

Boreal Alaska— Learning, Adaptation, Production

December 2012 quarterly report

Principal Investigators:

Glenn Juday

Jan Dawe

Tom Grant

AFES MP 2014-03

BAKLAP Technical Report Series

Betula neoalaskana



SCHOOL OF NATURAL
RESOURCES AND EXTENSION

University of Alaska Fairbanks

AGRICULTURAL & FORESTRY
EXPERIMENT STATION

AFES



Quarterly Report #4

contents

BACKGROUND AND PERSONNEL	1
SECTION 1: FOREST RESEARCH	3
Research Progress	3
Research Presentations and Outreach	11
SECTION 2: FOREST EDUCATION	17
Collaborations, Coordination, and Proposals	17
Student Research and Grant Proposals	17
Outreach	17
SECTION 3: K–20 STEAM EDUCATION COMPONENT	18
Deliverable 1.3: K–20 Curriculum Development: STEM to STEAM (STEAM)	18
K–12 Classroom Visits	19
Undergraduate Ecology Lab Participation	22
OLLI (Osher Lifelong Learning Institute) Workshop	23
Deliverable 1.4: Forest Entrepreneur Camp (FORENCA)	23
Deliverable 2.2: K–12 Teacher Professional Development Courses (K–12PD)	24
Deliverable 2.4: Citizen Science Field Training (CITFORSCI)	24

www.uaf.edu/snras/research/baklap/

To simplify terminology, we may use product or equipment trade names. We are not endorsing products or firms mentioned. Publication material may be reprinted provided no endorsement of a commercial product is stated or implied. Please credit the authors, the researchers involved, the University of Alaska Fairbanks, and the Agricultural and Forestry Experiment Station.

The University of Alaska Fairbanks is accredited by the Commission on Colleges of the Northwest Association of Schools and Colleges. UAF is an AA/EO employer and educational institution.

Boreal Alaska – Learning, Adaptation, Production (BAKLAP) Quarterly Report

2012 Quarter #4 (October 1, 2012 – December 31, 2012)

Authors of this report:

Glenn Juday – Professor of Forest Ecology, School of Natural Resources and Agricultural Sciences (SNRAS), University of Alaska Fairbanks (UAF) (gpjuday@alaska.edu; 907.474.6717).

Jan Dawe – Research Assistant Professor, SNRAS, UAF (jcdawe@alaska.edu).

Zach Meyers – Temporary Technical Assistant, UAF (zjmeyers@alaska.edu).

Tom Grant – Research Assistant Professor, UAF (tagrant@alaska.edu).

Ryan Jess – Research Aide, UAF (rdjess@alaska.edu).

BAKLAP Quarterly Report

2012 Quarter #4 (October 1, 2012 – December 31, 2012)

(project report #2)

Background and Personnel

The Boreal Alaska – Learning, Adaptation, Production project is funded by an appropriation under the 2012 Alaska Capital Budget (HCS CSSB 160(FIN) am H).

Mission Statement:

The goals of BAKLAP are:

- 1) To upgrade Alaska forest research facilities and management practices to improve the value of Alaska's forests in meeting the rapidly expanding demand for wood biomass energy in a changing environment, and
- 2) To improve STEM teaching and learning outcomes by developing a model integrated K–12 curriculum based on hands-on experiences with the Alaska boreal forest through inquiry science and art.

The BAKLAP project is being carried out under a Reimbursable Services Agreement (RSA) by the University of Alaska Fairbanks, School of Natural Resources and Agricultural Sciences (SNRAS) and the Alaska Department of Natural Resources (DNR), Division of Forestry. This is the **second** quarterly report of the project, covering the period October 1, 2012 through December 31, 2012.

Supported BAKLAP Project staff:

Zach Meyers, MS, UAF Biology 2012. Temporary technical (Grade 77). He was supported by BAKLAP funding from October through December 2012.

David Spencer, research technician (Grade 76). He was supported principally by BAKLAP funding from October through December 2012.

Miho Morimoto, PhD student.

Andrew Allaby, MS student.

Personnel status during Quarter #4, 2012:

Glenn Juday – on leave from Oct. 18 – Nov. 12.

Jan Dawe – applied for term-funded (BAKLAP) faculty status at SNRAS; presented Dec. 14 hiring seminar, offered position.

Tom Grant – applied for term-funded (BAKLAP) faculty status at SNRAS; presented Dec. 14 hiring seminar, offered position. On leave from Dec. 20 – Jan. 8.

Ryan Jess – Completed position as National Science Foundation (NSF)-supported student employee under grant for “Research Experiences for Undergraduates.” In late December was re-hired as research aide, UAF (rdjess@alaska.edu). Current position is supported by:

- » BAKLAP (50%) and
- » BLM (50%) funding.

Structure of this Quarterly Report

Quarter #4 of 2012 is the first quarter in which BAKLAP has been active the entire period. For accounting purposes, and because of the differing indirect cost rates, three BAKLAP accounts are maintained at UAF:

Forest Research (FR)

Forest Education Outreach (FE)

K2o STEAM Education (K2o STEAM)

This 2012 Quarter #4 report follows that three-fold division for reporting.

SECTION 1

Quarter #4, 2012 Activity: Forest Research

Alaska Boreal Forest Growth and Health Research Facilities

Research Progress:

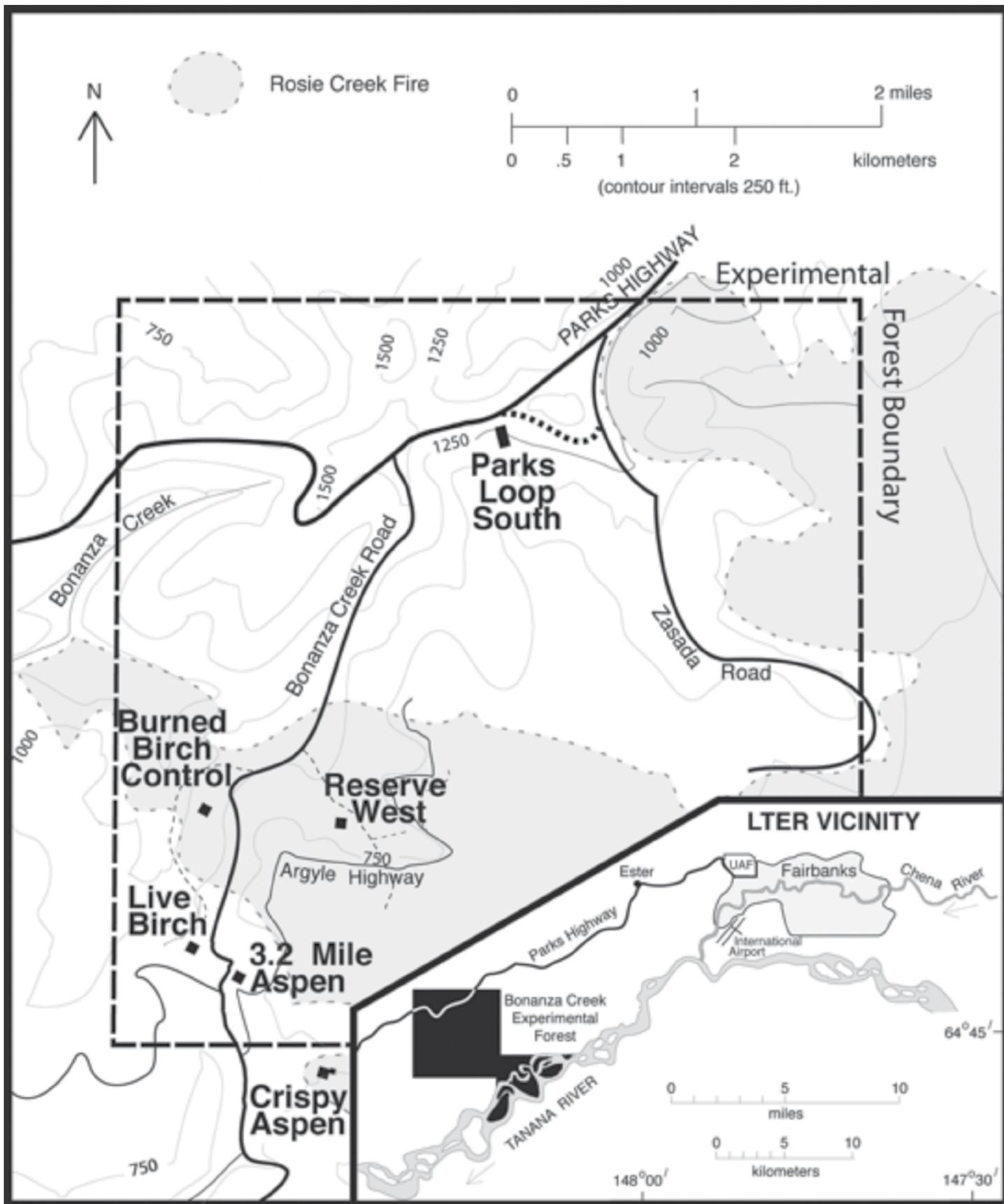
- » ***Parks Loop South Reference Stand Mapping and Database Development***, August – December 2012 (*Ryan Jess and others*)

During the months of August–December 2012, Ryan Jess worked on drafting and/or correcting a digital reference map and database of the Parks Loop South (PLS) Reference Stand in the Bonanza Creek Long Term Ecological Research (LTER) site. David Spencer was involved in aspects of PLS field work updating and obtaining archive files. The original PLS field sheets were drafted in pencil on waterproof paper at the 1:100 scale for the reference stand at the time of establishment. The upper hectare (1PLS) was field-drafted in 1986 and 1988, and the lower hectare (2PLS) in 1993. A half-hectare of 1PLS was then drafted in the program Adobe Illustrator in the late 1990s. The BAKLAP goal is to use the PLS site as a demonstration of the highest standard of documentation for the BAKLAP deliverable DAFRI (Data Atlas of Forest Research Installations).

Over the years a number of independent projects and studies have measured or sampled trees in the 1PLS and 2PLS stands, but the information exists in separate, uncoordinated databases without a common reference system, and with no provision for long-term archiving and future use of the data. The PLS stands have been a hub of studies from the 1950s when precursor studies were established by the USDA Forest Service, Institute of Northern Forestry, in what was designated as the Bonanza Creek Experimental Forest in 1963. The PLS location was one of the key locations for long term monitoring studies by Juday as part of the state-funded Rosie Creek Fire Research project in the mid and late 1980s. Shortly after that, the PLS location became a key location in the NSF-supported Bonanza Creek LTER program.

The BAKLAP map and database development at PLS compiles recorded measurements and information spanning the period from the stand's original documentation and measurement in 1986 to the present day. The original mapping of fallen logs, log decay status, and stem types occurred in 1986 and again in 1993, and subsequent recordings of tree diameter (DBH), tree ingrowth, mortality, tree coring (date of first ring), and stem breakage events (such as the 1989 and 1991 ice storms) have been recorded periodically since that time. The location of the LTER 1 m² vegetation monitoring plots, forest litter collection trays, and seed traps have been recorded. All trees have been tagged, and the tag numbers entered into a map layer.

All of this information covering 2 hectares (5.0 acres) of forest at PLS has now been included in the digital mapping (Figures 1a and 1b, page 5) in a format that allows the user to isolate and display any specific information desired. In addition, the digital format provides a unique and customizable holistic view of data collection through time, showing, for example, the special and temporal pattern of spruce mortality across the two hectares during the 26 years of monitoring. Figure 1 in this report shows the analysis that is now possible by organizing these data, and the great changes (50% mortality of trees during the monitoring period) that have occurred at this installation. The careful documentation of these changes and the consistency of similar findings at other research installation in central Alaska has been an important part of the confirming evidence for forest change that is the basis for the American Geophysical Union (AGU) abstract and Natural Areas Conference abstract of scientific findings in this quarterly report.



Reference map, showing the Bonanza Creek Experimental Forest Long Term Ecological Research Site and vicinity.

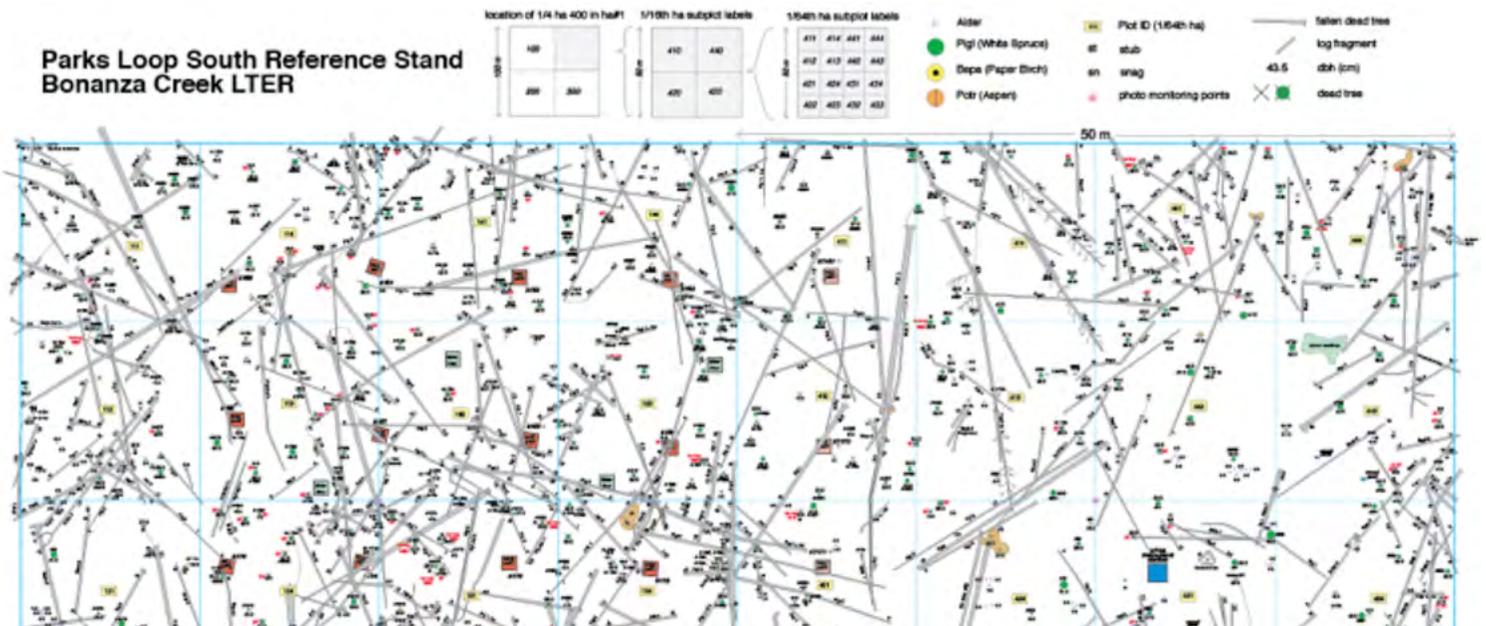


Figure 1a. Parks Loop South Data map example. Plot information gathered from 1986–2012 was digitally scaled and mapped into separate and isolatable layers.



Figure 1b. Detailed view of Parks Loop South mapping. Individual log types, log diameters, decay statuses, tree types, DBH, etc. are all displayed in a customizable digital map.

» **Copper River Aspen Collection**, October 2012 (David Spencer and Ryan Jess)

David Spencer and Ryan Jess conducted a late-season tree-ring sampling field effort with the assistance and support of the Division of Forestry, Valdez/Copper River Area Office. They obtained aspen disks from 4 sites and 28 trees collected along the road system in the Copper River Valley, well beyond the previous collection localities in Bonanza Creek LTER and along Interior rivers. The Copper Valley tree samples are furthest to the southeast in the existing UAF Climate Tree Ring Lab collections. The goal of taking these samples is to provide diverse coverage of sites similar to Bonanza Creek but with independent stand origins and to sample further along the gradient of cooler summers than previously completed.

The Copper Valley tree ring samples will be analyzed as a measure of climate sensitivities south of the Alaska Range outside the Interior boreal climatic region and are geographically distant enough that they may not be subject to the same defoliating insect outbreak cycles as central Interior boreal forest regions. The set of 2010–2012 aspen collections previously extended across nearly 500 km east to west, and nearly 300 km north to south. These Copper Valley samples extend sampling an additional 200 km to the south.

Preparation of the Copper Valley 2012 aspen stand samples was begun, involving drying, sanding, and cross-dating of disks. Drying is especially important because aspen wood must be polished to a very smooth surface to accurately see and measure ring boundaries, and moist wood particles clog the fine sandpaper (emery cloth) surfaces in a way that interferes with the clean cutting and polishing action required. Cross-dating is another critical step in producing accurate ring width chronologies. After tree disk surfaces are prepared, measurements along multiple radial tracks of the same disk are marked, and the identified years must agree along each. Finally, ring widths are measured along each radius and a statistical check is performed using the program COFECHA.

The COFECHA program uses a common variance procedure to drive the residual variance of the combined master chronology to a white noise level. It then removes each radius in turn from the master pooled version of the remaining chronologies and calculates deviations, highlighting potential dating errors when lower standard deviations from the master would be achieved at particular years by adding or deleting rings from the test chronology being examined. The user has control of the level of sensitivity (standard deviation units) that trigger flagging of potential dating errors. Once flags indicating potential dating errors are identified, then the potential dating error is examined and resolved either by making the adjustment or by confirming the original measurement sequence. The COFECHA cross-dating standards used in the UAF Climate Tree Ring Lab are rigorous, and the COFECHA files are being saved as an intermediate work product to document the quality control process in producing measurements.

» **REU Project/LTER New Site Network (NSN) Measurements**, October–December 2012 (*Ryan Jess, Glenn Juday mentoring/supervision*)

During the summer and fall of 2012, the BAKLAP project benefited from a competitively awarded NSF grant connected to the Bonanza Creek Long Term Ecological Research site (BNZ LTER). The program is Research Experiences for Undergraduates (REU), and it is designed to support undergraduate students as they are mentored in the conduct of research, gain skills, perform various research work, and then undertake and report on a project with assistance from a faculty mentor. Drs. Glenn Juday and Thomas Grant wrote the REU proposal, which was funded through the BNZ LTER, and then recruited Ryan Jess, UAF Natural Resources Management senior.

The purpose of Ryan Jess' REU research project was to apply the training he received regarding dendrochronology to measuring and analyzing the growth of black spruce located within the Bonanza Creek LTER's New Site Network (NSN). The BNZ LTER site is in the third year of an effort to establish a replicated geographically broad network of research installation focused on the black spruce forest type (55% of Alaska boreal forest land cover). The NSN will supplement several continuing research installations at BNZ LTER. The BNZ LTER is de-emphasizing existing installations within the Bonanza Creek Experimental Forest and the Caribou Poker Creeks Research Watershed (reducing frequency of re-measurement, abandoning selected installation), in order to establish the NSN. One purpose of BAKLAP is to extract the maximum value and future utility of installations with a history of BNZ LTER research.

Coupled with the tree sampling work of Dr. Juday, the data collected in the NSN can provide important information on tree response to changes in climate across Alaska. The black spruce that Ryan Jess measured were collected from Murphy Dome, Big Denver, and Wickersham Dome areas of interior Alaska. In total, rings

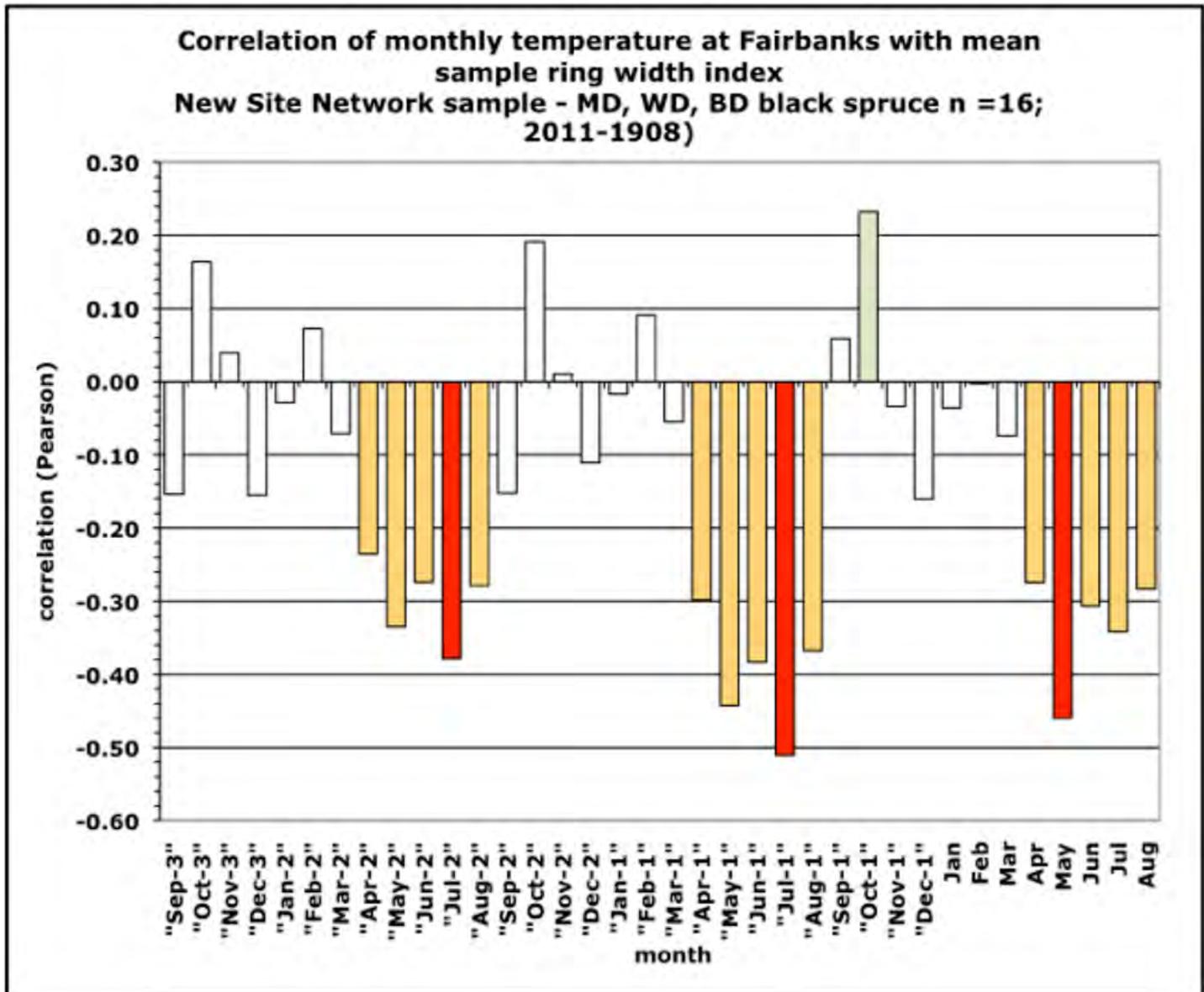


Figure 2. Correlation of ring width index of oldest black spruce trees from New Site Network sites at Murphy Dome (MD) Wickersham Dome (WD), and Big Denver (BD) with mean monthly temperatures at Fairbanks. The 36 months displayed include August in the year of ring formation (far right) and decrease to the left. Months with significant correlations are highlighted in color, and the three months that most efficiently model the growth of the sampled population of trees are highlighted in red.

and disks were measured from 160 trees. After the process of detrending (using a ^{13}C selection method) was completed, the measured growth of trees was compared to an index of climate data. The resulting information provides key insight into the effects of climate change on boreal forests. With increasing demand for biomass energy in Alaska, this information can also help calculate sustainable harvest levels in such extensive but low-productivity permafrost black spruce stands as Alaska's climate changes.

The analysis completed to date (partly for the 2012 AGU presentation) found that the black spruce samples measured from the New Site Network locations display a classic negative temperature sensitivity previously established for white spruce in low elevation boreal Alaska (Figure 2). This means that the growth of black spruce on the sites measured has responded negatively to rises in mean monthly temperatures. Mean monthly temperatures of May in the year of ring formation and the two previous Julys are highly correlated with detrended ring width.

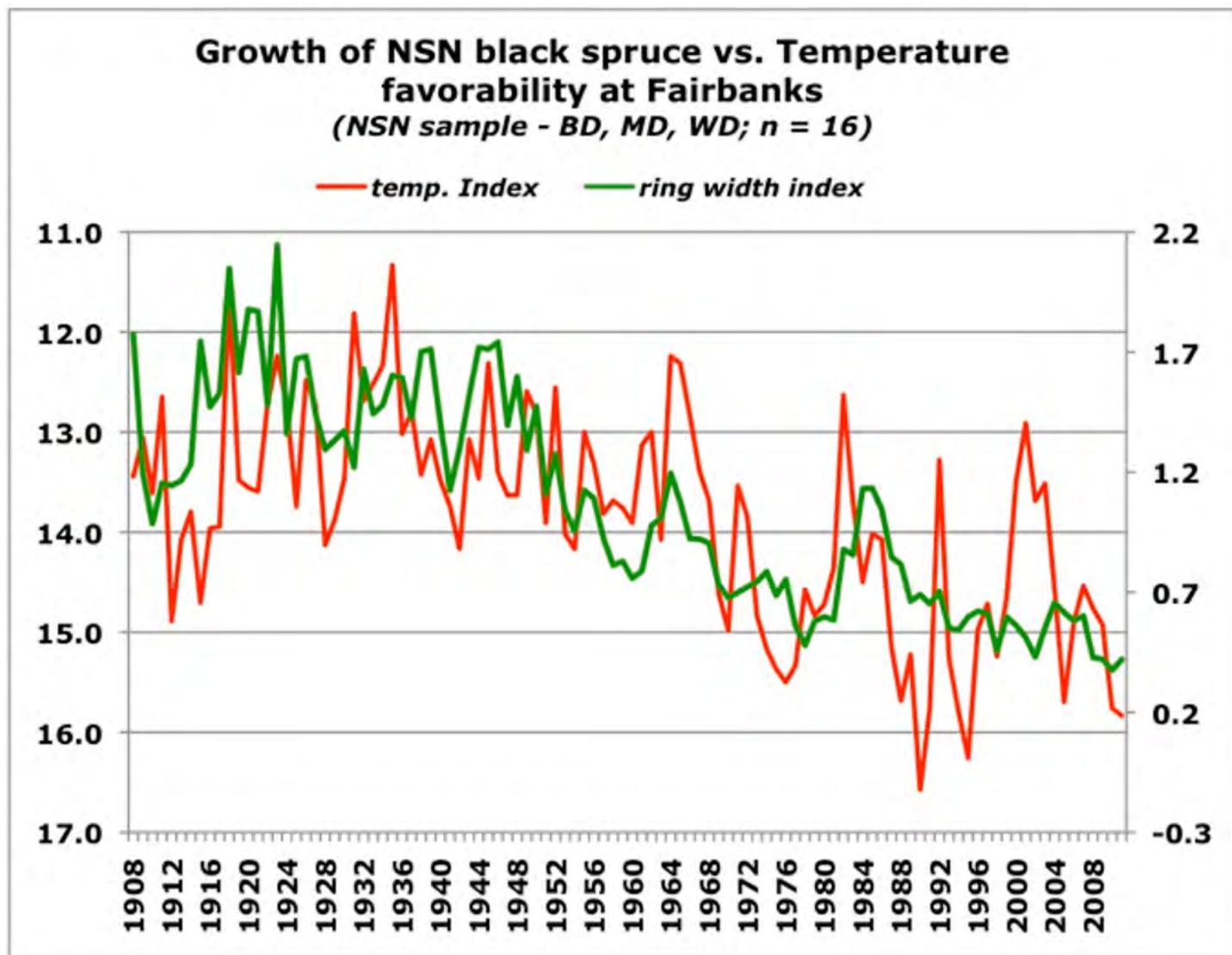


Figure 3. The temperature index (mean of May monthly mean temperature in the year of ring formation, and July of the two previous years) reproduces much of the annual variability of growth in the population of older New Site Network black spruce at Big Denver (BD), Murphy Dome (MD), and Wickersham Dome (WD).

When those three monthly temperatures (May, previous two Julys) are combined into a predictive index of temperature, the index reproduces most of the features of short, medium, and long-term variability (Figure 3). Temperature data from May in the year of ring formation and the two previous Julys provide the optimum temperature-based prediction of the growth for the contemporary year.

Both temperature favorability and actual growth have declined in recent decades, reaching lowest levels in the instrument-based climate record. The earliest twenty-first century relationship shows that, unique for the record, short-term recovery in climate favorability has not resulted in increased growth of this population, suggesting that either the fundamental relationship is changing, or that the trees are too stressed to recover. This is the same pattern we have documented for aspen and white spruce, although we do not have a well-tested explanation for the black spruce results and, in fact, the explanation may be different from aspen, for which leaf damage from aspen leaf miner is strongly implicated.

USDA CRIS (Current Research Information System) Report (AD 421)

Title: **Climate Sensitivity of Tree Growth and Forest Ecosystem Change in Alaska: Strategies for Management**

The BAKLAP project is a partnership of Alaska Division of Natural Resources (DNR), Division of Forestry and the University of Alaska Fairbanks and USDA through the McIntire-Stennis Cooperative Forestry Research Program that supports Dr. Glenn Juday's position for most of the academic year. At the end of each calendar year each investigator supported by McIntire-Stennis funds is required to submit an annual report termed an "AD 421," which is posted on the USDA CRIS website: <http://cris.nifa.usda.gov/aboutus.html>.

Juday's current McIntire-Stennis project runs from 2007 through March 2013. BAKLAP goals and objectives are compatible with the McIntire-Stennis project *Climate Sensitivity of Tree Growth and Forest Ecosystem Change in Alaska: Strategies for Management*, and so the 2012 CRIS report is included here to show the integration that has occurred at the end of the project. During Quarter #4 of 2012 Juday has been developing a McIntire-Stennis proposal for 2013–2017, which will be submitted in Quarter #1 of 2013. The new proposal will deepen and broaden the linkages between BAKLAP and McIntire-Stennis projects.

2012 McIntire-Stennis outputs: 2012/01 TO 2012/12 (3,200 character limit)

Tree-ring sampling in 2012 was carried out to update site types sampled more than a decade ago, broaden geographic coverage of aspen across Alaska, and to fill a strategic gap in a larger east-west transect study of productive white spruce along the Yukon and Tanana rivers known as the Grand River Transect (GRT). The entire GRT sample, including collections in 2003 and 2007–2010, now totals 540 dominant white spruce trees in 36 stands. Tree ring collections in 2012 include upland white spruce (11 stands, 54 trees), floodplain white spruce (3 stands, 32 trees), Alaska birch (2 stands, 16 trees), and aspen (9 stands, 63 trees). In a cooperative project with BLM we measured tree rings from a large sample of white spruce cores collected along clearwater rivers in interior Alaska, including Birch Creek (21 stands, 124 trees), Beaver Creek (25 stands, 205 trees), and Fortymile River (45 stands, 359 trees). We conducted a study of the climate sensitivity of aspen. For our existing collection of 177 aspen trees from 7 stands we detrended raw ring width using a carbon isotope chronology as a selection guide among alternate curve fitting forms. We then quantified the effect of aspen leaf miner damage on tree radial growth. We collected aspen disks from the Copper River Basin to compare with results from interior Alaska. Permanent ground photo monitoring at Bonanza Creek Experimental Forest (BCEF) in 2012 resulted in 2,068 pictures from 8 plots in the spring, summer, and fall on 14 different dates totaling 17.5 GB. We obtained airphotos of the 8 reference stand locations totaling 341 vertical airphotos in October with a light snow cover to enhance visibility of evergreen conifers. In the 25th year of measurement at the Reserve West reference hectare at BCEF, 2,271 white spruce trees remain alive, and they achieved a mean of 11.0 cm ht growth in 2012, for a mean total height of 186 cm (maximum 87 cm growth, 10.08 m total ht). The current protocol at Reserve West involves taking 8 measurements of each tree, including base diameter, diameter at breast height (137 cm), total tree height, height growth in the current year, spruce budworm damage, shade class, animal damage to leader, and notes of special conditions. These 8 parameters measured on 2,271 generated 18,136 measurements. Within BCEF all trees on the Liver Birch reference hectare (1LBR) and the first and second hectares at Parks Loop South (PLS) were remeasured in fall 2012. The 1LBR reference stand was first measured in

1986 (half hectare) and 1988 (half hectare), and at that time the hectare supported 313 live trees (307 Alaska birch, 18 spruce, 1 aspen), and an additional 84 standing dead trees for a total of 397 stems greater than 2 cm diameter. In 2012 all surviving trees were tagged and all diameters and selected tree heights were remeasured. All live trees at the 1PLS and 2PLS hectares were remeasured. We conducted the third year of a white spruce phenology study on the UAF campus, measuring height elongation at 21 dates on 56 trees. We initiated an integrated research-education-outreach project with the Alaska Division of Forestry, Boreal Alaska – Learning, Adaptation, Production (BAKLAP).

2012 McIntire-Stennis impact: 2012/01 TO 2012/12 (3,200 character limit)

The Grand River Transect (GRT) provides an unmatched opportunity for an analysis of the climate control of tree growth across boreal Alaska. Along the major river floodplains (glacial meltwater), productive forests have developed on the same soil type, from the same process of ecological succession, in a narrow elevation band, with no aspect/slope differences. In addition there are three 1st Order weather stations equally spaced across the area. The main factor affecting long-term forest growth across this area is the gradual change in climate from the warm, dry Interior, to the cooler and moist coastal region. The GRT sample is representative of trees with some of the greatest commercial wood production potential in Interior Alaska. The ring width growth record of the GRT white spruce provides an index of the productive potential of these sites. The purpose of the GRT analysis is to (1) verify the gradient in tree growth from east to west previously identified across diverse upland sites, and (2) identify where a change from positive to negative growth response to summer temperatures occurs in western Alaska. Areas with spruce populations that have positive growth response to temperature increases represent the future productive Alaska boreal forest that will provide better return on investments for forest production than areas of declining growth. Data from the post-fire white spruce monitoring at Reserve West in BCEF represent the largest and longest running annual plot-level forest measurements series we know of in the boreal forest of Alaska. The monitoring effort is providing unique insight into how forests develop in their early years and the key factors that influence their development after fire, particularly tree to tree competition and damage from drought, insect, mechanical damage, and animal browsing. The entire Bonanza Creek Experimental Forest photo monitoring project now includes pictures taken in 18 of the 23 years since inception in 1989, and annually since 2006. The collection is made up of 12,591 pictures totaling more than 83.7 GB. The project captures a rich visual record of many of the major changes in the boreal forest of central Alaska in the past quarter-century, including the transition on burned sites from small tree regeneration to an emerging forest, and the outbreak and now decline of major waves of insect defoliation and tree death since warm weather anomalies triggered outbreaks following a climate regime shift in the late 1970s. The photo and RSW tree regeneration database allow faster data entry, quicker search and retrieval of tree-specific information, and fewer errors during data entry and manipulation. The Boreal Alaska – Learning, Adaptation, and Production (BAKLAP) project is designed to upgrade Alaska forest research facilities and management practices to improve the value of Alaska's forests in meeting the rapidly expanding demand for wood biomass energy in a changing environment, and to improve STEM teaching and learning outcomes by developing a model integrated K–12 curriculum based on hands-on experiences with the Alaska boreal forest through inquiry science and art.

Research Presentations and Outreach

Presentation at American Geophysical Union Fall 2012 Meeting

Glenn Juday presented a paper on Alaska boreal forest growth and health he authored with Tom Grant, David Spencer, and Ryan Jess (UAF BAKLAP) on Dec. 7, 2012 at the American Geophysical Union fall meeting in San Francisco. The AGU fall meeting is the largest worldwide conference in geophysical sciences, with attendance of more than 22,000. The special session that took place involved an invitation to Dr. Juday and BAKLAP colleagues to contribute results from Alaska that parallel major findings of accelerated tree mortality across the western US (Craig Allen, USGS), where:

“...large growth declines or increased mortality from droughts or hotter temperatures also are being observed. We present and interpret information on regional variation in climate-tree growth relationships and trends, and on patterns and trends of climate-related forest disturbances, from western North America. From 235 tree-ring chronologies in the Southwest US we show that tree-ring growth records from warmer southwestern sites are more sensitive to temperature than tree-ring growth records from cooler southwestern sites. Assessment of 59 tree-ring records from 11 species in the Cascade Mountains of the Pacific Northwest shows that trees growing in cool places respond positively to increased temperature and trees in warm places respond negatively, implying that trees historically not sensitive to temperature may become sensitive as mean temperatures warm.”

A similar pattern of accelerated tree mortality was described for the Amazon rain forest by Greg Asner (Carnegie Institution of Stanford University, California), including an aircraft-based LIDAR and hyperspectral scanner instrument and software package capable of imaging individual dead trees, stressed trees, and healthy trees rapidly across tens of thousands of hectares at a time.

“The 2010 Amazon mega-drought is thought to have had a widespread impact on forest condition, including tree mortality. However, no large-scale, high-resolution information exists on changes in forest structure, function, turnover or other processes in response to the drought. ...Using the Carnegie Airborne Observatory Airborne Taxonomic Mapping System (AToMS), we assessed the impacts of the 2010 drought by repeat flying of approximately 500,000 hectares of lowland humid tropical forest in the Peru Amazon. The CAO AToMS Visible-to-Near-Infrared (VNIR) and Visible-to-Shortwave-Infrared (VSWIR) imaging spectrometers recorded changes in forest canopy spectral, chemical and physiological state from 2009 to 2011. ... measured highest rates of treefall and canopy gap formation in areas subjected to combined drought and logging, and on low fertility soils. The results provide the first spatially-explicit, large-scale and ecologically detailed information on the response of Amazonian forests to drought (<http://cao.stanford.edu>).”

BAKLAP presentation to: American Geophysical Union fall meeting (San Francisco, California). Session B52A. *Forest Dynamics Under a Changing Climate and Their Long-Term Context*, which took place from 10:20 AM–12:20 PM; 2006 Moscone West Convention Center (estimate 250 in attendance). Conveners were: Kristina Anderson-Teixeira (Smithsonian Institution), Robert Wilson (University of St. Andrews, Scotland), Laia Andreu-Hayles (Columbia University) and Benjamin Duval (USDA-ARS)

Title: *Early Stages Of Biome Shift in Boreal Alaska: Climate Sensitivity of Tree Growth and Accelerated Tree Mortality* Glenn P. Juday (presenter); Thomas Grant; Claire M. Alix (University of Paris, Sorbonne); David L. Spencer; Pieter S. Beck (Woods Hole Research Center, Massachusetts).

Abstract: The boreal forest region of Alaska is characterized by a major east-west climate gradient, in addition to a widely appreciated north-south gradient. Low elevations of the eastern and central Interior experience warm summer temperatures and low annual precipitation, while coastal western Alaska has cool summer temperatures and greater precipitation. In the Interior the four dominant tree species of white and black spruce, aspen, and Alaska birch on low elevation sites nearly all register a strong negative radial growth relationship to summer temperatures, concentrated in May and July. Precipitation, particularly in late winter and midsummer, plays a supplemental role as a positive factor in growth. Floodplain white spruce along the Yukon and Kuskokwim rivers transition from negative temperature response to positive response in western Alaska near the tree limit. Populations of white spruce on treeline sites display both negative growth response to July temperature and positive response to spring temperatures, with the negative response dominant in the east and the positive response dominant in the west. Across boreal Alaska summer temperatures increased abruptly in 1974, and have remained at historically high levels since. Correspondingly, climatic favorability for radial growth of Interior trees on most low elevation sites has been at extreme low levels particularly in the 21st century. Satellite-based NDVI coverage confirms that forest growth reduction is widespread in boreal Alaska since the 1980s. Defoliating and wood-boring insects have reached outbreak population levels across most of boreal Alaska, partly from release of direct temperature control on the insects and partly from increased tree host susceptibility. Major outbreak species include aspen leaf miner, spruce engraver beetle, and spruce budworm. About a dozen tall willow species have been subjected to widespread attack by willow leaf blotch miner, and a new disease and defoliating insect have spread rapidly in alder shrubs, so nearly all woody species face health challenges. Temperatures and precipitation on many Interior sites are now at or beyond tolerance limits for white spruce, aspen, and Alaska birch. Two episodes of acute drought injury were widespread in birch during the last decade. Deficits in climate predicted tree growth are synchronous with the major insect outbreaks as recorded in insect trapping records and aerial surveys of area affected. Over the past 25 years tree mortality of 50% or more occurred in nearly all long-term monitoring plots in mature stands on productive sites in the Interior, but to date trees have successfully regenerated on most disturbed sites (Figure 4). These environmental changes and tree responses, including opposite responses, are coherent, and consistent with early stages of a biome shift eliminating boreal forest on dry Interior sites, and emergence of a new climate optimum zone in western Alaska currently only sparsely populated with forest.

Presentation at Society of American Foresters National Convention

Spokane, Washington, 24–28 Oct. Forest Management & Operations Track. www.xcdsystem.com/saf/Program/index.cfm?ID=ZT8z51Y.

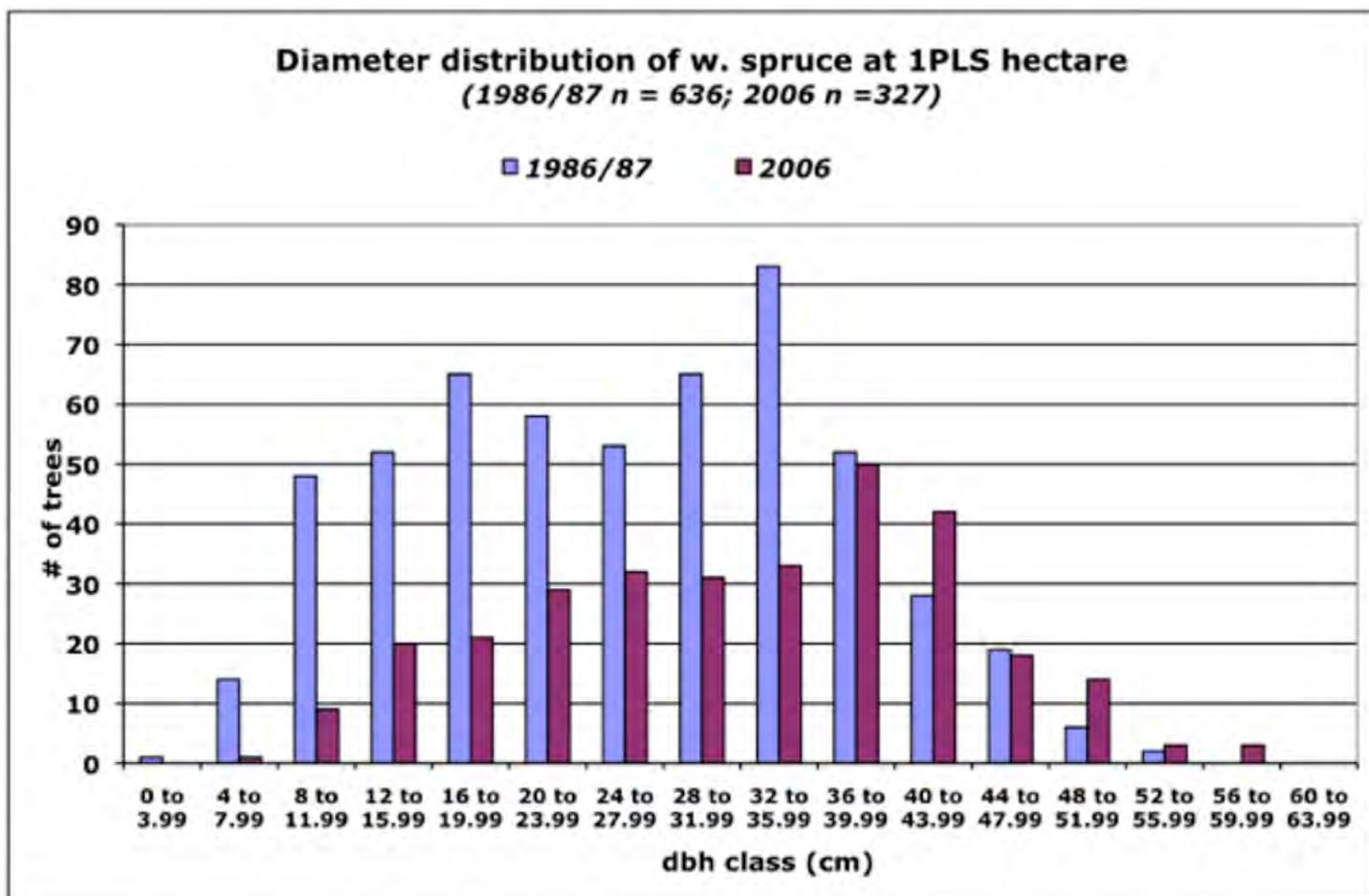


Figure 4. Diameter size class distribution of white spruce in 1986 and 2006 at Parks Loop South forest reference stand in Bonanza Creek Experimental Forest. During the 20-year monitoring interval, nearly 50% of the stems alive in 1986 died. Dying trees were concentrated in the small and medium size classes. Release of growing space from the death of neighbors allowed trees that were in the largest size classes in 1986 to advance another one or two size classes. BAKLAP-supported re-sampling of this installation was carried out in August and September 2012, and older and new data have been entered into the large map database and are being analyzed now.



Figure 5. Dr. Glenn Juday presenting results on forest growth and health in boreal Alaska Research Natural Areas at the 2012 Natural Areas Conference, October 12, 2012, Norfolk, Virginia. Data from forest research installations in the Tanana Valley State Forest, Bonanza Creek Experimental Forest, and White Mountains National Recreation Area were analyzed for this presentation.

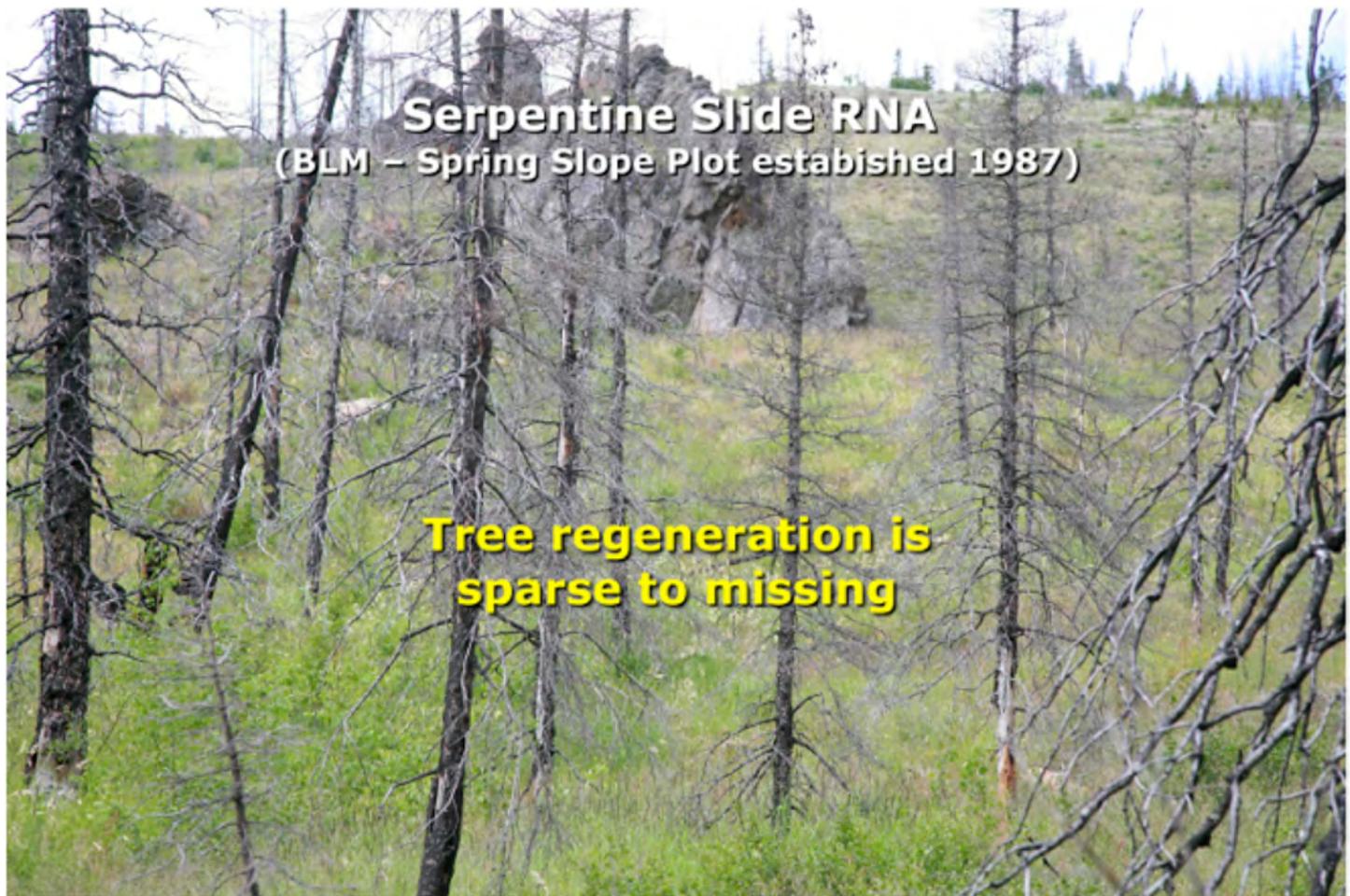


Figure 6. In the October 12, 2012 NAA presentation, Dr. Juday described an apparent case of tree regeneration failure following the 2005 fire at the Serpentine Slide Research Natural Area Spring Slope research installation, based on observations in July 2012.

Title: **Utilizing Alaska's Forest Resources for Energy in an Uncertain Climate** Valerie Barber, University of Alaska Fairbanks, Alaska Cooperative Extension Service and School of Natural Resources and Agricultural Sciences, Palmer Center for Sustainable Living, vabarber@alaska.edu (presenter), Glenn Juday, University of Alaska Fairbanks, School of Natural Resources and Agricultural Sciences, Forest Sciences Department, gpjuday@alaska.edu

Abstract: Energy costs in Alaska are high due to reliance on fossil fuels and isolation of rural communities. State and federal entities in Alaska are promoting renewable energy, primarily woody biomass for heat and power. Alaska has forest resources throughout the state of which very little is managed and logged. There is little infrastructure for a forest products industry so wood is in relatively low demand. Climate change, very much apparent in Alaska, is affecting growth and survival of the local species through different avenues. With increasing fire frequency in the state, pressure is high to cut major firebreaks around communities. This combined with an increase of acreage burned from wildfires and trees killed from insect infestations leaves an abundance of available low-value woody biomass. Dendroclimatology studies in boreal Alaska on local tree species casts uncertainty on the future regeneration of local forest stands under a warming, drying climate. Forest inventories in Alaska are not current or widespread, which increases uncertainty.

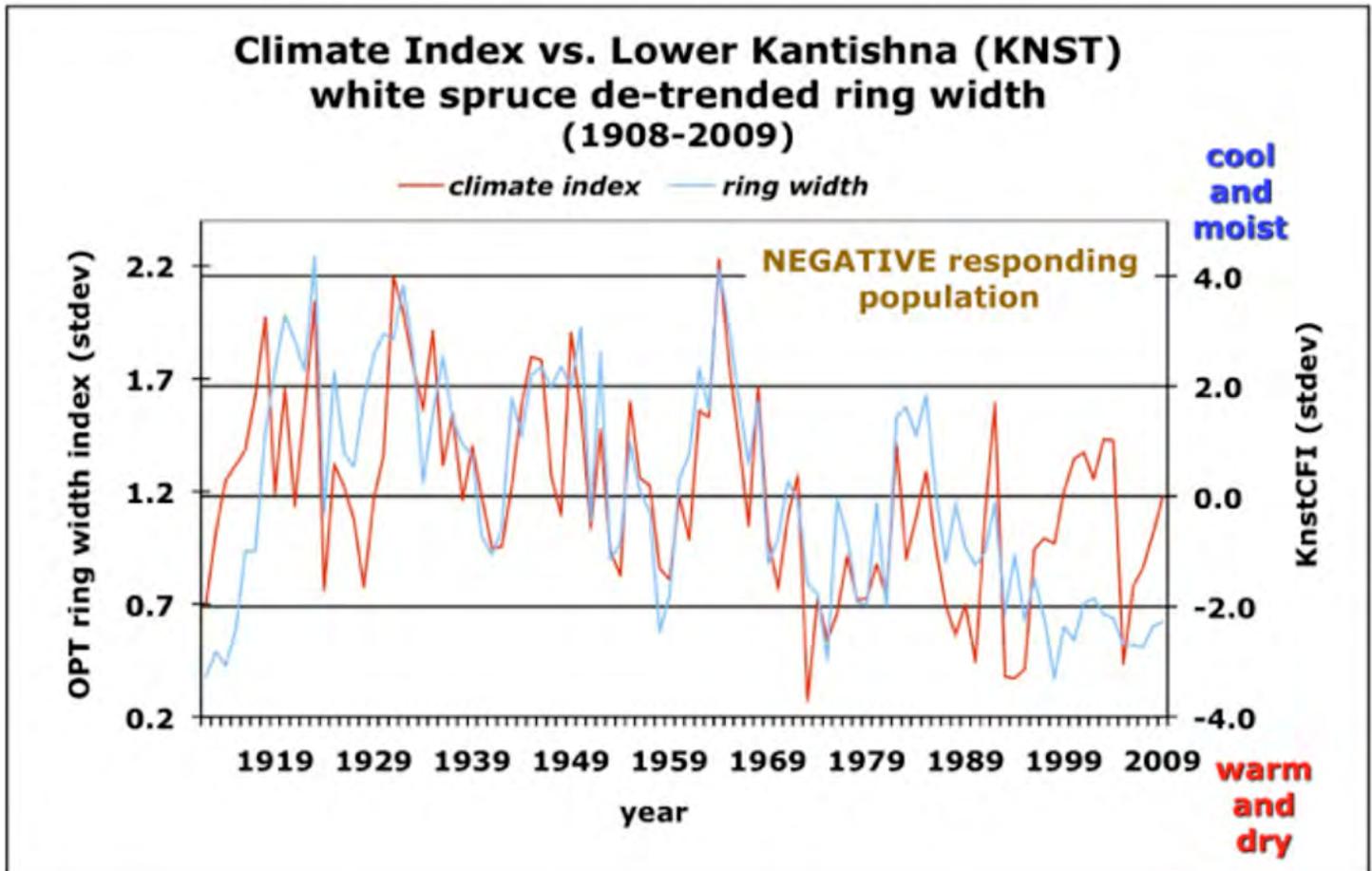


Figure 7. Detrended ring width (left axis, blue line) compared to a combined index of favorability of temperature and precipitation (right axis, red line) of white spruce at the KNST research location in the Oblique Lake Research Natural Area, Tanana Valley State Forest. This population of trees experiences a classic negative sensitivity to temperature (less growth at high temperatures, more growth at low temperatures) along with a positive response to precipitation in an index previously developed (Juday and Alix 2012) for other white spruce populations. In addition, the trees in the KNST sample on this droughty site have failed to respond to more favorable weather from the mid 1990s to early 2000s with improved growth, suggesting that either cumulative stress has weakened the population or an insect attack removed growth potential.

With the sustainability of forests in question, managers are wary of increasing dependence on woody biomass for heat and power without a management plan in place. Agroforestry and plantations of fast-growing broadleaf species, such as local and hybrid poplar, offer possible solutions for revegetation and demonstration projects are planned for interior Alaska. We also plan to re-evaluate the outcome of older management treatments and experiments in terms of relative productivity and to explore adaptation scenarios with respect to changing climate to determine what is sustainable and socially acceptable.

Presentation at the 38th Natural Areas Conference, Oct. 9–12, Norfolk, Virginia

Title: **Climate Sensitivity of White Spruce Growth in Boreal Alaska Research Natural Areas Suggests a Biome Shift** Glenn Juday, David Spencer, and Thomas Grant, School of Natural Resources and Agricultural Sciences, University of Alaska Fairbanks (gpjuday@alaska.edu; dlspencer@alaska.edu; tagrant@alaska.edu)

Abstract: A network of Research Natural Areas (RNAs) containing mature and old growth white spruce stands was established across central Alaska in the 1980s. Recent tree-ring sampling and monitoring of permanent plots in the RNAs allow analysis of forest health and climate control of radial growth during the period of available climate record in interior Alaska, from 1906 to present. Strongest correlation of radial growth is with mean temperatures for May of the growth year and the previous July. Correlation coefficients of a temperature index combining these terms reach 0.7 in dominant trees. At Caribou Crossing (CBX) RNA white spruce growth on floodplain, lower slope, and ridge summit sites all exhibit strong negative temperature sensitivity. Spruce growth on an extensive dune surface at Oblique Lake (OBL) RNA is even more highly correlated with the temperature index during the period 1906–1996, at which point growth underperforms the index because of insect attack. Spruce growth at Limestone Jags RNA is generally negatively related to the temperature index, but some high elevation floodplain trees are positive responders. Since a warming regime began in the mid-1970s, climate favorability for white spruce at low elevations in eastern and central Alaska has been exceptionally poor, and is approaching lethal levels. Extensive mortality from temperature-controlled insect outbreaks and very large, short interval fires are altering the landscape across much of boreal Alaska. These results are consistent with a biome shift, and the concept of natural areas in this region must now shift as well (Figures 6 and 7).

Alaska Wood Energy Conference

Tom Grant attended and presented a poster at the Alaska Wood Energy Conference, October 9–11 in Ketchikan: <http://uafcornerstone.net/conference-to-focus-on-community-biomass-projects/>

The Alaska Wood Energy Conference (AWEC) occurs every 18 months, and in 2012 was coordinated by the UAF Cooperative Extension. The other principal sponsors were the Alaska Energy Authority and the UAF Alaska Center for Energy and Power. The conference was focused on community use of wood biomass, highlighting success stories from Alaska communities that have implemented wood biomass projects. Other topics addressed include sustainability and environmental impacts of biomass harvest and production, new biomass technologies, biobrick fabrication and micro-pellet mills. The conference was addressed by public officials and community leaders, and included a tour of the Ketchikan Library boiler and the Tongass Forest Enterprise Pellet Plant.

Dr. Grant presented a poster at AWEC, highlighting the integrated nature of research, education, and outreach within BAKLAP.

Pacific Land Grant Universities (PLGA) Meeting

Drs. Janice Dawe and Thomas Grant attended and presented two presentations at the PLGA's stakeholder meeting in Hawaii (Oct. 25–26, 2012). The PLGA is a consortium of approximately ten land grant universities in the Pacific region. UAF's SNRAS, CES, and BAKLAP are assuming leadership for upcoming PLGA grants related to climate change. Dr. Grant's presentations focused BAKLAP programs and on the similarities in issues facing Pacific islanders and Alaskans, especially concerning climate change, agriculture, and food security (Co-Author Dr. Glenn Juday). Funding for the travel and all expenses was paid by UAF's School of Natural Resources and Agricultural Sciences.

SECTION 2

Quarter #4, 2012 Activity: Forest Education

Collaborations, Coordination, and Proposals:

Drs. Thomas Grant and Janice Dawe participated in an NSF Math and Science Partnership proposal with PIs Anupma Pratash (UAF Geophysical Institute) and Gwen Holdmann (UAF Alaska Center for Energy and Power, or ACEP). The proposal is a multi-million dollar proposal to improve science education in rural Alaska communities through connecting science education to energy projects (biomass, wind). Drs. Grant and Dawe are science experts for forestry and STEM (Science, Technology, Engineering, Mathematics) education programs. If funded, the NSF proposal will augment existing BAKLAP education programs, especially in rural communities.

Dr. Grant is collaborating with Dr. Jane Wolken (UAF Scenarios Network for Alaska & Arctic Planning, or SNAP) to conduct research on the influence of topography on black spruce's sensitivity to climate change. Preliminary results show a positive response of the ridge forests (high elevation) to precipitation and a negative response of the bottomlands to temperature. Results are relevant due to the broad distribution of black spruce in interior Alaska and the potential for large-scale harvest for biomass energy in the future.

Dr. Grant is coordinating with Alaska's DNR Division of Forestry and the US Forest Service to develop research in the areas affected by the large wind event in the Tok/Delta areas (September 2012).

Student Research and Grant Proposals:

BAKLAP is supporting a graduate student (Andrew Allaby) to investigate tree regeneration following large disturbances (Tok/Delta Wind Event). The research will improve our understanding of how forests establish following natural or anthropogenic disturbances and will be coordinated with DNR Division of Forestry and US Forest Service Forest Health and Protection programs.

BAKLAP PhD student Miho Morimoto is submitting a proposal to the UAF Global Change Student Grant Competition. Ms. Morimoto's proposal will focus on tree regeneration following timber harvest and will augment existing BAKLAP research on the topic.

Outreach:

BAKLAP's **website** is currently under development by Dr. Grant. The information-rich website will be hosted within the UAF School of Natural Resources and Agricultural Sciences website.

BAKLAP assisted in the development and implementation of a monthly **Biomass Brown Bag Lunch** meeting. The monthly meeting gathers diverse people interested in biomass energy and Dr. Glenn Juday was featured as the speaker at the first meeting.

BAKLAP and ACEP are coordinating to consolidate information concerning biomass energy and the potential for additional collaboration.

SECTION 3

Quarter #4, 2012 Activity: K–20 STEAM Education Component



Figure 8. Jan Dawe, BAKLAP Executive Team leader for K–20 STEAM Education, with Alaska birch seedlings in the UAF AHRB Research Greenhouse in January 2013 (left). These seedlings were sown in October 2012 in containers and distributed to participating seventh- and eighth-grade teachers and classrooms in the Fairbanks North Star Borough School District. The seedlings represent an experiment relating to the effects of watering and temperature regime versus potential genetic effects on growth of birch. Advanced stage of development achieved by birch seedlings in 13 weeks (right). This seedling has undergone multiple growth flushes and has developed crystals of an anti-browsing chemical on its stem in the artificial growing season made possible by the controlled environments created in each participating classroom with mentoring and lighting source provided by project BAKLAP.

Deliverable 1.3: K–20 Curriculum Development: STEM to STEAM (STEAM)

Developments since the September 30 quarterly report:

Six of the eight classroom teachers who had expressed interest in working with OneTree/K–20 STEAM (STEM + Art) Education before the start of the project worked extensively with it from October 1 through December 21 (the start of the holiday break). The other two teachers, who had not worked with the project before, Sarah Drew and Timothy Ludwig, were unable to join mid-semester. A map giving the locations of participating schools is shown below (Figure 9, opposite), followed by a summary table of schools, teachers, grade levels, and size of classes visited (Table 1, page 20).

During the fall, classroom visits were customized to each class's interests. We found, however, that conducting unique empirical research projects in each class was beyond the scope of the project at this point. We had insufficient staffing to make weekly visits to each classroom, which is, minimally, what it would take to keep experiments in all 10 classrooms on track. Instead, we made a main focus of our attention the middle school classrooms at Randy Smith Middle School, where the age and number of students allowed for more robust experiments (see individual teacher/school write-ups below).

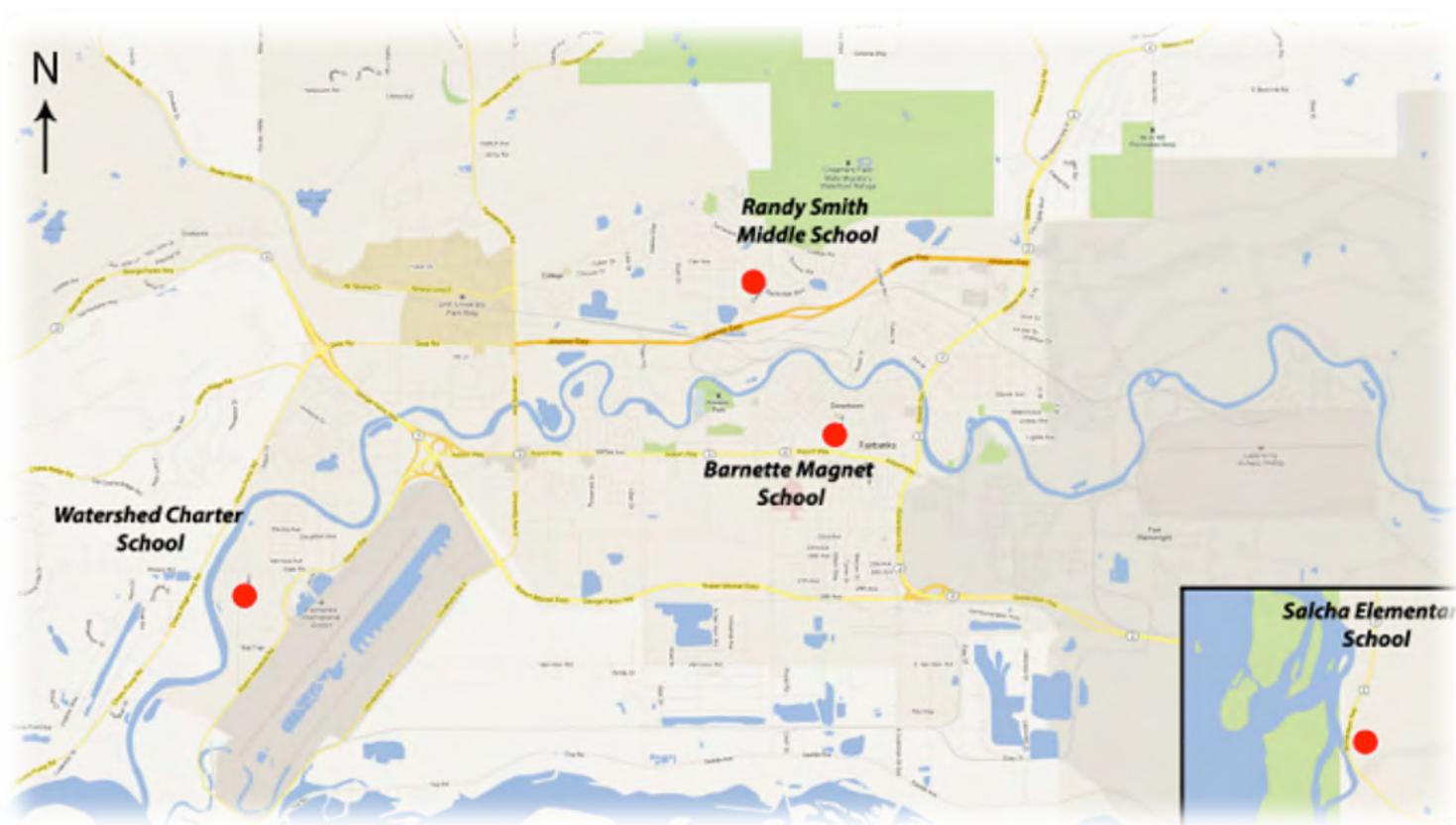


Figure 9. Map of the schools that the K-20 STEAM Education team visited throughout the months of October and December.

In addition to K-12 visits, K-20 STEAM Education staff developed a lab with a UAF undergraduate biology class (see section titled “Undergraduate Ecology Lab Participation,” below) and provided an OLLI afternoon workshop (see section titled “OLLI (Osher Lifelong Learning Institute) Workshop” at the end of Deliverable 1.3.

Lesson learned during Quarter 4, 2012:

Germinating birch seeds and tending germinants is difficult for elementary school children, and results in unnecessary levels of seedling mortality. To rectify this situation, K-20 STEAM Education staff will start seedlings in the greenhouse at the university, and tend the germinants until they have grown large enough to have true leaves and taproots and can be thinned. At this point, seedlings are hardy enough to tolerate uneven classroom watering regimes and will be delivered to participating classrooms that want to work with the seedlings.

K-12 Classroom Visits

From October 1 until December 21, 2012 the K-20 curriculum team of Jan Dawe, Zachary Meyers, and Andrew Allaby implemented lessons through 50 classroom visits. Activities and lesson plans ranged from investigating seed shapes and textures to recording germination rates with each class’s Alaska white birch schoolyard Adopt-A-Tree. More than 200 students, six teachers, and four schools (see Table 1, next page) participated in K-20 STEAM Education activities.

Watershed Charter School	Marlene McDermott	K	1	22
Watershed Charter School	Moira O'Malley	1 st – 2 nd	1	25
Salcha Elementary School	Ronda Schlumbohm	2 nd – 3 rd	1	21
Barnette Magnet School	Deborah Bennett	3 rd	1	24
Randy Smith Middle School	Chris Pastro	7 th – 8 th	2	17
Randy Smith Middle School	Mike Geil	7 th – 8 th	4	100

Table 1. Shows the number of schools, teachers, grade levels, and number of students who participated in K-20 STEAM education activities from October 1 to December 31, 2012.

Marlene McDermott/Kindergarten Teacher, Watershed Charter School (Figure 10):

McDermott's young kindergarten students selected an Alaska white birch tree in a forested area across the street from the school and collected seeds to grow in the classroom. McDermott's main goal with the tree-growing activity is to introduce principles of scientific observation and have her students begin to see and describe the process of plant growth. Throughout the fall, Zachary Meyers and Andrew Allaby made weekly visits to enrich the students' observations with discussions of plant physiology, leaf anatomy, and seed dispersal. A second



Figure 10. Two students (left) from Watershed Charter school count the number of seedlings in their container. A kindergartener (top right) looks through a microscope to examine seed textures of common fruits and vegetables from the supermarket. Zachary Meyers (bottom right) and a kindergartener plant birch seeds collected from outside the school to grow in the classroom.

observational study was conducted in the classroom, forcing winter-dormant branches from their Adopt-A-Tree to release from dormancy and proceed to spring condition (budburst, pollen shed, exertion of female catkins).

Moira O'Malley/First- and Second-Grade Teacher, Watershed Charter School:

O'Malley's class conducted an empirical exploration with respect to seedling growth under different color lights. A lesson on the properties of light was given prior to the experiment where the student used color filters to blend different wavelengths. The wavelengths of green and blue light were used to determine overall growth differences. Seeds were harvested from a tree near the school ground. Each student planted 20 seeds, 10 in each plant container. The seeds were then subjected to full-spectrum light. Once seedlings from both containers emerged they were separated into blue and green light. The class used height

measurement as a proxy for fitness. A total of four measurements were made throughout the months of October and December. There was no substantial change in growth between the two wavelengths. The class concluded that there was too much natural light in the classroom.

Ronda Schlumbohm/Second- and Third-Grade Teacher, Salcha Elementary School (Figure 11):

Schlumbohm's second and third graders designed an experiment to compare germination rates of collections made from individual Alaska white birch trees (2) and a bulk sample of seed sources from many trees in a natural stand on Eielson Air Force Base. The students designed their experiment in an iterative process. In Step 1, they learned the difference between a seed and its subtending scale (the reduced floral part that protects the developing seeds) by trying to germinate both. Once the students could tell the difference between these two reproductive structures,



*Figure 11. (Top left) A student from Salcha Elementary conducting a budburst/forcing experiment, investigating dormancy from an Alaska white birch (*Betula neoalaskana* Sarg.) tree near the school. (Bottom left) Jan Dawe shows a student buds and male catkins on a branch of a birch tree. (Right) A student counting the number of leaves on her sapling.*

they moved on to the next germination trial, in which they compared germination rates amongst three sets of trees: cohorts from each of two maternal trees vs. a (third) bulk sample representing many trees. Prior to this germination trial, each student made a prediction. Daily observations over a 10-day period were made to determine percent germinated. Their results showed slightly higher germination percentages in seeds from the whole stand of trees. Prior to the experimental investigation, a primer on seeds and seed anatomy was given to the class. The activity involved technology, an important component of STEM (Science, Technology, Engineering, Math), in that the students learned to use a binocular microscope to draw the different shapes, colors, and textures of diverse seeds.

Deb Bennett/Fourth- and Fifth-Grade Teacher, and Sixth- through Eighth-Grade Science Teacher, Barnette Magnet School:

Bennett’s class chose an Adopt-A-Tree in a forested area on their school campus. An experiment comparing the germination rates of collections made from individual Alaska white birch trees (i.e., one] from their Adopt-A-Tree; 2] from Nenana Ridge) and a bulk sample of seed sources from many trees in a natural stand on Eielson Air Force Base. The class then tested tree growth in two different water environments: one cohort top watered only vs. one with both top watering and continuous bottom watering (no water limitation). Unforeseen classroom interruptions from leaky pipes prevented students from maintaining standardized watering conditions throughout October and December.

Chris Pastro/Seventh- and Eighth-Grade Teacher, Randy Smith Middle School Extended Learning Program:

Pastro’s 17 Extended Learning Program (ELP) seventh and eighth graders conducted an experiment throughout the fall testing the response of three genotypes to three (artificial) soil types. Weekly measurements were made from mid-November until December 21, and included tree height, number of leaves, and length and width of largest leaf. Students also made weekly sketches to track their seedlings’ growth, and conducted branch dormancy time trials similar to Mike Geil’s classroom experiments (see below Figure 12).



Figure 12. Shows leaf drawings from Chris Pastro’s ELP class.

Mike Geil/Seventh- and Eighth-Grade Teacher, Randy Smith Middle School Science:

Geil’s four life sciences classes conducted a two-factor experiment with Alaska white birch collected near their school grounds to investigate influences of moisture and temperature on germination rates and growth. Each class, with 25–30 seventh-grade students, made weekly observations and collected data on seedling height and number of leaves three times at intervals during the semester. In addition, the classrooms collected multiple branches from their birch trees to investigate the trees’ behavior during dormancy. Three branches from each of Geil’s four Adopt-A-Trees were used in the dormancy time trials. Each successive week, the accumulated heat sum needed for branches to release from dormancy and proceed to budburst, exertion of female catkins, and pollen shed was recorded, as a means to establish, retrospectively, the approximate date each tree entered winter dormancy. Supplemental lessons concerning experimental design, plant anatomy, physiology and phenology were developed as background information for both investigations.

Undergraduate Ecology Lab Participation

During the first week of October, 45 UAF students taking BIOL F271 (Principles of Ecology) collected

data on Alaska white birch (*Betula neoalaskana* Sarg.) in the Generation OneTree Long-term Ecological Monitoring (LTEM) plot located at the T-field of the Agricultural and Forestry Experiment Station, University of Alaska Fairbanks. The students' task was to calculate branch density as a proxy to describe and quantify tree architecture. Protocols for the activity were developed by instructor Karen Mager, four teaching assistants, and BAKLAP K-20 STEAM members Dawe and Meyers. The protocols concerned tracking the effect of initial growing-season length (three months vs. five months, see Figure 13 below) on tree architecture. Tree height and placement of branches along the main stem were measured for each of 80+ trees. For each tree, a sketch showing the position of branches accompanied the measurements. The results demonstrated a substantial difference at three months and five months in tree architecture between trees grown.

OLLI (Osher Lifelong Learning Institute) Workshop

On October 26 Zachary Meyers co-taught an OLLI workshop, "OneTree Alaska," with Karen Stomberg. OLLI is designed to provide learning opportunities

and intellectual stimulation for students from 50 years of age on up, without the stress of tests and grades. Students were given a brief history of OneTree Alaska along with an overview of drawing (i.e., shading, complimentary colors, and scale) as well as a plant anatomy/physiology lesson. Pressed Alaska white birch leaves from the Generation OneTree Long-term Ecological Monitoring plot were given to each participant to sketch and color, with the challenge of capturing as much detail as possible.

Deliverable 1.4: Forest Entrepreneur Camp (FORENCA)

Developments since the September 30 quarterly report:

1) Re: BAKLAP staffing and level of effort: Andrew Allaby will spearhead K-20 STEAM Education's premier entrepreneurial project: "Tapping Into Spring" during the spring semester of 2013. He will invite all teachers who worked with the project during the fall to have their classrooms participate in tapping schoolyard Adopt-A-Trees for spring sap, and produce birch syrup or other birch sap products from it.

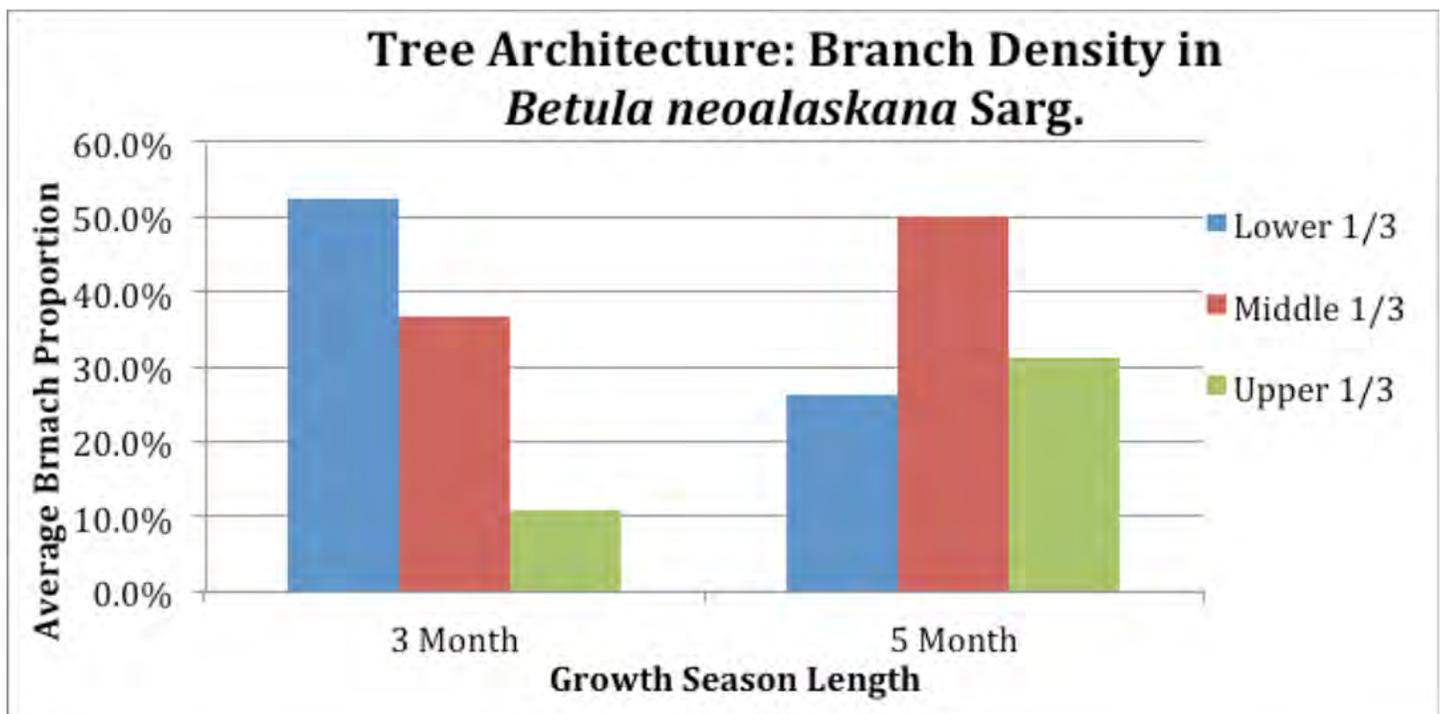


Figure 13. The chart shows differences in tree architecture between three- and five-month growing seasons. Trees grown at the three-month treatment clearly demonstrated a strategy for branches at the lower portion of the tree versus the five-month seasons, which show a tendency for middle to upper portions.

2) Re: Entrepreneur Camp: Jeff Mann, Principal of Hunter Elementary School in downtown Fairbanks has approached BAKLAP about being part of a summer camp at Hunter. Mann is specifically interested and trained in junior entrepreneurial efforts (from the Kauffman Foundation of Kansas City). There is a good link to be forged between BAKLAP and Hunter Elementary which, as a Title 1 School, has identified that it has special needs for enriching its STEM curriculum. Mann proposes that “STEAM into School” be a two-week endeavor held sometime in the period from late July through the first half of August. Stomberg, as our FNSB School District liaison and Art Coordinator of the District’s Art Center, and Dawe will begin to meet weekly in January 2013 to develop plans for the entrepreneur camp.

3) Re: monthly ‘maker workshops’ as a mechanism to build interest in a longer entrepreneur camp: BAKLAP K–20 STEAM Education is still interested in developing this approach as a way to test activities and gauge interest in the longer entrepreneur camp. However, it’s clear that Allaby—who had been considered the point person for these monthly workshops—will have his hands full with Tapping Into Spring. We await the right person to take charge of the monthly maker workshops (STEAM Works).

Deliverable 2.2: K–12 Teacher Professional Development Courses (K–12PD)

Developments since the September 30 quarterly report:

During the first week of October, the FNSB School District began to coordinate plans for a one-credit phenology NRM continuing education course to be offered as a NRM class for the ten-member Core K–12 STEAM Educator Group. Later in the month it was decided to postpone the start of the course until January 2013. Stomberg is serving as liaison with the FNSB School District Curriculum Office and will co-teach portions of the course. Dawe has developed the syllabus and will be the instructor and Meyers and Allaby will serve as the co-facilitators. The course is being developed to aid and extend K–12 teachers’ knowledge of experimental design, especially as it relates to tree germination and growth experiments.

Deliverable 2.4: Citizen Science Field Training (CITFORSCI)

Developments since the September 30 quarterly report:

Generation OneTree Long-term Ecological Monitoring Plot:

During the first week of October, the 45 students in the undergraduate Biology F271 course: Principles of Ecology completed a lab using the LTEM plot in the T-field. Students measured the heights and placements of branches along the main stem of 80-plus trees, representing two cohorts of progeny differing in their initial growing season length (three months and five months) to ascertain potential differences in tree architecture and habit as the local birch resource responds to climate change drivers. More details can be seen under Deliverable 1.3 K–20 Curriculum Development: STEM to STEAM (STEAM) – section “Undergraduate Ecology Lab Participation.”

Community Service Project:

Treecycler acknowledged our September tree-planting efforts on Birch Hill by awarding our project “Seeds to Trees—Rearing the Next Generation” one of its quarterly “welcome” awards (± \$250). It has also highlighted our project at various times throughout the fall on its website: www.treecycler.com.

Development of Augmented Reality and Visualization Tools:

Virtual T-Field Plot in Google Earth: The accessibility of augmented reality (AR) technology in the last decade due to tools such as virtual globes, smartphones, and tablets has dramatically changed the way we see our environment, especially for young learners. Educators are implementing this technology in their classrooms to supplement lessons. Children tend to remain focused and more engaged in these types of activities due to the immersive experience that is often achieved. Examples of AR span the gambit of subjects from chemistry (visualizing a 3D molecule and their hydrostatic interactions) to biology (virtual dissections) and English (interactive textbooks/stories). The K-20 STEAM Education team is working on integrating this technology into lessons and activities to enrich the experience of the students in a similar fashion. The establishment of a long-term ecological monitoring (LTEM) plot at the T-Field has offered a great opportunity to develop and implement AR technology. The goals of the LTEM are to 1) track long-term physiological and phenological changes of 144 Alaska white birch (*Betula neoalaskana* Sarg.) exposed to three different growing conditions and measured (i.e., at three, four,

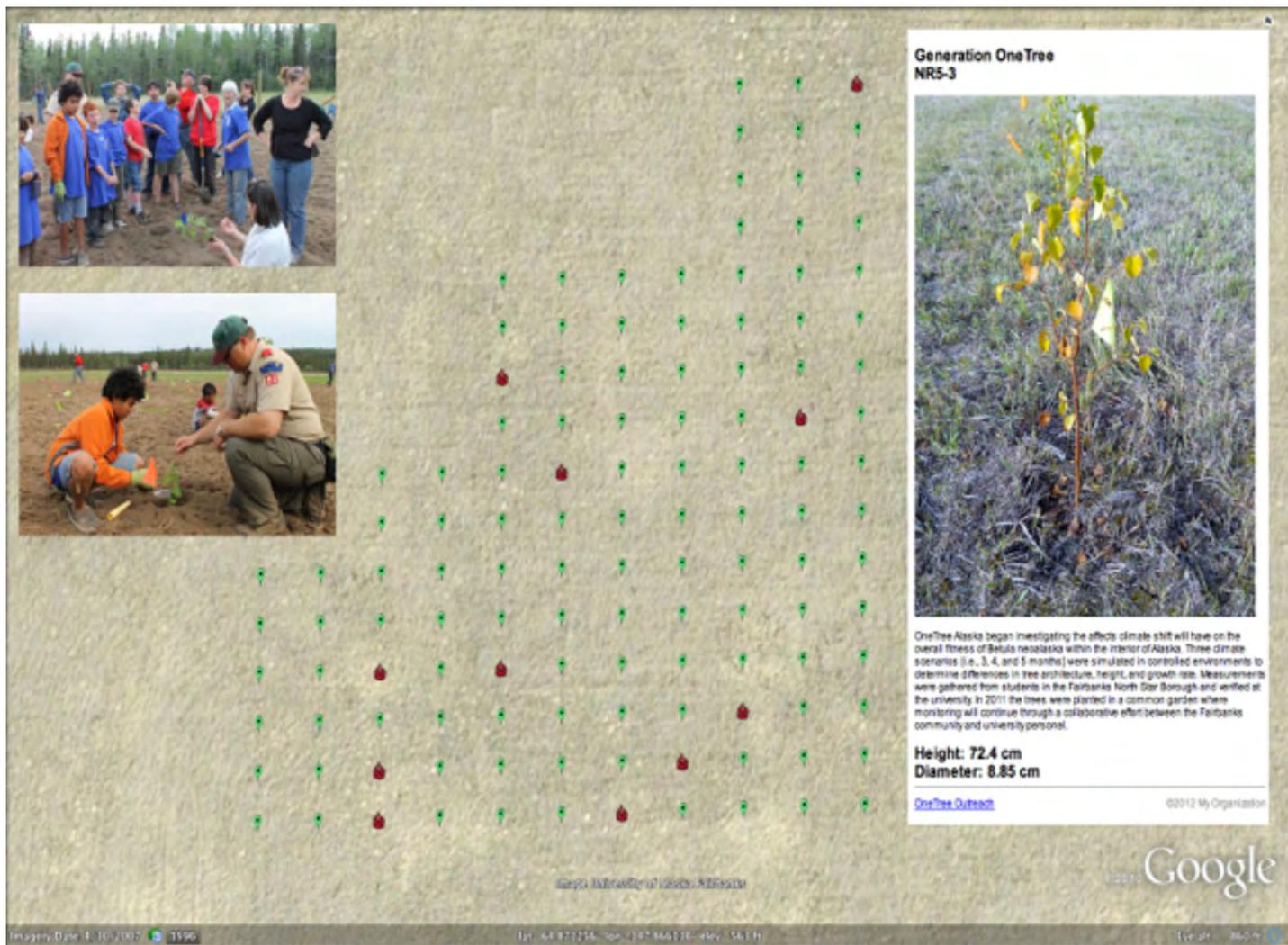


Figure 14. Volunteers from Troop 92 and their leaders help plant birch saplings for the establishment of the Generation OneTree LTEM plot. The Google Earth tool illustrates the mortality of the trees (fire symbol) over the past two years of growth. When the user selects a given icon (represented in green), a picture of each tree from the current year, along with height and diameter measurements, is also displayed.

and five months) during the first year of growth. 2) Train citizen scientists to track phenological changes. 3) Offer a resource for classes to conduct experimental research and data collection using digital devices and real-time updating in Google Earth (Figure 14, previous page).

The most popular virtual globe, Google Earth (GE), offers a suite of spatial visualization tools to display rich data layers. Zachary Meyers created a relational database in December 2012 to provide dynamic updates of the Generation One Tree LTEM plot in GE. This allows the public to view real-time observations from the LTEM at the T-Field (i.e., the current year's height, date of first leaf-out, and date of budset). This coming summer the K–20 Education STEAM team hopes to develop an iPad application to enter data in real time and link it to the GE tool. This scientific experiment offers the public a transparent window into research at the University of Alaska and also invites volunteers to participate in data collection. The GE tool also allows users to examine complex data in virtual space. The height measurements of 2012 from 144 Alaska white birch trees were displayed, categorized by treatment in GE (Figure 15). This allows cryptic patterns that would otherwise be less apparent to be visualized. Additional steps are being taken to develop this technology in school experiments so that a forum of information exchanges can be established.

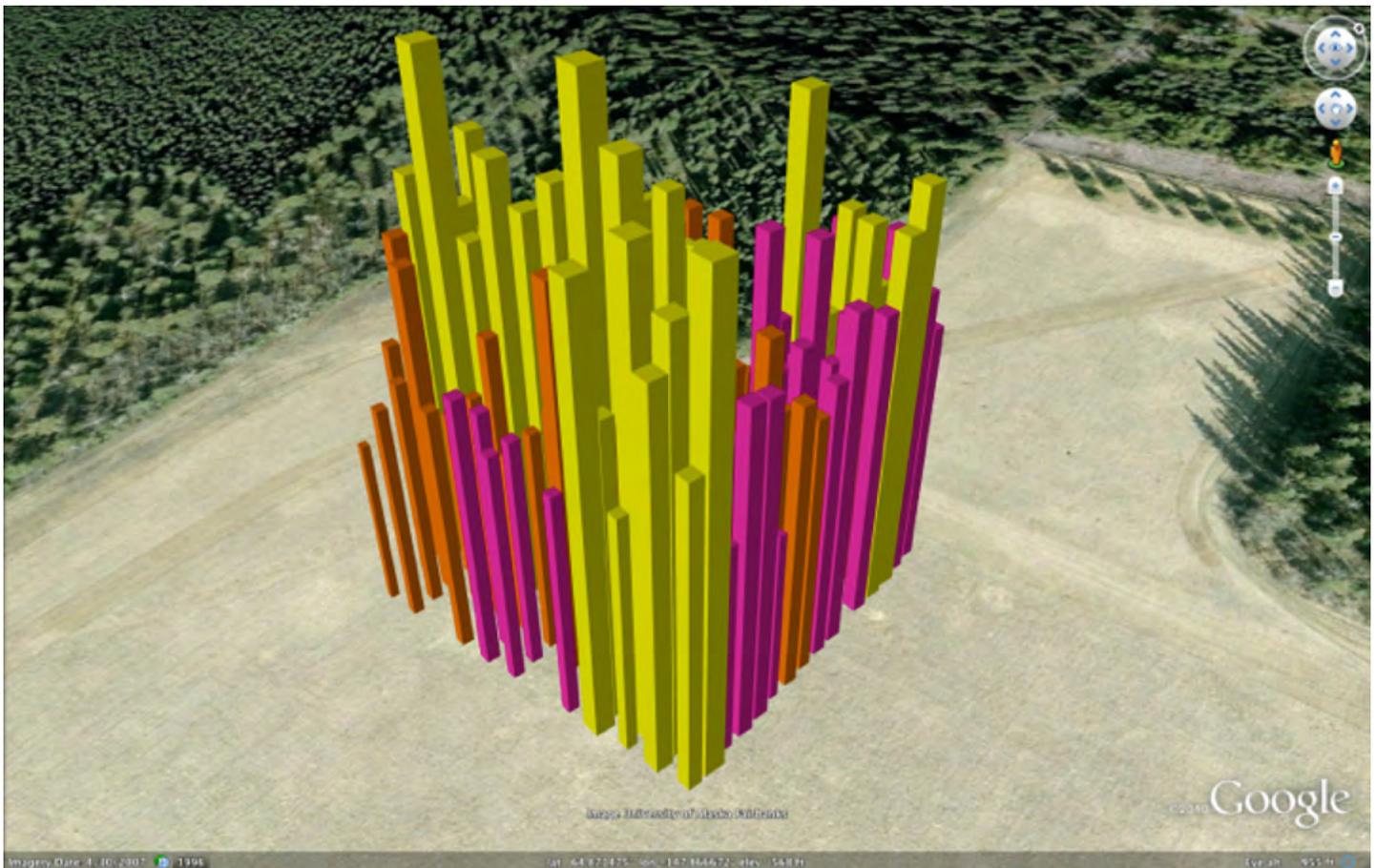


Figure 15. Google Earth provides the necessary visualization tools to communicate the differences in growth among the Alaska white birch trees planted in the LTEM plot. Above represents a 3-D bar graph of the 2012 height measurements from individual trees under the growth conditions the saplings were first exposed to (three months = Orange; four months = Pink; five months = Yellow).