990-present; Science Advisor, Discovery Channel 50-min TV Program "Glaciers, Rivers of Ice", also TV documentary program on global warming effects on Alaska forests produced by the Danish Broadcasting Corporation (Danmarks Radio), July 1997; Member, Steering Board, Alaska Boreal Forest Community Forum Member 1992-94; Member of Governor's Task Force, Alaska Forest Products Sector Review, 1995.

Current: Major Advisor, 1 Ph.D. student (completion, 1998), 2 M.S. students (completion 1997), 4 senior thesis students; Member, Graduate Committee, 2 Ph.D. student, 3 M.S. students; Completed to date: 1 Ph. D., 2 M.S. (all within past 5 years), 4 senior theses. Total - 10 graduate students, 2 post-doctoral scholars.

Recent and relevant publications
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