

Patterning and Change Dynamics of a Distinct Forest-Tundra Ecotone Type in Bristol Bay, Alaska

Project Background and Description

Dendrochronological studies provide critical proxies for studying global environmental change in subarctic forest-tundra ecotones. The response of treeline to climatic changes has been investigated in some areas of Beringia and used as an indicator of current and/or future landscape evolution and change. While previous studies have focused dominantly on alpine and arctic treeline, three distinct and enigmatic treeline ecotone types have been observed south of their latitudinal and/or below their elevational ranges in the Bristol Bay region of Southwest Alaska. These sites provide an opportunity to study potential growth response of trees, stands, and treeline dynamics to a variety of climatic and microsite forcings. My overall graduate study will describe these ecotones, conduct dendrochronological and site analysis, and test hypotheses regarding possible limiting factors for forest growth at these sites. Special emphasis will be on possible edaphic properties (e.g. soil moisture, active layer depth), disturbance, and geomorphology. Financial support from the Hopkins Fellowship will aid in my study in providing travel to and around one of my field sites, King Salmon, Alaska for the 2009 field season. By analyzing tree growth and recruitment response to these variables in Southwest Alaska, this study may improve the accuracy and validity of dendroclimatic studies and aid in prediction and planning for future climate and landscape change in arctic and subarctic ecosystems.

The forest-tundra ecotone can be defined as the transition zone in between two adjacent and competing ecosystems, in this case spruce forest and shrub tundra, controlled spatially and temporally by a variety of environmental factors (Hufkens et al., 2008). Through preliminary research and reconnaissance work, my advisor, Patricia Heiser, and myself have observed three distinct 'treeline boundary types' that may reflect different limiting factors for tree recruitment and growth, in addition to mean July temperature that is typically associated with growth and recruitment limitation at arctic and alpine sites.

Field Site Description

One of the three distinct treeline boundary types is located in and around King Salmon, AK near the west end of Naknek Lake. The Hopkins Fellowship will assist in fieldwork at this site. This ecotone is characterized by a diffuse treeline that exhibits what appears to be two distinct size cohorts, that may be representative of age. From the air, the treeline landscape appears to be an open-spruce parkland with tall spruce trees (one size/age cohort) intermingled with small spruce trees (another size/age cohort). Several sites show a perimeter of larger spruce growing in the margins around dry lakebeds. Similar patterns around dry lakebeds have been documented around thaw lakes on the Seward Peninsula and attributed to soil moisture changes (Lloyd et al., 2003). This may be influencing treeline growth patterns in the Naknek region and I will test this hypothesis as part of my project.

Two additional treeline types have been observed in Southwest Alaska. In Dillingham, treeline is comprised of distinctive islands of spruce that abruptly transition into tundra. Preliminary studies from research I conducted as an undergraduate suggest a divergent response of tree growth and recruitment to temperature, precipitation, and soil moisture. These studies suggest drought stress as a factor, similar to tree growth patterns found south of arctic treeline in interior Alaska (Barber and Juday, 2000).

The third field site is located at the southwest end of Nonvianuk Lake in Katmai National Park. The forest-tundra boundary in this area appears as a distinctive and anomalous "tongue" of spruce trees that extends southwest out of Colville Lake valley, across the Alagnak River and extends up river valleys to the north. Preliminary study tree cores collected from a site near the west end of Nonvianuk Lake suggest a recruitment event approximately 100 years ago, in possible correlation with the Katmai eruption and subsequent ash deposition of 1912 (P. Heiser, personal communication, 2008).

I will conduct fieldwork in these sites as well as at King Salmon and integrate the data to analyze and identify tree growth patterns and responses to change.

There are three main objectives for this study at the three proposed field sites.

1. Describe the gradient, community structure, and morphology of distinct forest-tundra ecotone sites in Southwest Alaska.
2. Conduct dendrochronologic, vegetation, and soil surveys at study sites on the east side of Bristol Bay to determine the age of stand recruitment and tree ring growth response in trees at these sites.
3. Determine if relationships exist between tree recruitment and/or growth response and:
 - i. Climate and weather events over the past 100 years
 - ii. Geologic disturbance such as volcanic ash deposition
 - iii. Geomorphic processes including changes in permafrost active layer thickness and/or soil moisture

Field and Lab Methods

I will conduct fieldwork in King Salmon, Alaska in the summer of 2009. My methods will closely follow those of a study of limiting factors in arctic treeline on the Seward Peninsula conducted by *Lloyd et al.* [2003].

Specifically, my methods are as follows:

1. Establish 2-4 survey transects across the forest-tundra ecotone using a hand-held GPS unit at each endpoint and survey horizontal distance and vertical relief using a transit survey.
2. Create study plots at relevant intervals along transects as determined upon ground inspection of each site. Within plots, describe plant community structure and composition at the treeline ecotone. Trees will be counted in 4x10 m plots within forest and shrubs will be counted in 5x2 m plots at the transition and in treeless tundra. Stem diameter and number will be counted for trees and tall shrubs while percent cover will be used to estimate non-woody and low-lying ground vegetation (Lloyd et al., 2003).
3. Using increment borers, take cores from all spruce with a basal diameter >5cm within each plot. The ages of smaller trees will be estimated using annual stem internodes (Lloyd et al., 2003).
4. Describe soil properties including active layer depth, soil moisture (using dielectric constant moisture probe, and geomorphic features. At a minimum of three locations along each transect (interval determined by surface morphology or other indicators), dig soil pits to describe horizons, mineralogy, as well as the presence/absence/thickness and depth of volcanic ash.
5. Conduct dendrochronologic and dendroclimatic analysis using standard practice (e.g. Lloyd et al., 2003; Wilmking and Juday, 2005). Cores will be mounted and sanded to count annual tree rings. Tree ring width will be quantified using an incremental measuring bench and recording device in Glenn Juday's tree ring lab at UAF. I will cross-date ring chronologies using COFECHA (Holmes, 2000)
6. I will explore relationships between forest structure, ecotone type characteristics, and tree recruitment and growth response to environmental factors using standard statistical practices (Wilmking and Juday, 2005), including but not limited to one-way analysis of variance and independent sample t-tests of variables such as permafrost active layer, soil moisture, and vegetation cover and abundance (Lloyd et al., 2003).

This research will be integrated with my previous and current work from Dillingham and Nonvianuk Lake and compared with relevant treeline studies (e.g. Lloyd et al., 2003, Driscoll et al., 2005). Future studies will be able to build from this research to incorporate remote sensing and GIS technology, as well as long-term climate models to expand the understanding of the distribution, structure and limiting factors of treeline ecotone types and their implications for subarctic and arctic environmental change projections and planning. This study investigates different potential drivers of ecological change on the Beringian landscape. While this work focuses primarily on the Holocene, it may assist in providing a better understanding of how spruce trees, stands, and treelines respond to changes in geomorphology, climate, or volcanic eruptions. This study may therefore help interpret Quaternary paleo records in subarctic landscapes subject to disturbance and rapid changes.

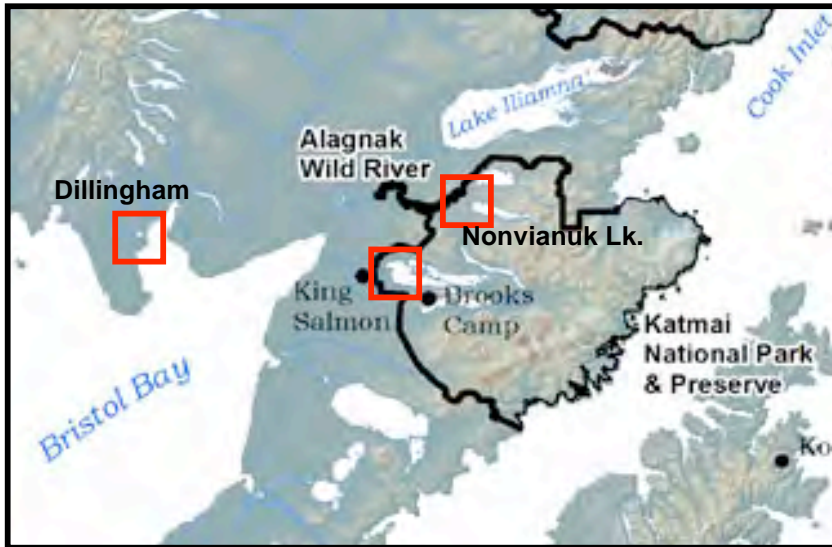


Figure 2: Bristol Bay region of Alaska showing location of proposed field sites. Map from ADF&G.

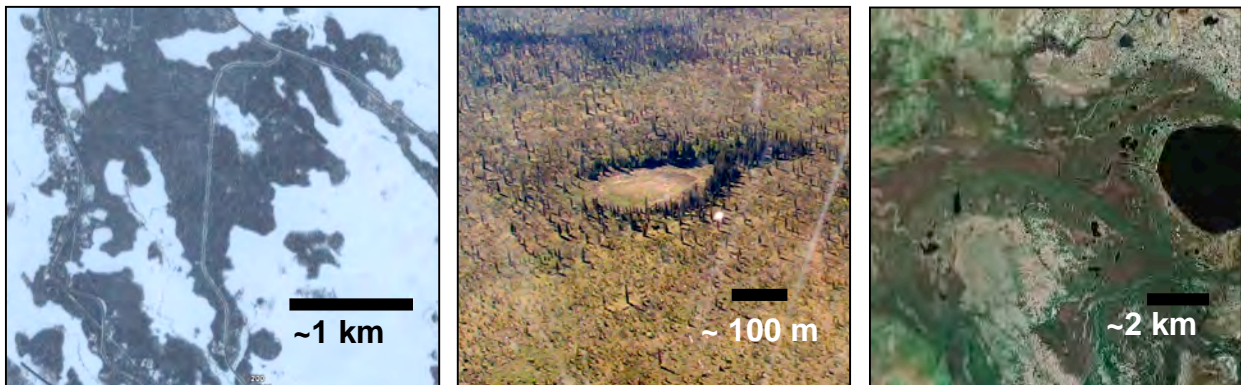


Figure 1 : Images of treeline ecotone types a. 'Tree Islands' (Dillingham) b. 'Diffuse Dual Cohorts' (Naknek/King Salmon) and c. 'Anomalous Forest Tongue' (Nonvianuk/Alagnak). Images taken from GoogleEarth.

References:

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- Holmes, R. 2000. *Dendrochronological Program Library*. Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ.
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Permit

Fieldwork conducted near King Salmon will not require any special permits.

<u>Budget</u>		
Description	Amount	Source of Funding
Travel		
RT airfare Fairbanks-King Salmon, AK	600.00	Hopkins Fellowship*
RT airfare for field assistant Fairbanks-King Salmon	600.00	<i>Currently seeking funding</i>
ATV rental in King Salmon, AK	400.00	Hopkins Fellowship*
Field and Lab Supplies		
Field: notebooks, batteries, quivers, etc.	200.00	Hopkins Fellowship*
Lab: Tree core mounts, external hard drive, sandpaper, etc.	600.00	<i>Currently seeking funding</i>
Amount requested from AQC (max \$1200)	1200.00	
TOTAL Project:	2400.00	

Budget Justification:

The overall aim of this project requires travel to and from three separate field sites. For the purposes of this grant and field season, I am seeking funding only for the King Salmon/Naknek Lake field site.

I am asking funding for a plane ticket for myself to and from King Salmon, AK. Airfare as quoted from www.alaskaair.com is currently between \$575 and \$641. I am seeking funding for airfare for a field assistant from other sources. Once in King Salmon, costs should be relatively low as I am able to borrow the majority of necessary field gear and equipment (e.g. increment borers, soil augers, GPS units, survey tools, and permafrost probes) from Dr. Heiser and the School of Natural Resource Management.

Travel while in King Salmon will be largely by foot but also requiring the use of an all-terrain vehicle. Cost of ATV rental is based on estimates from Branch River Air in King Salmon, AK. Funding from the Hopkins Fellowship will allow for ATV rental and therefore provide access to treeline sites inaccessible by foot and/or over difficult and wet terrain.

Additionally, I am asking funding to cover various in-field equipment needs such as field notebooks, batteries, and additional tree coring equipment.

Most of my lab work will be conducted at UAF in Glenn Juday's tree-ring lab and the soils lab in SNRAS, for which most of the necessary equipment is available for my use.

I am supported on a teaching assistantship for the spring and fall semesters, however as I just started my graduate program in January, I do not currently have research support for the 2009 field season.

I am currently seeking funding from other sources to cover additional costs, however, the funding from the Hopkins Fellowship would be critical in that it would provide the basics necessary to conduct this research (airfare, field supplies, ATV rental) without any additional funding.