

University of Alaska Fairbanks  
School of Natural Resources & Agricultural Sciences  
Alaska Agricultural & Forestry Experiment Station

# Annual Report for 2004



Above: The genetics of wildlife such as *Ursus maritimus*, polar bears, are the subject of study by SNRAS researchers (pp. 42–43).

—PHOTO COURTESY US FISH & WILDLIFE SERVICE

Below: Feed and reproductive studies of the semidomesticated reindeer (pp. 12–15) are of ongoing importance to herders in Alaska and elsewhere in the world.

—PHOTO COURTESY REINDEER RESEARCH PROGRAM



Left: Student employee Jen Brorson with reindeer Rip (also pictured above as a three-week-old calf) at the annual SNRAS Welcome Back chili potluck. Research projects by the Agricultural Research Service and SNRAS are investigating the movements of reindeer and caribou and the effects of climate change on their rangeland and forage (pp. 33, 36). Other studies examine forest growth and ecosystem dynamics (pp. 38–41, 46–53), new uses for fish processing byproducts (pp. 42–44), and more.

—PHOTO BY DEIRDRE HELFFERICH, SNRAS

This report is published by the Agricultural and Forestry Experiment Station, University of Alaska Fairbanks.

For more information about our research and education programs, please contact us at:

**School of Natural Resources & Agricultural Sciences**

P.O. Box 757140  
Fairbanks, AK 99775-7140

Office of the Dean  
(907) 474-7083  
fysnras@uaf.edu

Student Information  
(907) 474-5276

or visit our website:

<http://www.uaf.edu/snras>

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P.O. Box 757200  
Fairbanks, AK 99775-7200

fynrpub@uaf.edu

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Managing Editor  
Deirdre Helfferich

Information Officer/Science Writer  
Doreen L. Fitzgerald

Webmaster  
Steve Peterson

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## Letter from the dean:

September 10, 2005

The Honorable Frank Murkowski  
Governor of Alaska  
P.O. Box 110001  
Juneau, Alaska 99811-0001



Dear Sir:

I submit herewith the annual report from the Agricultural and Forestry Experiment Station, School of Natural Resources and Agricultural Sciences, University of Alaska Fairbanks, for the period ending December 31, 2004. This is done in accordance with an act of Congress, approved March 2, 1887, entitled, "An act to establish agricultural experiment stations, in connection with the agricultural college established in the several states under the provisions of an act approved July 2, 1862, and under the acts supplementary thereto," and also of the act of the Alaska Territorial Legislature, approved March 12, 1935, accepting the provisions of the act of Congress.

Our research reports are organized according to our strategic plan, which focuses on high-latitude soils, high-latitude agriculture, natural resources use and allocation, ecosystems management, and geographic information. These areas cross department and unit lines, linking them and unifying the research.

Very respectfully,

Carol E. Lewis  
Dean and Director

# AFES Statement of Purpose:

The Alaska Agricultural and Forestry Experiment Station (AFES) provides new information to manage renewable resources at high latitudes, and to improve technology for enhancing the economic wellbeing and quality of life at these latitudes. While foresters, farmers, and land managers use our research results, all Alaskans benefit from the wise use of land resources. Our research projects are in response to requests from producers, industries, and state and federal agencies for information in plant, animal, and soil sciences; forest sciences; and resources management.

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Experiment station scientists publish research in scientific journals, conference proceedings, books, and in experiment station bulletins, circulars, research progress reports, and miscellaneous publications. Scientists also disseminate their findings through conferences, public presentations, workshops, and other public information programs.

Administratively, AFES is an integral part of the School of Natural Resources and Agricultural Sciences at the University of Alaska Fairbanks. This association provides a direct link between research and teaching. Scientists who conduct research at the experiment station also teach, sharing their expertise with both undergraduate and graduate students.



Aerial view of the Palmer Research and Extension Center laboratory, taken from B.O.B., the Bicamera Observation Blimp.

—PHOTO COURTESY NORMAN R. HARRIS



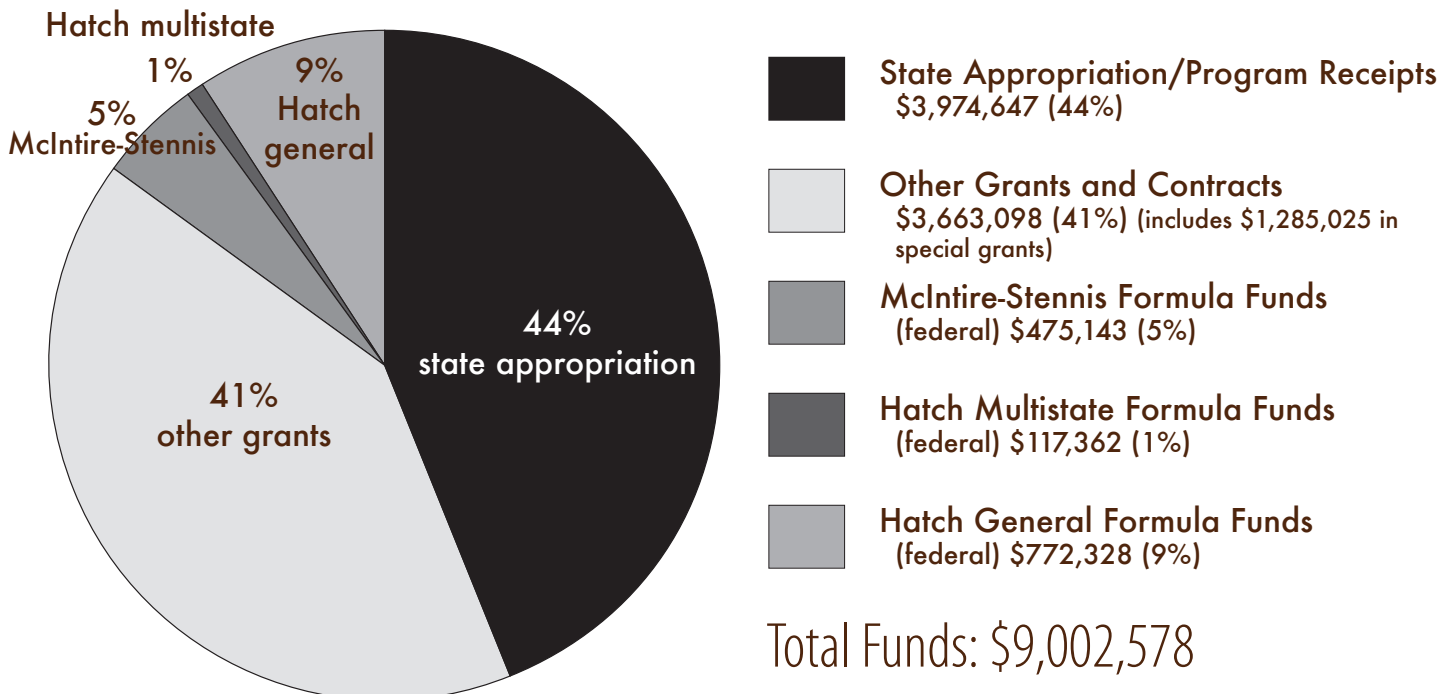
Cow and calf reindeer at the Fairbanks Experiment Farm.

—PHOTO COURTESY REINDEER RESEARCH PROGRAM

# Financial statement

## Expenditures: July 2004 through June 2005

The following statement of expenditures of federal and state funds for the fiscal year beginning July 1, 2004 and ending June 30, 2005 (FY 05) is not an accounting document.



# Grants

## GRANTS & CONTRACTS / SPECIAL FUNDS

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Forest Products III	Barber	USDA / CSREES
Forest Wood Products IV	Barber	USDA / CSREES
Southeast Forest Products Program V	Barber	USDA / CSREES
LTER IV - Long Term Ecological Research	Chapin	National Science Foundation
LTER Forest Research II, PNW-IAB	Chapin	Forest Service / PNW
LTER V	Chapin	NSF
BP Liberty SEIS	Cronin	British Petroleum
Natural Resource Research	Cronin	Governor's Office
NRCS Cooperative Agreement FY05	Finstad	NRCS
Food Products	Finstad	USDA / CSREES
Seasonal Habitat & Diet Composition	Finstad	BIA
Reindeer Herding	Finstad / Greenberg	NSF
CESU, USGS	Fix	USGS
CESU, BLM	Fix	BLM
Alaska Resident Statistics Program	Fix	Forest Service
CESU - NPS	Fix	NPS
Alaska Resident Statistics Program	Fix	BLM
Alaska Residents Statistic Program	Fix	National Park Service
Wrangell-St. Elias Nat'l Park	Fix	National Park Service
CESU	Fix	Forest Service
FY05 ARSP	Fix	US Fish & Wildlife Service
Regional Economic Data	Geier	NOAA
International Model King/Snow Crab	Greenberg	NRPB
Near-Earth Remote Sensing	Harris / Wurtz	USDA Forest Service
AML Reclamation	Helm	DNR
Foundation Botanical Garden	Holloway	UA Foundation
GBG Children's Garden	Holloway	UA Foundation
Food Products	Holloway	USDA / CSREES
Environmental Changes 2	Juday / Barber	Columbia University
Berry Research	Karlsson	USDA / CSREES
Berry Research II	Karlsson	USDA / CSREES
Greenhouse Crop Production	Karlsson	USDA / CSREES
IGERT (IAB)	Kofinas	NSF
New Crops III, New Crops for New Markets	Lewis	USDA / CSREES
New Crop Opportunities IV	Lewis	USDA / CSREES

Special Funds, continued:		
AK Seed Grower Assistance	Lewis	USDA / CSREES
UA Integrated Geography Program	Lewis	UA Foundation
Ethnobotany	Lewis	USDA / CSREES
Fairbanks Task Order, FY05	Lewis	ARS
New Crops and Livestock Opportunities V	Lewis	USDA / CSREES
EPSCOR	Lurman	NSF
Development of Virus-Free Potato	McBeath	ARS
Maintain AK Potato Export Status	McBeath	DNR
Palmer Task Order, FY05	Mitchell	ARS
Wet Soils Monitoring	Ping	SCS
Biocomplexity	Ping	NSF
Flux and transform of carbon	Ping	NSF
Fire-Mediated Changes -- Rupp	Rupp	NSF (IAB)
Understanding Fire Severity Pattern	Rupp	Murdock Trust
Joint Fire Science Project	Rupp	US Fish & Wildlife Service
FRCC Implementation	Rupp	Forest Service
Weather-Related Vectors	Smeenk	ARS
Global Change Eduation	Sparrow, E.	NSF
Global Climate Variability	Sparrow, E.	DNR/NASA
Integrated Phenology	Sparrow, E.	Utah State Univ.
Geospatial Science Learning	Stephens, S.	NSF
Remotely Monitor Ice	Verbyla	National Park Service

Natural Resources Fund		
Circumpolar Regional Database	de Wit	NRF
Management plan for UA experimental forest	Fox	NRF
UA/MIT Agreement/NRF	Lewis / Trent	NRF
AFES Plant Research	Mitchell / Sparrow / Zhang	NRF

FORMULA FUNDING, FEDERAL		
Oct 1 to Sept 30 Fiscal Year		
Hatch Multistate		
Regional Administration (W-106) #ALK 99-05	Lewis	USDA
Lurman (W-192)	Lurman	USDA
Soilborne Plant Pathogens (W-1147) #ALK 94-01	McBeath	USDA
Shipka (W-112) #ALK 00-11	Shipka	USDA
Zhang (NC-218) #ALK 05-02	Zhang	USDA

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Hatch General		
Reindeer Production & Meat Quality #ALK 04-07	Finstad	USDA
AK Natural Resources #ALK 01-10	Greenberg	USDA
Spatially Modeling Dist of Beef Cattle #ALK 03-03	Harris	USDA
AFES Horticulture Crop #ALK 01-11	Holloway	USDA
Natural & Supplemental Light #ALK 00-09	Karlsson	USDA
Cultivar Selection #ALK 01-02	Leiner	USDA
Production Practices #ALK 01-09	Leiner / Smeenk	USDA
Laws Affecting Environment #ALK 05-01	Lurman	USDA
Forage & Turfgrass #ALK 02-05	Mitchell	USDA
Palmer Administration #ALK 99-01	Mitchell	USDA
Black Spruce Forest Soils #ALK 03-02	Ping	USDA
Domestic Ruminants #ALK 00-01	Shipka	USDA
Potential Forage Crops #ALK 02-01	Sparrow, S.	USDA
Enviromental Decisions #ALK 02-07	Todd	USDA
Yield & Quality of Barley #ALK 04-03	Zhang	USDA
Variety Testing #ALK 02-06	Zhang / Sparrow, S.	USDA
McIntire-Stennis		
Forest Timber Harvest #ALK 99-06	Fox	USDA
Boreal Forest #ALK 05-04	Fox	USDA
Ectomycorrhizae #ALK 00-02	Helm	USDA
Forestry Ecology #ALK 01-08	Juday	USDA
Forest Stand #ALK 03-12	Packee	USDA
Soil Carbon Balance #ALK-01-07	Valentine	USDA
Remote Sensing to Investigate Fire #ALK 05-05	Verbyla	USDA
Forest Ecosystem Monitoring #ALK 01-01	Yarie	USDA
Animal Health		
Mineral Flux in Reindeer #ALK 03-07	Finstad	USDA

# Students

## Graduates as of May 2005

### Baccalaureate Degrees

George Aguiar, BS, Natural Resources Management (PASS)  
 Cody Noel Burgess, BS, Natural Resources Management (Forestry) *cum laude*  
 Jeannine Marie Gallagher, BS, Natural Resources Management (Resources)  
 James E. Hazlett, BS, Natural Resources Management (PASS)  
 Melanie M. Hess, BS, Geography (Environmental Studies)  
 Dennis Hochstetler, BA, Geography  
 Kurt Roland Mueller, BA, Geography  
*Golden Key Honor Society*  
 Kathryn Navarro, BS, Natural Resources Management (PASS)  
*Student Leadership Honors*  
 Matthew K. Neville, BS, Natural Resources Management (Resources)  
 Bethany Elizabeth Sweet, BS, Natural Resources Management (PASS)  
*cum laude*  
 Timothy W. Walsh, BS, Natural Resources Management (PASS)  
 Matthew Sean Willison, BS, Natural Resources Management (PASS)

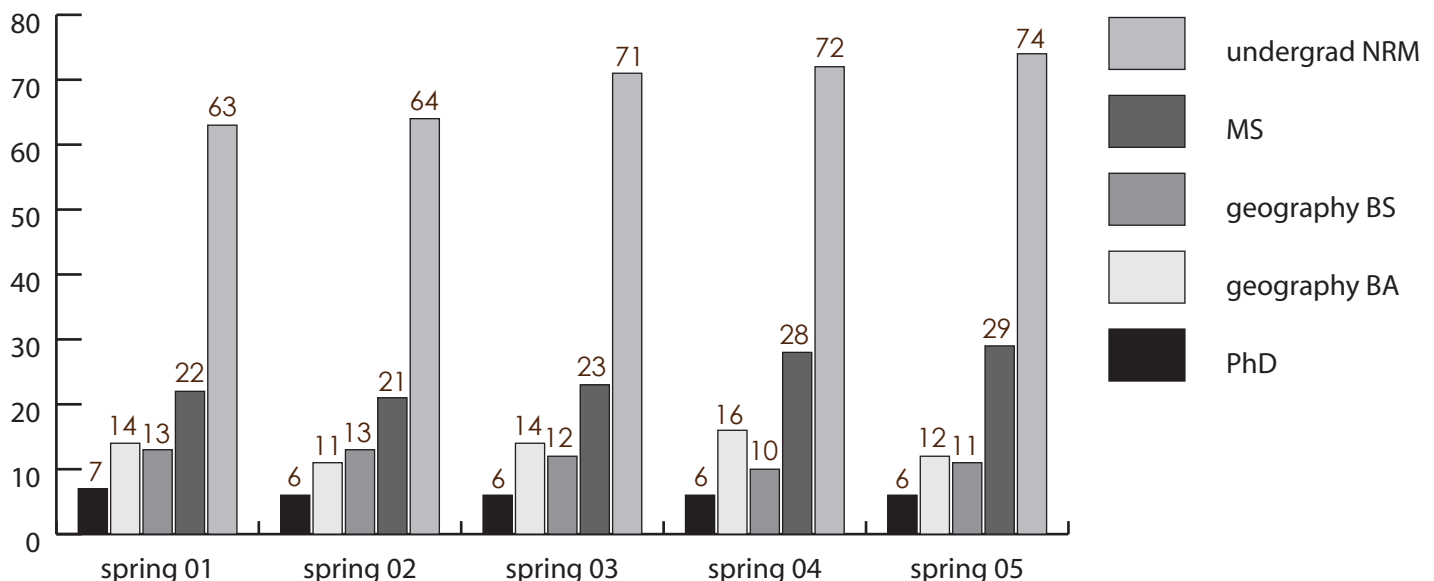
### Masters Degrees

Daniel L. Cheyette, MS, Natural Resources Management  
 BA, Rice University (Texas), 1991  
 JD, Lewis and Clark College (Oregon), 1996  
 Karen Joanne Clyde, MS, Natural Resources Management  
 BA, Ryerson University (Canada), 1993  
 Justin Frederick Epting, MS, Natural Resources Management  
 BS, California Polytechnic State University, 1996  
 Scott Harris, MS, Natural Resources Management  
 BS, University of Texas, 1990

Kimberley Anne Camille Maher, MS, Natural Resources Management  
 BS, Boston College (Massachusetts), 1998  
 Sarah Masco, MS, Natural Resources Management  
 BS, Western Washington University, 1998  
 Paul C. McKee, MS, Natural Resources Management  
 BS, University of Alaska Fairbanks, 1993  
 Todd F. Nichols, MS, Natural Resources Management  
 BS, University of Alaska Fairbanks, 1995  
 Brian Riordan, MS, Natural Resources Management  
 BS, Oregon State University, 2001  
 Carolyn Rosner, MS, Natural Resources Management  
 BS, Southern New Hampshire University, 1988  
 Lijie Zhu, MS, Forestry, Soils, Ecology and Environmental Reporting (Interdisciplinary Program)  
 BA, Lanzhou University (China), 2001  
 JD, Lanzhou University (China), 2001

### Doctor of Philosophy

Mingyuan Cheng  
 Plant Pathology: Interdisciplinary Program  
 Thesis title: Mechanisms Involved in the Cold Tolerant *Trichoderma atroviride* Biocontrol  
 BS, Jilin Agricultural University (China), 1986  
 MS, Shenyang Agricultural University (China), 1989  
**Abstract:** *Trichoderma atroviride* produced chitinases, glucanases and proteinase at room temperature and at 7°C. A purified basic serine proteinase and a purified endo- $\alpha$ -1,3-glucanase showed a strong antifungal activity. The 73 kDa N-acetyl- $\alpha$ -D-glucosaminidase gene sequences showed the *T. atroviride* was unique. The expression of  $\alpha$ -1,6-glucanase and N-acetyl- $\alpha$ -D-glucosaminidase were complex.  
**Major Professor:** Dr. Jenifer Huang McBeath



# Research Reports

The school and experiment station pursue their missions with faculty in four departments: Plant, Animal, and Soil Sciences; Forest Sciences; Resources Management; and Geography. Research is also done in cooperation with the US Department of Agriculture (USDA) Agricultural Research Service (ARS) and the Boreal Ecology Cooperative Research Unit (BECRU). Crossing departments and units are five areas of emphasis: 1) geographic information; 2) high-latitude agriculture; 3) high-latitude soils; 4) management of ecosystems; and 5) natural resources use and allocation. Reports are organized within these major areas of emphasis, by project title under experiment or subject focus.

## *Agricultural Research Service*

The Subarctic Agricultural Research Unit of the USDA-ARS was reestablished in the winter of 2002–2003. ARS has been hosted at the School of Natural Resources and Agricultural Sciences since 1948. The unit studies .

## *Boreal Ecosystem Cooperative Research Unit*

This unit facilitates conservation and informed management decisions by conducting research to improve knowledge of high-altitude and high-latitude ecosystems. It provides support and coordinates and organizes research at the Bonanza Creek Long-Term Ecological Research (LTER) and other research programs. Major research areas are biodiversity, climate/disturbance interactions, hierarchical scaling of processes, and improved forest harvest outcomes.

## Report Subject Index

- 8 **geographic information**
  - 8 • geography
  - 9 • wildland fire
  - 10 • invasive plants
  - 10 • livestock and range management
- 11 **high-latitude agriculture**
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  - 15 • bedding plants and garden crops
  - 16 • controlled environments
  - 17 • field crops
  - 23 • pest and disease control
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  - 32 • climate research and global change
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  - 38 • forests
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- 43 **natural resources use and allocation**
  - 43 • fisheries
  - 46 • forests and trees
  - 53 • policy, use, and planning

## Geographic Information

### geography

#### **Exploratory study of near-earth remote sensing of tundra and boreal forest study sites**

Norman Harris

##### purpose

This study explored the feasibility and utility of our near-earth remote sensing platform (tethered blimp) for complementing and assisting in categorization of permafrost soil study sites.

##### approach

We traveled to permafrost soil study sites with the NRM 489/689 class and obtained color and color-infrared photography of the landscape and vegetative communities surrounding soil classification pits.

##### progress

We traveled the Dalton Highway to Deadhorse and obtained aerial photography of tundra and boreal forest research sites. Our blimp preformed well even in adverse conditions of heavy rain and moderate wind. The color and color-infrared images obtained of most sites were excellent and highly detailed. Mechanical problems with the blimp trailer prevented us from obtaining images of two sites.

##### impact

The study provided information of how high-resolution imagery can be obtained economically and in a timely fashion. The value of imagery to delineate visually, and in great detail, the characteristics of study sites was demonstrated.

#### **Perceptual geography of Alaska**

Cary de Wit

##### purpose

This study explores how popular perceptions of Alaska affect national opinions on Alaska political and environmental issues.

##### approach

I am collecting imagery from advertising, postcards, films, television programs, and other sources of widely disseminated images of Alaska. I categorize and analyze images according to source, intended purpose, location of production, and type of Alaska image portrayed.

##### progress

Image collection continues and work has begun on an analysis structure and a set of perceptual themes in which to organize the images.

##### impact

The strength and persistence of these images in the American psyche, however inaccurate, can significantly influence national sentiments toward many salient political and environmental issues, such as pipeline development, snowmobile



use, and oil exploration on federal lands in Alaska. This study will help those who are trying to educate the public on Alaska political and environmental issues to assess whether accurate perceptions of those issues are being conveyed to state and federal lawmakers and to the voting public, whether the citizens of Alaska or of the United States.

## Place-based geospatial science learning and applications in rural Alaska (MapTEACH)

Sidney Stephens

### purpose

This project aims to provide geospatial IT science and technology education to teachers and students in rural Alaska that is directly applicable to understanding the local geographic context and problems, and that relates modern science and information technology to traditional knowledge.

### approach

MapTEACH is a three-year project to develop a place-based educational program for middle-and high-school students in Alaska that emphasizes hands-on experience with geology and spatial technology in conjunction with traditional activities. It will draw upon the combined expertise of teachers, education researchers, remote sensing specialists, geoscience professionals, and Native Elders and others with traditions-based knowledge. Interviews and recordings of local experts discussing landmarks, place names, and stories will serve as the basis for creating digital and hard-copy landscape maps that will be integral to the MapTEACH curriculum and experience. The proposed program will be piloted in the Nenana, Nome, and Fairbanks areas in two separate formats having equivalent content. This project involves three collaborating institutions with differentiated roles: the University of Wisconsin-Madison's Environmental Remote Sensing Center (GsIT infrastructure, web-serving, and interface), Alaska Division of Geological & Geophysical Surveys (imagery and trail logs), and the University of Alaska Fairbanks (curriculum development and evaluation).

### progress

(UAF portion only): Meetings have been held with teachers, elders, and community members in all pilot communities and were quite successful in that all parties are eager to participate in this project and seem well-poised to take it on. An integrated curriculum matrix has been created and development of draft lessons is underway. The first school pilots are scheduled for May 2006.

### impact

When the project is complete, there will be several related benefits: a blueprint for region-specific educational modules that can be adapted for use elsewhere in Alaska; web-based data resources hosted by the Alaska Division of Geological & Geophysical Surveys and the Environmental Remote Sensing Center that are accessible after the end of NSF support; and a cadre of students who have proficiencies in GsIT and who can connect these understandings to local issues and local knowledge.

## wildland fire

### Assessing the vulnerability of human populations to wildfire in the Lake States

T. Scott Rupp (SNRAS); Rich Howard (Assisi Software Corp.); Robert Haight (USFS)

### purpose

Wildfire risk within the Lake States (Minnesota, Wisconsin, and Michigan) is high. This region has large numbers of fire ignitions and areas of fire-prone forest types. Moreover, fire suppression and forest management has led to uncharacteristically expansive tracts of fire-susceptible ecosystems with altered age-class distributions of short-lived species (e.g., jack pine and balsam fir). These changes produced serious forest health concerns, including insect infestations and natural senescence resulting in increased fuel loadings, and hence fire risk.

### approach

This research will develop new approaches to regional fire risk assessment that couple ecological and social factors into a fire risk and consequence model, with an emphasis on reducing the potential for loss of life and property. The overall goal is to provide managers with a scientifically based decision support tool for prioritizing fire risk reduction activities in a regional, landscape, and local context.

### progress

The first component of this research has been completed. We determined at a regional scale the relative risk of severe wildfire in wildland-urban interface areas and the numbers of people and houses in high-risk areas. This research was published in the 2004 October/November issue of the *Journal of Forestry*. The second component of this research has been the development of a spatial model for evaluating fuel treatment plans using genetic algorithms as a novel optimization strategy. A peer-reviewed journal article was submitted to the journal *Forest Science* in July 2005.

### impact

Analysis of community vulnerability to wildfire will produce spatial data sets of current vulnerability based on biophysical-based fire risk, human settlement patterns, and suppression resources. Spatial data sets of community vulnerability to wildfire will provide critical current fire risk information to fire management personnel, as well as long-term information to both fire managers and planners.

### Remote sensing of burn severity in the Alaska boreal forest

Andy Ruth, Dave Verbyla

### purpose

We hope to map where within black spruce stands wildfire has burned through most of the organic soil layer. This will make it possible to predict where broadleaf vegetation is likely to dominate during the revegetation of these sites.

### approach

We used the differenced Normalized Burn Ratio (dNBR) as an index of burn severity for several 2004 fires and one area that burned in 1986.

progress

The project has just begun. We sampled vegetation from the 1986 burn across a gradient of low to severe 1986 dNBR values to determine the pattern of revegetation in relation to the remotely sensed index. We will sample duff consumption from the 2004 burns across a gradient of high to severe dNBR values to determine the response of dNBR in relation to duff consumption.

impact

Mapping burn severity using dNBR may be useful for immediate post-fire applications, such as assessment of potential high erosion areas. Based on our preliminary analysis, dNBR was poorly correlated with revegetation response 19 years after a fire. This may be due to the inability of a remote sensing product to map the depth of organic soil left after a fire.

## invasive plants

### Remote sensing techniques for the study of white sweet clover on the Matanuska River flood plain

Tricia Wurtz, Norman Harris (SNRAS)

purpose

This study addresses issues of resolution and types of spectral data necessary to accurately detect and map infestations of white sweet clover (*Melilotus alba* Desr.) on the Matanuska River flood plain.

approach

At various times in the summer, spectral data is acquired using a small, tethered, helium-filled blimp carrying a digital camera and a 35mm-camera loaded with color infrared film. Shots are obtained of study plots at four different altitudes. Photos are also photogrammetrically processed to create mosaics of the study area.

progress

Shots were obtained in the beginning of June and again in August. In between dates, seven out of our ten plots were affected by high water, and the structure of the flood plain changed considerably. Time series mosaics effectively mapped the influence of flood events and plant population dynamics. Spectral analysis and classification indicated that white sweet clover was easiest to detect on true color imagery taken in late August.

impact

Land managers can effectively and cost efficiently use remote sensing data to detect and monitor weed infestations, if the data has sufficient resolution for the project.

## livestock and range management

### An evaluation of the effectiveness of livestock distribution practices in grazed watersheds

M. George (UC/Davis); D. Johnson (Oregon State Univ.); D. Bailey (Montana State Univ.); D. Ganskopp (USDA ARS Burns, OR); Norman Harris (SNRAS)

purpose

This is a multistate, collaborative effort to identify factors

that control or influence livestock movement and landscape use. The information will be used to develop a comprehensive livestock distribution and forage utilization model.

approach

The study started in October 1, 2000 and will continue until September 30, 2005. Researchers in each state use global positioning system (GPS) collars and visual observations to track animal movements and quantify animal activities on the landscape.

progress

Animal observations are being collected for use in validation of predictive models. Multicriteria modeling software, KRESS, has been developed, and we have expanded its analytical capabilities through the generation of validation statistics.

impact

Land managers can effectively predict landscape use patterns of livestock and model the effects of management actions to help them more efficiently manage public and private lands.

### Satellite radiotelemetry and reindeer herding

Darrell Blodgett, Suzanne Worker, Greg Finstad

purpose

Many reindeer herders are unable to locate all groups of free-ranging reindeer roaming over large, remote, and inaccessible grazing ranges. Proper range management requires that locations and grazing patterns of animals are known. The Reindeer Research Program (RRP), in collaboration with the Reindeer Herders Association, continues to improve a satellite telemetry mapping program for use in reindeer management.

approach

Location data were obtained from collared reindeer by the National Oceanic and Atmospheric Administration satellite system, via Service Argos, Inc. Maps were created using an automated mapping system developed by the RRP and placed on a herder-accessible website. The herder is able to view current locations of reindeer and caribou on the Internet to plan herding activities. Animal location records were examined to evaluate seasonal grazing impacts and movement patterns of reindeer.

progress

Reindeer in eleven herds were equipped with thirty-nine satellite collars and their movements monitored and mapped during 2004. Duty-cycle modifications were made on several collars to give more frequent location updates. USGS topography map overlays were integrated into the current mapping system to provide more detailed geographical references. Reindeer herders began to recognize atypical movement patterns of their reindeer due to predators, caribou, or changes to the range.

impact

Reindeer herders are increasingly using this system to improve the productivity of their herds. They can monitor conditions of heavily grazed areas, locate animals prior to herding activities, and be alerted if predators or caribou are affecting their animals.

## Spatially modeling the distribution of beef cattle and reindeer on ranges at high latitudes in Alaska

Norman Harris, Beth Hall, Randy Fulweber, Greg Finstad  
purpose

The promotion of meat animal production is culturally and economically important in Alaska. A better understanding of animal interactions with their environment will allow producers to optimize feed rations and minimize adverse effects on the landscape.

approach

We will analyze observational studies of domestic and semidomestic livestock using spatial/temporal analysis to develop parameters specific to Alaska for use with the KRESS predictive model.

progress

In this ongoing study, we converted the previous year's observational data of the UAF beef cattle herd at the Matanuska Experiment Farm to digital format, and are using the data to test the KRESS modeling software. We collected further temperature data to produce detailed maps of thermal patterns in our pastures.

impact

This modeling effort will give Alaska meat producers another tool for developing cost-effective management strategies. Consumers will benefit from the further development of an Alaska-based meat industry.

## USGS topography map overlays for the satellite collar mapping system

Darrell Blodgett, Greg Finstad

purpose

The Reindeer Research Program maintains a satellite collar mapping system that allows Seward Peninsula reindeer herders to retrieve timely maps showing the location of their satellite-collared reindeer. A weak area in the current mapping system is the lack of complete map features and/or place names for the Seward Peninsula. USGS topography map overlays could provide more detailed features and place names.

approach

Digital USGS topography maps had already been acquired. A method for creating reindeer location maps with USGS topography overlays using GMT (Generic Mapping Tools) was developed. These maps supplement existing maps.

progress

A digital topography map of the entire Seward Peninsula was created using Global Mapper to stitch together the required USGS topography maps. A method of cutting out a section of this map and overlaying it onto a GMT map was developed. These maps were incorporated into the existing satellite mapping system

impact

Reindeer herders have access to more detailed maps showing the location of their satellite-collared reindeer.

## Using GIS for stratifying aerial moose surveys

Karen Clyde, Dave Verbyla

purpose

We seek to predict where moose are likely to be located on the landscape during early winter aerial surveys.

approach

For an area in western Yukon Territory, Canada, we used statistical predictive models to describe the distribution of radio-collared moose as a function of topographic and vegetation GIS variables.

progress

Based on radio-collared moose data from two winters, moose were likely to be present in aerial survey blocks that were at high elevations, with relatively large patches of alpine shrub vegetation. A resource selection model based on the number of patches within a survey block correctly predicted over 80 percent of the survey blocks where moose were present. The moose population in the study area existed at low densities relative to other moose populations in the subarctic.

impact

Modeling where moose are likely to occur will help improve the precision of aerial surveys for estimating the early winter moose population.

# High-Latitude Agriculture

## animal husbandry

### Cattle genetics (Chirikof Island)

M.A. Cronin, M.D. MacNeil (USDA)

purpose

Feral cattle on Chirikof Island, Alaska, have an uncertain ancestry. It has been hypothesized they are descended from ancient Russian cattle. If so, they may represent a unique germ plasm genetic resource. However, modern European breeds were imported to the island during the 1900s. Regardless of the source of the animals, the selection imposed under feral conditions, and genetic drift on the isolated island may have resulted in a unique and useful gene pool. We aim to quantify the genetic variation in the Chirikof Island cattle and compare them with other breeds.

approach

We will quantify genetic variation at 34 microsatellite DNA markers from the cattle gene map in Chirikof Island cattle and from several other breeds. We will calculate genetic distances and infer relationships between the Chirikof Island cattle and other breeds.

progress

We obtained tissue samples from 24 Chirikof Island cattle and from ten other breeds. Lab analysis is underway at the USDA lab in Miles City, Montana.

impact

The Chirikof Island cattle may represent a valuable genetic resource, either because of unique ancestry or because of the

selection imposed under feral conditions on the isolated island. The data may affect management decisions regarding use of the cattle on the island as a livestock resource, and whether to leave them on or remove them from Chirikof Island.

## **Chronic wasting disease surveillance in Alaska reindeer**

Greg Finstad, Suzanne Worker

### **purpose**

Chronic wasting disease (CWD) is an emerging disease found in deer species of North America. Detection and control of the disease is important for both animal health and ensuring the wholesomeness of Alaska food products.

### **approach**

The Reindeer Research Program in collaboration with the Reindeer Herders Association and the Alaska State Veterinarian are collecting brain stems from reindeer slaughtered on the Seward Peninsula to be analyzed for detection of CWD.

### **progress**

All slaughtered animals sampled and tested in 2004 were found to be negative for CWD.

### **impact**

Ensuring that Alaska livestock are free from disease is important for animal health and productivity. A surveillance program for disease also ensures a safe food supply. Effective control and eradication efforts may be initiated if CWD is detected early in livestock or game animals found in Alaska.

## **Elk genetics**

M.A. Cronin, M.D. MacNeil (USDA); J.C. Patton (Texas A&M University)

### **purpose**

We sought to develop methods for molecular genetic assessment of domestic elk, and to assess genetic variation and genetic components of performance trait variation in elk.

### **approach**

We emulated the USDA research program for assessing quantitative trait loci in cattle to assess molecular genetic variation in elk and to determine associations or genetic variation and performance traits.

### **progress**

Molecular data quantifying genetic variation in elk was previously generated. During 2004, we analyzed the data for a manuscript to be written in 2005.

### **impact**

We have established a genetic database for Alaska domestic elk and begun work similar to that used to assess the genetics of cattle performance traits. This research and the resulting database may allow use of molecular genetics in selection and breeding programs of domestic elk.

## **Effects of melengestrol acetate fed to yearling reindeer bulls prior to and during rut**

M.P. Shipka, J.E. Rowell, A.M. Hirth

### **purpose**

Rutting reindeer bulls are aggressive, dangerous, and destructive. Seasonal rutting activity depletes up to 35 percent of body weight. Synthetic progestins may modify bull physiology during the rut period. Nonapproved use of depo-provera, a synthetic progestin, is used on commercial reindeer farms to stop rut behavior. Melengestrol acetate (MGA) is approved for use in food animals. The effect of MGA on rutting behavior in reindeer bulls has not been previously investigated.

### **approach**

Five intact reindeer were fed MGA. Five intact yearling reindeer males and five steers served as controls. At two-week intervals, animals were weighed and their blood sampled. Antlers were photographed and dates of cleaning and casting were recorded. Seasonal changes in body weight, plasma testosterone, and antler development were determined. Libido was recorded by exposure to estrous females.

### **progress**

This project was stopped in early September '04 when it became clear that bulls treated with MGA showed no depression in rut-associated aggression towards other males and humans. All MGA-treated males began courting estrous cows. Seasonal body weight change was not different from untreated intact bulls.

### **impact**

The use of oral melengestrol acetate (MGA) to control rut-induced behavioral and physiological changes in male reindeer is ineffective. MGA treatment is not effective in preventing rut behavior and handling the bulls remained dangerous.

## **Heavy metal concentrations in Alaska reindeer tissue**

Greg Finstad, Suzanne Worker

### **purpose**

The people on the Seward Peninsula live a subsistence lifestyle where a high percentage of their diet comes from local plants and animals. They are particularly concerned that contaminants from air pollution (arctic haze), mining operations, and dumpsites are concentrating in the tissue of subsistence animals and pose a health risk.

### **approach**

The Reindeer Research Program attended reindeer slaughters and village hunting expeditions on the Seward Peninsula in 2004 to collect muscle, kidney, and liver samples from slaughtered reindeer and harvested caribou. These samples were then analyzed for concentrations of heavy metals; mercury (Hg), cadmium (Cd), lead (Pb) and cesium (Cs<sup>137</sup>).

### **progress**

Concentrations of heavy metals in reindeer tissue from the Seward Peninsula varied regionally, but all levels were near or lower than found in other circumpolar reindeer and caribou populations, and were below human health thresholds. This data suggests that heavy metal contamination of forage consumed by Seward Peninsula reindeer is negligible and that consuming reindeer meat poses no threat to human health.

impact

Many people living in rural Alaska are concerned that contaminants are finding their way into the local human food web. The results from this study suggest that very little heavy metals are accumulating in tissue of locally raised reindeer.

### Meat quality characteristics of electrically stimulated reindeer carcasses

Eva Wiklund, Greg Finstad, George Aguiar (SNRAS); Peter Bechtel (School of Fisheries and Ocean Sciences, ARS); Kristy Long (Cooperative Extension Service)

purpose

State regulation allows Alaska Native producers to sell field-slaughtered, uninspected carcasses to local retail outlets. This field slaughter can take place if ambient air temperature is less than 32°F and there is snow on the ground, and the carcasses must freeze as soon as possible and stay frozen all the way to the final consumer. The market potential for this product is limited because field-slaughtered meat cannot be added to other meat products, (such as sausage), and cannot be sold to restaurants or be exported out of the state. Electrical stimulation accelerates post-mortem glycolysis and rigor onset, so that carcasses can be rapidly cooled or frozen without risk of toughening the meat.

approach

Reindeer from the Seward Peninsula were shot in the field. Carcasses were electrically stimulated directly after bleeding. Shoulder meat was boned in the field and left to freeze in wax-lined boxes. Loin samples were collected from the carcasses to determine tenderness and water-holding capacity (WHC). The frozen shoulder meat was thawed (tempered) and then diced and cooked. The cooked meat was evaluated in a consumer test.

progress

No differences were observed in tenderness or WHC in the loin samples. Shoulder meat from electrically stimulated carcasses was judged by the consumers to be more tender than meat from non-stimulated carcasses.

impact

The results indicate that electrical stimulation is a technique that can be used to improve tenderness of meat from field-slaughtered reindeer. Sensory tests using a trained panel will further evaluate effects of electrical stimulation on important quality attributes of reindeer meat.

### Reindeer genetics

M.A. Cronin, M.D. MacNeil (USDA), J.C. Patton (Texas A&M University), Milan Shipka, Greg Finstad

purpose

We sought to develop methods for molecular genetic assessment of reindeer, and to assess genetic variation and genetic component of performance trait variation in reindeer.

approach

We emulated the USDA research program for assessing quantitative trait loci in cattle to assess molecular genetic variation in reindeer and to determine associations or genetic variation and performance traits.

progress

We analyzed the initial data on Alaska reindeer genetics in 2004, and reported in a manuscript written in calendar year 2005, submitted to *Journal of Heredity*.

impact

The project has established a genetic database for Alaska reindeer and begun work similar to that used to assess the genetics of cattle performance traits.

### Reindeer Research Program online database

Darrell Blodgett, Greg Finstad

purpose

The Reindeer Research Program collects many types of data from the resident research herd. In the past this data has been stored in many different spreadsheets, making it a time-consuming process to retrieve, integrate, and analyze datasets. A relational database management system was needed to allow both simple and complex queries to work on the entire data collection. Also desired was access to the data collection from multiple locations, both local and remote.

approach

The Reindeer Research Program uses a combination of MYSQL database server, Apache Web Server, and PHP scripting language to manage and store other data collections such as satellite collar data and Seward Peninsula reindeer data. We took advantage of our existing database infrastructure and created a new database for storing the Fairbanks reindeer data. Data entry and retrieval PHP scripts were also needed to manage the database.

progress

A MYSQL database and tables for the Fairbanks reindeer herd data were created. Existing data was ported from the spreadsheets to the new database tables. PHP scripts for entering, retrieving, managing, and graphing the data were developed.

impact

The complete collection of data can be accessed from one page from anywhere on the internet (password required). A complete history of either an individual animal or the whole herd is available with several mouse clicks. Body weight and other measurement data and graphs for individuals or the entire herd is also available from the point and click interface to the database.

### Seasonal changes in circulating levels of leptin, insulin like growth factor-1, and thyroid hormone in muskoxen and reindeer

M.P. Shipka, J.E. Rowell, M.C. Sousa

purpose

We sought to provide specific information on seasonal changes in circulating leptin (using an assay specific to ruminant species), insulin like growth factor-1 (IGF-1), and thyroid hormone levels in reindeer and muskoxen.

approach

We prepared an initial radioimmunoassay hormone analysis on archived plasma from both muskoxen and reindeer, and

conducted additional blood sampling from muskoxen and reindeer at targeted times during specific physiologic reproductive states.

progress

Assays for leptin and IGF-1 have been completed on archived plasma collected from 10 pregnant and 5 nonpregnant reindeer from September through May and from 21 muskoxen collected from August to October.

impact

These data have provided preliminary information on seasonal changes in circulating leptin and IGF-1 levels in reindeer and muskoxen. This information will increase knowledge of arctic species managed as livestock.

## 14 **Seasonal variation in carcass quality of reindeer from the Seward Peninsula**

Eva Wiklund, Greg Finstad (SNRAS); Peter Bechtel (School of Fisheries and Ocean Sciences)

purpose

Reindeer producers on the Seward Peninsula want to enhance their operations by reliably delivering a high-quality product from animals slaughtered outside the midwinter months. In this study we want to determine reindeer body condition dynamics, carcass characteristics, and composition and yield of adult reindeer bulls and steers through a nine-month slaughtering season, July through March.

approach

Reindeer from the same herd on the Seward Peninsula were slaughtered at three different times; mid-July, late November, and mid-March. Carcass deboning followed a protocol developed for this study.

progress

The reindeer bulls showed a bigger seasonal variation in body composition than the steers. The proportion and total weight of two of the most valuable cuts, striploin and topside, did not show a great variation between the sexes or over the season.

impact

These results will generate information necessary for Alaska reindeer producers to develop an operational plan to increase the value and expand the delivery of reindeer products demanded and accepted by upscale markets and consumers.

## **Sensory and technological properties of meat from free-ranging reindeer or reindeer fed soybean meal or fishmeal-based rations**

Greg Finstad, Eva Wiklund (SNRAS); Peter Bechtel (School of Fisheries and Ocean Sciences, ARS); Kristy Long (Cooperative Extension Service)

purpose

The Reindeer Research Program has developed a feed mix for reindeer made from products grown in Alaska (barley, brome hay, and fish meal). In this study we evaluated effects of the feed mix on properties related to the eating quality of reindeer meat.

approach

Reindeer steers from the Fairbanks Experiment Farm herd were fed a 16 percent crude protein diet based on either 6.8 percent soybean meal or 3.0 percent fishmeal for 12 weeks and then slaughtered at a USDA-approved abattoir. Adult free-ranging reindeer were slaughtered on the Seward Peninsula, Alaska. Loin muscle was excised and evaluated for cooking loss, tenderness, and sensory characteristics using a trained panel and a consumer test.

progress

No differences were found comparing the three groups for cooking loss, tenderness, or the trained panel's scores for juiciness, tenderness, meat flavor, and off-flavor. More consumers characterized the meat from free-ranging reindeer by various off-flavor attributes compared with the meat from fishmeal-fed animals.

impact

We could not find any negative effects on eating quality of reindeer meat from animals fed low levels of fishmeal. Fishmeal demonstrates promise as a cost-effective feed component for intensively managed reindeer operations in Alaska.

## **Steroid endocrinology during pregnancy in reindeer**

M.P. Shipka, J.E. Rowell, M.C. Sousa, A.M. Hirth

purpose

Endocrine profiles of bred female reindeer from the breeding season until calving were analyzed. This is an effort aimed at understanding the basic reproductive biology of the female reindeer. Furthermore, observation of  $E_1S$  during early pregnancy has been used in some other species as a pregnancy diagnostic tool. This investigation was undertaken to see if the use of  $E_1S$  could be used for pregnancy diagnosis in reindeer.

approach

Radioimmunoassay was used to assay plasma for progesterone, estradiol  $17\beta$ , estrone, and estrone sulfate.

progress

Estrone sulfate followed a very similar pattern to that of the other estrogens measured ( $E_{17\beta}$  and estrone), remaining at baseline (assay detection limits) until approximately 24 weeks' gestation. As progesterone declines, the estrogens coincidentally rise until parturition.

impact

Collectively these studies demonstrate a marked species specificity regarding the appearance and concentrations of  $E_1S$  in maternal peripheral circulation. This study demonstrates that in reindeer  $E_1S$  does not appear early enough in pregnancy to be of value as a pregnancy diagnostic tool.

## **bedding plants and garden crops**

### **Annual flower cultivar trials**

Patricia S. Holloway, Alfreda Gardiner, Grant E.M. Matheke, Janice T. Hanscom, Eileen Van Wyhe, Victoria Hill

purpose

Annual flowers were evaluated for their usefulness in home and commercial landscapes.

approach

Three hundred annual flowers were grown as bedding plants in a greenhouse (except direct-seeded sweet peas) and transplanted outdoors at the Georgeson Botanical Garden during the first week of June. Flowers were grown in unreplicated beds for three seasons and plants were evaluated weekly for flowering season, flower quality and quantity, plant height and spread, disease problems, and frost tolerance.

progress

Because of the warm growing season, flowering was earlier than normal, and many species grew taller than normal. Plants that were more than 6 inches taller than normal included some, but not all, cultivars of marigolds, *Nicotiana glauca*, petunias, rudbeckia, *Salvia farinacea*, sunflower, and zinnia. Flower size did not correspondingly increase with the warmer season. Nearly all cultivars grew well with the exception of: agastache 'Apricot Sprite', cleome 'Solo', cosmos 'Campus Apricot', 'Candy Stripe' and 'Daydream' (poor flowering), Cupid's dart, dianthus 'Dynasty White Blush', flaxleaf pimpernell, love-in-a-mist 'Miss Jekyll', nemesia 'Nana Compacta Orange', penstemon 'Violet Dusk', phlox '21st Century Rose Star', safflower 'Quadricolor', and sunflower 'Double Dandy'. These cultivars had poor flower development, and in most instances died out early in the season.

impact

The greenhouse/nursery/landscape industry is the largest agricultural industry in Alaska, and bedding plant production is the most important component of that industry. These trials provide basic information on adaptability of flowers to interior Alaska gardens for home and commercial use.

## Herb species and cultivar trials

Herb Bunch Volunteers, Patricia S. Holloway, Grant E.M. Matheke, Alfreda Gardiner

purpose

Annual and perennial herbs were evaluated for adaptability to Alaska home and market gardens.

approach

Herbs were grown in raised beds containing Fairbanks silt loam soil amended with plant-based compost. Perennials were planted in 2003 and 2004 and annuals in June 2004 in unreplicated beds according to recommended commercial spacing or design specifications. Plots were evaluated during the third week of August and included evaluation of height, spread, flower and foliage color, presence of disease and insect pests, winter survival of perennials, and overall subjective comments on growth, usefulness as a culinary or medicinal herb, and ornamental appeal.

progress

Eighty-six annual and perennial herbs were evaluated during 2004. Nearly all of the annual herbs grew well and produced abundant leaves, flowers, and/or stems for culinary uses. Herbs growing poorly included *Echinacea purpurea*, *Zingiber sp.*, *Physalis Alkekengi*, *Angelica polymorpha*, *Cymbopogon citrates*, *Lymnophila aromatica*, *Rumex acetosa* 'Rhubarb Pie', and *Thymus thracicus*. Herbs that overwintered well included *Angelica archangelica*, *Allium schoenoprasum* 'Grande', *Chrysanthemum*

*balsamita*, *Levisticum officinale* 'Magnus', *Mentha x piperita* var. *piperita* (chocolate mint), *Mentha arvensis* 'Variegata', *Allium altaicum*, *A. senescens*, and *A. fistulosum* 'Gribovski.

impact

Nearly all commercial greenhouse businesses in the Tanana Valley offer herbs in their mix of products for spring and summer sales. This research will assist local market gardeners and home gardeners in evaluating the usefulness of herbs, mostly for culinary purposes. It will also identify herbs that will overwinter in interior Alaska.

## Vegetable cultivar trials

Grant E.M. Matheke, Janice Hamscom, Patricia S. Holloway, Alfreda Gardiner

purpose

One hundred sixty-five vegetables were grown to evaluate their usefulness in home and market gardens and to compare new cultivars to standards that have been grown in the Tanana Valley for many years.

approach

Each vegetable cultivar is tested for three years and where possible, compared to long-term standard cultivars that have proven valuable over many years. Warm season vegetables, celery, leeks, and cole crops were started as greenhouse bedding plants and transplanted outdoors during the last two weeks of May. All other vegetables were direct seeded into Fairbanks silt loam soil following fertilization with 10-20-20s (4 lb per 100 sq ft, 195 g per sq meter). Plots were irrigated as needed. Harvest began with spinach the third week of June and continued three times weekly through September. Data consisted of yield as well as observations on disease, insect pests, off-type plants, and deformities.

progress

The summer was hot and dry, so yields were very good for most vegetables. Vegetables that performed very well included: beet 'Sangria'; broccoli 'Early Dividend', 'Shogun'; cabbage 'Dynamo'; cauliflower 'Andes'; cucumber 'Sweet Success', 'Sweeter Yet'; eggplant 'Early Bird'; kale 'Red Russian'; lettuce (butterhead) 'Ermosa', (crisphead) 'Burgundy Ice', (leaf) 'Galactic'; summer squash 'Eight Ball', 'Papaya Pear', 'Raven', 'Super Zuke Hybrid'; and Swiss chard 'Neon Lights'.

impact

The vegetable cultivar trials provide information for home and market gardeners to identify appropriate high yielding, good quality vegetables for the Tanana Valley.

## controlled environments

### Black-eyed Susan responds to the difference between day and night temperatures

Meriam Karlsson, Jeffrey Werner

purpose

The difference between day and night temperatures is known to be instrumental in determining plant form and growth of many plants. Opportunities to manage growth for desired plant features using different day and night tempera-

tures were determined for Black-eyed Susan (*Rudbeckia hirta* 'Toto Gold').

approach

Black-eyed Susan was grown at 60°F average daily temperature and a 16-hour day length. The temperatures were selected to provide a positive or negative difference of 5 or 10°F between day and night conditions. As a comparison, a constant 60°F environment was included.

progress/result

Although the average temperature was the same, there were differences in flowering rate and plant height. Plants grown with the largest difference between day and night temperatures, either positive or negative, flowered 87 days from seeding. At 5°F diurnal variation or at constant 60°F, flowering was 10 days slower. Plant height was shortest in conditions of negative difference with a higher night than day temperature. All other plants were 2 inches taller at an average height of 10 inches.

impact

Selecting specific day and night temperatures offers opportunities to manage crop production to meet market stipulations and dates.

**Controlled environment culinary herb production**

Jeffrey Werner, Meriam Karlsson

purpose

Fresh culinary herbs have poor shelf life and limited potential for maintaining quality during long-distance transportation. Uninterrupted year-round production of fresh herbs may be a lucrative local controlled environment crop.

approach

Several culinary herbs including basil, chives, Greek oregano, parsley, peppermint, sage, spearmint, rosemary, French tarragon, and thyme have been grown and examined for continuous uninterrupted greenhouse or controlled environment production.

progress

The studied culinary herbs all grew well with distinct potential for year-round production. For instance, Golden Lemon thyme produced 1.5 oz of fresh or 0.2 oz of dried thyme per four-inch pot every four weeks. From each six-inch pot, production was 1.3 oz of fresh or 0.1 oz of dried peppermint (*Mentha piperita*) and 2 oz of fresh or 0.2 oz of dried spearmint (*Mentha spicata*) every three weeks.

impact

These results assist in selecting and cultivating culinary herbs suitable for local marketing and year-round controlled environment production.

**Geothermal-powered greenhouse production**

Jeffrey Werner, Meriam Karlsson

purpose

We explored geothermal resources as an efficient energy source for local greenhouse and controlled environment crop production.

approach

We identified perishable fresh market crops suitable for local production in a collaborative partnership with the Chena Hot Springs Resort.

progress

A high-tunnel greenhouse operated by the resort staff supported fresh produce production during the 2004 growing season, supplying the resort restaurant through the summer with fresh tomatoes, cucumbers, green beans, raspberries, leafy greens, and culinary herbs.

impact

Technology for securing geothermal energy works well for controlled environment and greenhouse applications. The experience and knowledge brought together at Chena Hot Springs Resort provide implementation opportunities in other remote areas where local greenhouse crop production is pursued.

**Leafy lettuce and specialty greens produced in a high-tunnel greenhouse**

Jeffrey Werner, Meriam Karlsson

purpose

Temporary high-tunnel plastic greenhouses offer opportunities to extend the production season, increase yield, and elevate the quality of field-grown horticulture crops.

approach

Leaf lettuce and specialty greens including tatsoi, mizuna, spicy lettuce mix, and beet greens were planted inside and in the field immediately outside a high-tunnel greenhouse.

progress

The leaf lettuce and specialty greens grown inside the high tunnel matured for harvest earlier than lettuce outside. Trimming bruised or spoiled portions was virtually eliminated as the tunnel-grown leafy greens remained clean and of exceptionally high quality. For these greens, the tendency to bolt was less inside the tunnel compared to the immediate outside field.

impact

These results suggest high-tunnel greenhouses positively alter the local growing environment to support increased yield, quality, and season for high-value field crops.

**Production temperatures for sunflower**

Meriam Karlsson, Jeffrey Werner

purpose

Temperature recommendations are needed to efficiently produce sunflowers as flowering potted plants or cut flowers.

approach

Sunflower 'Pacino Gold' was grown at 60°F using five day and night temperature combinations.

progress/result

Variation between day and night temperatures promoted growth and flowering compared to a constant temperature. The 60°F environment resulted in sunflowers with open flowers after 92 days from seeding. A positive or negative difference of 5 or 10°F between day and night temperatures resulted in 6 to 7 days faster flowering. Constant or higher day than night temperatures produced plants of 16-inch height. Temperature



alteration with a 5°F higher night than day temperature reduced plant height by 2.8 inches and a 10°F difference reduced height by 4.4 inches.

impact

Varying the temperature during the day is recommended to accurately time, produce, and meet defined market demands for sunflowers.

## Sunflowers respond to the length of the day

Meriam Karlsson, Jeffrey Werner

purpose

Day length alters plant form, growth, and flowering of many plants. Day length was tested as a method to manage growth of sunflower (*Helianthus annuus* 'Pacino Gold') for essential and desired plant features.

approach

Sunflowers were grown at 8 or 16 daily hours of light. To study the effects of alternating short and long day conditions, some plants were shifted to the opposite day length after three weeks.

progress

Flowering was earliest after 54 short days. Long days delayed flowering by two weeks. Plants grew 8.7 inches tall with short days and more than doubled to 20 inches with long days. Compared to continuous short days, three initial weeks of long days followed by short days produced five days faster flowering and increased plant height by five inches. Flower size increased as plants grew taller, such that at short days flower diameter was 4.5 inches, and at long days increased to 6.5 inches for the taller plants.

impact

Combining short and long day conditions offers opportunities to manage crop production for exact marketing specifications and dates.

## field crops

### Selection, variety testing, and evaluation of cultural practices for alternative agronomic crops for Alaska

Robert M. Van Veldhuizen, Mingchu Zhang, Stephen D. Sparrow

purpose

This ongoing research provides annually updated information on new and better-adapted agronomic crop varieties (barley, wheat, oats, and sunflowers), and on the response of these crops to dryland farming conditions at Fairbanks, Delta Junction, and Palmer.

approach

Variety trials included four 2-row and three 6-row hulless barley varieties and two 2-row hooded forage barleys (*Hordeum* sp.); four hulless oat varieties (*Avena* sp.); and three hard red spring wheat varieties (*Triticum* sp.) selected from northern Canadian and US sources for evaluation against standard Alaska varieties ('Thual' hulless barley, 'Weal' hooded forage barley, 'Toral' yellow oat, and 'Ingal' hard red spring wheat).

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[www.uaf.edu/snras/](http://www.uaf.edu/snras/)

Replicated trials of all varieties were planted at all three locations, with the exception of the hooded forage barley varieties, as there was not enough seed. Therefore, the forage varieties were planted only at the Fairbanks location.

Agronomic crop breeding selections: One final selection from a hulled feed barley cross (*Hordeum* sp.) was planted in replicated trials at all three locations for comparison with three adapted varieties ('Otal', 'Albright', and 'Finaska' feed barley). This selection exhibited the best plant growth characteristics (early maturity, high yield, and good standability). This variety will eventually be released as a named variety.

Twelve selections from a hulless barley cross (*Hordeum* sp.) that have shown the best characteristics for standability, yield, early maturity, and hulless seed were planted in replicated trials at all three locations for continued evaluation with an adapted hulless variety ('Thual'). At the end of the 2004 season, the six that exhibited the best plant growth characteristics were chosen for further evaluation.

In 2004 continued selections from the dwarf, open-pollinated Sunwheat (*Helianthus* sp.) were made primarily for early maturity. The seed was hand harvested, threshed, and cleaned for distribution to local gardeners and farmers for testing and evaluation in the 2005 season. Eventual release as a named variety is expected after local evaluation and testing is completed.

progress

The cool wet spring of 2004 resulted in excellent germination and emergence at all three locations. However, this was followed by a dry, hot summer resulting in below average yields at all three locations. Despite the lower overall average yields, the average yields for the 2-row hulless barley varieties were better than the 6-row varieties at all three locations, including the standard test variety 'Thual'. Both forage and grain yields from the 2-row hooded forage varieties were slightly higher than that from the standard test variety 'Weal'. Average yields of hulless oats and hard red spring wheat varieties were lower than the standard test varieties, 'Toral' yellow oat and 'Ingal' hard red spring wheat. This indicates that even with the extra heat units for plant growth during the 2004 season, both hulless oats and hard red spring wheat are still marginal crops for Alaska. The average yields from the final selection of the hulled feed barley cross was comparable to or better than the standard test feed barley varieties at all three locations.

In 2005 a third 2-row hulless barley variety will be tested along with the 2-row hooded forage barley varieties at all three locations. The final selection of hulled feed barley will be tested again in 2005, and the seed lot will be increased for eventual release after it has become an officially named variety. Continued comparisons of the six selections of the hulless barley cross will be made with one selection to be made at the end of the 2005 growing season.

Testing done by the local gardening community with the open-pollinated Sunwheat selection will be compared with long-term data collected at the Fairbanks Experiment Farm. This will, we hope, result in an eventual release of an adapted dwarf oilseed sunflower for Alaska. Additional oilseeds to test for the 2005 season will be canola at the Delta Junction location and borage at the Fairbanks location.

impact

This ongoing study provides producers with updated information on new and better-adapted agronomic crop varieties, as well as the response of these varieties to dryland farming conditions.

### Hay quality for reindeer

M. Zhang, G. Finstad, R.M. Van Veldhuizen

purpose

This study examines cutting frequency and rate of nitrogen (N) fertilizer on bromegrass hay quality for reindeer.

approach

The research started in May 2004 and will end September 2006. There are three N fertilizer rates (0, 50, and 150 kg N/ha) and two cutting regimes: either one or two cuttings over the growing season. Each plot is 9.1 x 182.8 m. Five plant and soil samples were collected for each fertilizer treatment at each sampling in 2004. The first cuttings were on June 7 and June 16; the second cutting was on August 22. Hay samples were analyzed for nitrogen, phosphorus, potassium, and sulphur concentrations, and for neutral detergent fiber (NDF) and acid detergent fiber (ADF) concentrations as well.

progress

The first year results showed that N application rate greatly increased hay yield, but nitrate concentration in tissues for the highest N rate (150 kg N/ha) was less than 0.1% (safety nitrate level for cows). Hemicellulose concentration in hay was similar among different fertilizer treatments and cutting times, although the total hemicellulose production increased as the N application rate increased. For bromegrass, most N uptake occurred from May to mid June. From June to August, only 10 to 13% of applied N was recovered by bromegrass.

impact

The results demonstrated that high rate of N application increased hay yield and protein content in both cuttings and that the increase was not accompanied by reduction of hay quality for reindeer. This information can improve hay production for reindeer in Alaska.

### Nitrogen mineralization in soil: How much do we know?

M. Zhang, R.M. Van Veldhuizen

purpose

Determining the amount of nitrogen (N) release from soil organic matter is important in environmental N management for crop production. A variety of methods have been used to assess mineralizable N in soil, including acid hydrolysable N, neutral salt hydrolysable N, and extractable mineral N in soil. Since these methods are developed in the temperate and tropic regions, there is a need to determine their effectiveness in subarctic Alaska.

approach

In June and August 2004, soil samples were collected from fields where different N fertilization rates had been applied. The samples were incubated in aerobic and anaerobic conditions for 0, 2, and 4 weeks. The samples were then extracted

by: 1) 2 M KCl; 2) 2 M hot KCl (100°C); 3) 1 M HCl (100°C); and 4) deionized water. Ammonium (NH<sub>4</sub>-N) was determined in HCl extraction. Both NH<sub>4</sub>-N and NO<sub>3</sub>-N were determined in KCl and hot KCl extraction. Total nitrogen was determined in deionized water extraction.

progress

Extraction and determination were only done for aerobic incubated soil samples. The preliminary results showed that deionized water extractable N at 0 week of incubation was highly related to field crop N uptake ( $r^2 = 0.927$ ). The other extraction methods didn't correlate soil N status and crop N uptake. The amount of N released in soil apparently was associated with dissolved soil organic N, but not acid hydrolysable N or neutral salt hydrolysable N.

impact

The results provided fundamental information on soil N mineralization in subarctic Alaska soil. This information will help to improve soil N tests and fertilizer recommendations in Alaska. Improving N fertilizer recommendations will reduce fertilizer costs for crop production, and reduce the risk of environmental contamination from fertilizer applications.

### Antioxidants in Alaska wild berries

Roseann Leiner, Patricia Holloway

purpose

This study surveyed Alaska wild berries for the range of antioxidant capacity in frozen fruit.

approach

Samples of wild berries were collected in 2003 and sent to Brunswick Laboratories for analyses in 2004. The berries were analyzed for water soluble antioxidant capacity and levels of quercetin, which is a phytochemical that has antioxidant activity.

progress

Eighty-eight samples of berries were analyzed, including 34 bog blueberry (*Vaccinium uliginosum*) and 10 lingonberry (*Vaccinium vitis-idaea*). The water-soluble antioxidant capacity for bog blueberry ranged from 52 to 124 micromole Trolox equivalents per gram. Lingonberry had higher capacity, ranging from 139 to 320 micromole Trolox equivalents per gram. These values are considered high. For comparison, potatoes are reported to have values of 10 to 15 micromole Trolox equivalents per gram. Quercetin was detected in all the wild berries tested. Quercetin may contribute over 50 percent of the antioxidant capacity for bog blueberry. Quercetin contributed less than 25 percent of the total antioxidant capacity for lingonberry, highbush cranberry, and crowberry.

impact

This research provides basic information on some of the health benefits of Alaska's wild berries. It may be used by people who harvest wild berries for personal use or companies that process wild berries in Alaska.

## Micropropagation of lingonberries and bog blueberries

Rose Meier, Patricia S. Holloway

### purpose

Methods of tissue culture propagation have been identified for lingonberry cultivars and Alaska bog blueberry for use in field establishment for cultivation of these wild berries as well as management of wild stands for berry production.

### approach

All experiments were conducted in Percival growth chambers with varying levels of light and temperature. Actively growing shoot tips were placed on a variety of media with a single shoot tip per container. Each treatment consisted of six shoot tips with five replicates per experiment. Light and temperature experiments were repeated in different growth chambers to eliminate chamber effects. Data were analyzed by regression analysis or analysis of variance depending on the experiment.

### progress

Beginning in December 2003, propagation protocols were developed for two cultivars of lingonberries, 'Snowball' and 'Gilmore'. Varying light levels from 30 to 150  $\mu\text{Mm}^2\text{s}^{-1}$  in a Percival Growth chamber at 15° and 25°C produced similar numbers of microshoots. Bog blueberries produced abundant microshoots from leaf tissue when grown on Woody Plant Medium supplemented with 2iP hormone rather than benzyladenine. Microshoot production began within four weeks of placing leaves on the medium. Microshoots were spindly and difficult to handle. Attempts to transfer microshoots to solid peat-based medium have been difficult with a high rate of loss.

### impact

This project was initiated at the request of Moose Creek Farms, Trapper Creek, Alaska. The project will provide an environmental protocol for the rapid and consistent production of lingonberries by tissue culture that will lead to the development of lingonberries as a cultivated crop. Without a reliable means of propagation, a lingonberry industry will not develop in Alaska. It will also provide baseline information on somaclonal variation necessary for the potential release and patenting of 'Snowball' and 'Gilmore' cultivars.

## Storage cabbage trials

Roseann Leiner, Jeff Smeenck

### purpose

In Palmer field experiments, four varieties of green storage cabbages were grown at three spacings. The cabbage heads were compared for size at harvest and quality after several months of storage.

### approach

Cabbage seedlings were transplanted into field plots in May. The plants were spaced at 12, 14, and 16 inches between plants in a row. Heads of cabbage were harvested in September 2004. Cabbages were stored with refrigeration for four months and observed for changes in quality.

### progress

Storage cabbage varieties form heads more slowly than fresh market types. Varieties that mature in 85 days ('Survivor', 'Gideon') stored well to December, and varieties that mature after 100 days ('Arena', 'Safekeeper II') stayed green past January. In general, Gideon had larger head size and less response to spacing, as well as a higher incidence of damage from moose browsing in the one trial located adjacent to woods. Small head size was the most common reason for non-marketable heads. The incidence of small head size usually decreased with larger spacing in rows.

### impact

Some cabbage varieties can maintain quality for months after harvest. By choosing varieties and production practices that promote storage quality, cabbage sales can be extended into the winter season.

## Growing baby greens for salads

Roseann Leiner, Jeff Smeenck, Kate Brainard

### purpose

Many types of greens in the cabbage family can be harvested as young leaves for salads. The 2004 trials evaluated Asian greens, kales, arugula, and mustard in field experiments at Palmer.

### approach

Seeds of seven varieties of baby greens were planted to compare three rates of fertilizer (10-20-20): 600, 800, and 1000 lb/Ac. *Brassica* greens were direct seeded at approximately 2 seeds per inch in narrow rows and harvested when leaves were 4-6 inches long, usually 3-5 weeks after planting.

### progress

Kale ('Toscano', 'Red Russian') grew thick leaves slowly and showed a growth response to higher rates of fertilizer. Spicy greens (arugula, Red Giant mustard) and Asian greens (mizuna, Tokyo bekana, tatsoi) were ready to harvest sooner than kale and had a variety of leaf color, shape, and taste. Samples of leaves were dried and will be analyzed for mineral concentrations, including calcium.

### impact

Gardens can produce a variety of baby greens throughout the summer for fresh, colorful salad mixes. Different types of baby greens should be sown separately and mixed after harvest because the leaves grow at different rates and respond differently to fertilization.

## Head lettuce variety trials

Roseann Leiner, Jeff Smeenck

### purpose

New selections of lettuce are evaluated for their performance in the long days and cool soils of Alaska because seed companies change the varieties that are available.

### approach

Twelve varieties of crisphead lettuce were transplanted at two times and two locations in the Matanuska Valley. Head weight and diameter were measured and marketability at harvest was evaluated.

progress

Nine varieties were included in field trials for the second year, and three varieties from previous years were grown for standard comparison. The varieties 'Sniper' and 'Liberty' compared favorably with 'Alpha', the variety commonly planted on commercial farms. A variety susceptible to tipburn, 'Calicel', was included in all four plantings of lettuce to observe the potential for tipburn damage in each planting. The internal tipburn damage seen on Calicel ranged from 9 to 57 percent incidence among the four plantings. The internal tipburn seen on Sniper and Liberty was less than half the damage seen on Calicel. Field conditions in 2004 were conducive for tipburn. The season had clear skies and sunshine in June and July that can lead to high rates of transpiration in rapidly growing plants. Tipburn damage occurs when the margins of inner leaves die, probably in response to a localized lack of calcium related to uneven water transport. Though tipburn damage is unsightly, small head size was the most common reason for non-marketable heads.

impact

Performance of lettuce varieties in field conditions is important information for growers. Some varieties show good potential for crop production in Alaska, while other varieties are not adapted to local growing conditions.

## Seed cover materials for producing high quality lettuce transplants

Jeffrey Werner, Meriam Karlsson

purpose

Compact vegetable transplants with a well-developed root system and a short stem segment below the lowest leaf are best suited for mechanical transplant, field establishment, and crop productivity. A reflective mulch or soil cover may support desired early transplant growth.

approach

Perlite, a white expanded volcanic rock material, was used as a thin covering of the seed during transplant production of head lettuce 'Alpha'. Perlite particle size classes of less than 1 mm, 1 to 2 mm and larger than 2 mm were used. As comparison, a layer of the peat-lite propagation medium, with white or black plastic film cut to allow seedling emergence were included as seed cover materials.

progress

The below-leaf stem segment was shortest using perlite and longest with black plastic or propagation medium. White plastic resulted in slightly longer seedlings than perlite but considerably shorter than the black plastic. Perlite of 1 to 2 mm large particles was most efficient because the smallest grade perlite reduced drainage and larger perlite was too abrasive for the tender emerging seedlings.

impact

These results suggest that perlite with 1- to 2-mm size particles is effective as a nonchemical method for producing compact, high-quality transplants of lettuce or other vegetables.

## Cicer milkvetch, forage galega, and lupinaster clover as forage crops for interior Alaska

Stephen D. Sparrow, darleen t. masiak

purpose

We seek to determine the potential of cicer milkvetch (*Astragalus cicer*), forage galega (*Galega orientalis*), and lupinaster clover (*Trifolium lupinaster*) as forage crops in Alaska's Tanana Valley.

approach

In 2002 we seeded six varieties of cicer milkvetch and 'Gale' forage galega (the only released variety of this crop) at Delta Junction, Fairbanks, and Nenana. We were unable to obtain enough seeds of lupinaster clover to plant full plots, so we planted individual rows with various small seed lots at Fairbanks.

progress

These crops are typically slow to establish, thus plant growth was too meager to obtain harvests at any locations in the establishment year. Stands were so poor at Nenana that we abandoned the plots. At Delta Junction, none of the crops survived the 2002–2003 winter, so we reseeded in 2003. Again, survival was too poor to produce harvestable stands, indicating that these crops are not suitable for the soil and climate conditions there. At Fairbanks yields were quite low (less than 1.5 ton/ac) in the year following establishment (2003) In 2004 at Fairbanks, 'Gale' galega produced 3.0 tons dry herbage per acre and cicer milkvetch produced an average yield of 2.9 ton/ac. Stands remained poor in some of the plots in 2004. Results indicate that these crops may have potential as viable forage crops for some areas in interior Alaska, depending on the development of appropriate management practices.

impact

This research will aid farmers in selection of forage crop species to include in their cropping regimes.

## Forage and turfgrass research

G.A. Mitchell, T.A. Evers

purpose

We are evaluating cultivars and management practices that will reduce winter damage to greens and fairways on golf courses, sports fields, and home lawns.

approach

We have established turfgrass variety trials on a sand-based green and on a soil-based fairway at the Matanuska Experiment Farm. In 2003, we also established a trial at the public Settlers Bay Golf Course to provide a different environment for evaluating varieties for winterhardiness, disease resistance, and aesthetic qualities.

progress

The winter of 2004–2005 marks the fourth overwintering evaluation of a range of cultivars and further eliminated candidate grasses on the sand-based green and soil-based fairway plots. We have tested 37 turfgrass cultivars at the Matanuska Experiment Farm. On the sand-based green, three roughstock bluegrasses (*Poa trivialis*) and two bentgrasses (*Agrostis* sp.) have winterkilled. One perennial bluegrass (*Poa reptans*, 'Trueputt' var.) and five bentgrass cultivars have survived;

however, they green up and become playable only after May 15, thus disqualifying them for serious consideration. The cultivars showing superior survival, early greenup, and overall quality include 'Nugget' Kentucky bluegrass (KBG), '18th Green' creeping bentgrass, 'Velvet' bentgrass, 'Laser' roughstalk bluegrass, and 'Penn G-6' creeping bentgrass. The on-site plots at the Settlers Bay Golf Course offered an evaluation at a location that, unlike the Matanuska location, enjoys winter-long snow cover. At that location, we evaluated three bluegrasses ('Nugget' KBG, 'Supina' bluegrass, and 'Laser' roughstalk bluegrass) and five bentgrasses ('SRO 1020', 'Colonial', 'Velvet', 'Penn G-6', and '18th Green'). With snow cover, all cultivars survived the winter and demonstrated excellent greenup by May 10. 'SRO 1020' was rated best for overall quality in early May. In mid-July, '18th Green' and 'SR 1020' demonstrated near perfect quality (NTEP ratings of 8.6 and 8.3, respectively). All 24 cultivars entered in the fairway trial survived the first two winters. In 2003, winter damage resulted in bentgrass cultivars being slightly behind the bluegrasses, fescues, and native hairgrass greenup in spring; however, all were playable by May 10. In 2004, bentgrasses lagged significantly behind and did not green up until mid-June. In 2005, all the bentgrasses and some KBG cultivars were severely winter damaged. By June 10, only seven of the 24 cultivars were playable (these included Alaska cultivars 'Nugget' KBG, 'Arctared' red fescue, 'Nortran' hairgrass, and 'Touchdown', SR2000, and 'Blueknight' KBG. By July 1, only 'Velvet' and 'Penncross' among the bentgrasses had greater than 50 percent live cover.

#### impact

In 2004, results from this project were disseminated to golf course superintendents at a field day at the Matanuska farm and presented at an interagency seminar attended by horticulture and landscape professionals. Information generated by this work is changing turfgrass management practices at a number of golf courses, sports fields, and on private and public lawns in southcentral Alaska.

### Forage grass variety trials

Stephen D. Sparrow, darleen t. masiak

#### purpose

We sought to determine the potential of various native and introduced grasses as forage crops in Alaska's Tanana Valley.

#### approach and progress

In 2001, 2002, or 2003 we established 16 varieties of forage grasses representing 9 species at the Fairbanks Experiment Farm, the Delta Junction Field Research Site, and Bill Spencer's farm near Nenana. The grasses tested represented both introduced and native species. At Delta Junction, stands were poor and slow to establish, probably due to dry soil conditions, so no harvests were obtained in 2004. At Fairbanks, all plots were harvested twice in 2004. Polar bromegrass, which is genetically derived from smooth bromegrass (*Bromus inermis*) and arctic bromegrass (*B. pumpellianus*), produced a total dry herbage yield of 4.5 ton/ac, which was highest among all the grasses tested. Smooth bromegrass varieties averaged 3.5 ton/ac, with 'Leif' producing the highest average yield at 3.9 ton/ac. Fleet meadow bromegrass (*Bromus riparius*) produced

3.2 ton dry herbage per acre and timothy yields averaged 2.7 ton/ac. Among the native grasses, Wainwright slender wheatgrass (*Elymus trachycaulus*) and Siberian wildrye (*Elymus sibiricus*) produced highest yields, both greater than 3.5 ton/ac. At Nenana, smooth bromegrass produced highest average yields, with 'Carlton' producing 4.0 ton/ac. Forage analysis indicated that all of these grasses, if harvested at the appropriate stage, can produce good quality forages for livestock.

#### impact

This research will aid farmers in selection of forage crop species to include in their cropping regimes.

### Harvest management practices to maximize forage production and quality in interior Alaska

Stephen D. Sparrow, darleen t. masiak

#### purpose

We hope to determine optimum cutting height and time of second seasonal harvest for several forage crops in interior Alaska.

#### approach

We initiated a harvest trial on smooth bromegrass at Delta Junction in 2002, on smooth bromegrass and alfalfa at Fairbanks in 2003, and forage galega and cicer milkvetch at Fairbanks in 2004. We harvested all plots in mid-June and then imposed different harvest treatments for the second harvest. Treatments consisted of harvesting at different times (every two weeks from early July until late September) and three clipping heights (low, about 2 inches; medium, about 4 inches; and high, about 6 inches). Plots were again harvested in mid-June of the following year to determine residual effects of previous harvest management.

#### progress

As the season progressed, yields generally increased and forage quality decreased. With increased cutting height, yields decreased and forage quality increased. For smooth bromegrass and alfalfa, second harvests done in late July to mid-August generally resulted in lowest yields in June of the following year; late-season second harvests usually resulted in highest subsequent year yields. There appeared to be little effect of cutting height on subsequent year yields. We do not yet have results for second harvest cutting date or height effects on subsequent year yields of cicer milkvetch or forage galega. This study will continue through the 2006 growing season.

#### impact

This research will aid farmers in determining best harvest management practices for forage crops in interior Alaska.

### The effects of compaction during baling, color of plastic wrap, and preservatives on the quality of haylage in Alaska

C. Lussier, Norman Harris, Beth Hall

#### purpose

Some years hay producers do not have sufficient dry weather to produce good quality hay. The production of haylage (fermented hay) is a viable solution that has never before been studied in Alaska.

approach

Haylage is baled using different levels of compaction, colors of plastic wrap, and with or without preservative. Self-recording thermistors were inserted into bales. At various times, bales are cored and samples removed for chemical analysis using CHN analyzer and high-performance liquid chromatography.

progress

We were only able to produce one cutting of haylage this year because of inadequate regrowth on our study fields. Bales were cored at two weeks, one month, three months, and six months after baling. Samples were analyzed for fiber and fermentation products. Initial indications were that the fermentation was incomplete across all treatments.

impact

The economical production of quality feed for livestock is critical to the Alaska dairy and meat industries. Haylage can supply quality feed that will foster increased milk and meat production.

### Peony cultivar trials

Patricia S. Holloway, Janice T. Hanscom

purpose

Thirty cultivars of peonies were evaluated for four seasons to identify the most appropriate cultivars for field grown cut flower production.

approach

Thirty cultivars of peonies were planted in 2001 in completely randomized design in double-row raised beds covered with landscape fabric. Spacing was 18 inches (46 cm) between plants within each row and between adjacent rows on the same 39-inch wide (1m) raised bed. Each raised bed was 59 inches (1.5m) on center between beds. Plots have been evaluated for the past three years using nondestructive evaluation methods including counts of flower buds, bud blast, vegetative stems, and measurements of stem length. The first cut flower harvest year will be 2005.

progress

The most productive cultivars for cut flower production were 'Duchess de Nemours' and 'Felix Crouse'. Five cultivars equaled or exceeded the requisite stem length for U.S. No. 1 grading standards: 'Bowl of Beauty', 'David Harum', 'Felix Crouse', 'Shawnee Chief' and 'Therese'. Five additional cultivars met the standards for US No. 2: 'Duchess de Nemours', 'Festiva Maxima', 'Gay Paree', 'Kansas', and 'Sarah Bernhardt'. In 2002 and 2003, the flowering period began on 30 June for all cultivars and ended during the last week of July or first week of August. In 2004, flowering was as much as ten days earlier than the previous two years because of warm summer temperatures. Only one cultivar ('Pink Parfait') had open blooms in August. Although most peony growers at lower latitudes end peony production in late June, an unseasonably warm summer in Alaska may result in earlier harvest dates and an overlap in harvest seasons with growers at lower latitudes. A warm spring will negate somewhat the northern geographic advantage of late-season cutting for export markets.

impact

This research is providing baseline information for growers interested in commercial production of peonies. Currently, three growers or potential growers in the Fairbanks area, one grower in Nenana, and one in Palmer have expressed interest in this research. Two growers in the Fairbanks area have planted trial plots of peonies at their location.

### Spacing and soil amendments for field grown peony cut flowers

Patricia S. Holloway, Janice T. Hanscom

purpose

'Sarah Bernhardt' peonies were planted on soils amended with peat and plant-based compost to determine if soil amendments benefit the establishment and growth of peonies as field grown cut flowers. Plants were grown at different row spacings to identify the planting levels necessary for optimum cut flower production.

approach

One hundred forty-four 'Sarah Bernhardt' peonies were planted in 2002 in Fairbanks silt loam soils alone or amended with a 15-cm layer of Lemeta peat or a 10-cm layer of garden compost incorporated into the top 20 cm of soil. Plantings were made at three between plant row spacings: 120 cm, 75 cm, or 45 cm. Spacing between rows was 45 cm within the raised bed and 1.5 m on center between raised beds. The 2 x 2 factorial experiment was replicated five times in a randomized split plot design.

progress

No differences were recorded in number of flowering stems, stem length, stem diameter, and number of vegetative stems per plant on peonies planted on silt loam soils compared to those amended with peat or compost. No differences occurred among plants grown at three different spacings. The between-plant variation was very large and masked any treatment effects. The 2004 season was the third year for growth, and plants were still in the establishment phase. At least for the early establishment years, plants do not benefit from soil amendments, and crowding of plants does not influence flower production. The project will be continued for long-term evaluations.

impact

This project will identify methods needed to establish peonies for long-term production of field grown cut flowers. Since peony fields are productive for ten or more years, any soil amendments would have to be added before planting. These practices add to production costs, so growers will benefit by knowing if this practice is necessary. Also, plant spacing will ultimately determine cut flower productivity per acre.

### Potato field experiments in Palmer

Jeff Smeenk, Roseann Leiner, Gregg Terry

purpose

We compared horticultural practices and evaluated potato varieties for yield and quality in field trials in the Matanuska Valley.

approach

In 2004, potatoes were planted and harvested in seven replicated trials and two demonstration trials at AFES in Palmer.

progress

Southcentral Alaska had an outstanding growing season for potato production with irrigation. For the 2004 season, 17 varieties were included in the irrigated potato yield trial. The variety 'Chieftain' had the highest yield of marketable potatoes at 24 tons per acre. 'Red Ruby' had the lowest yield of marketable potatoes at 8 tons per acre. The average US#1 yields for the trial was 19 tons per acre. Management optimization trials evaluated the effects of plant spacings and fertilizer regimes on marketable yield on six varieties that are commercially grown in the region. The varieties 'Russet Norkotah', 'Shepody', and 'BakeKing' exhibited marketable yield increases of almost 10 percent when plant spacing was decreased from 11" to 9" between seed pieces. Changing the nitrogen fertilizer regime from all at planting to a split application did not significantly influence marketable yields. One demonstration trial used flame weeding techniques to control weeds in organic systems that do not allow herbicides. Tolerance of flame distance and flame contact duration was evaluated on three varieties of potatoes. We confirmed that potato plants can survive flaming conditions that kill weeds.

impact

Fresh market potatoes are produced in Alaska and sold every month of the year. Information on production practices can be used to make good management decisions for variety selection and cultural practices.

## Tomato cultivar trials

Grant E.M. Matheke, Janice Hanscom, Patricia S. Holloway

purpose

Short-season tomato cultivars for field production in home and market gardens were evaluated to expand the choices of tomatoes useful in interior Alaska gardens.

approach

Tomato trials were conducted from 2000 to 2004 by growing six cultivars in replicated beds in the Georgeson Botanical Garden. Plants were grown through infrared-transmitting plastic mulch and irrigated throughout the summer. Fruit were harvested between mature green and fully ripe stages, and yield was recorded three times each week.

progress

Tomato cultivars recommended for field cultivation on warm sites include 'Prairie Fire', 'Glacier', 'Kootenai', 'Northern Delight' and 'Stupice'. 'The cultivar 'Prairie Fire' was especially productive. It produced 2-inch diameter fruit that outweighed the standard outdoor tomato, 'Subarctic 25' by about three times.

impact

This research project expanded the recommended outdoor tomatoes for interior Alaska. This information will be useful for home gardeners and small market gardeners throughout the area.

## pest and disease control

### Arctic plant germplasm research and introduction

Alberto Pantoja, David Ianson, Joseph Kuhl, Nancy Robertson (USDA)

purpose

The primary mission of the Arctic Plant Germplasm Introduction and Research Project (APGIR) is the acquisition, propagation, storage, and distribution of plant germplasm for agricultural and nonagricultural plant species from arctic, subarctic, and alpine regions of the world. APGIR serves as a grow-out site for seed and clonal samples for certain cool season accessions from other plant germplasm repositories within the NPGS.

The mission includes research on certain diseases and physiological features of germplasm of arctic, subarctic, and alpine crop and noncrop species (see impact, below). Plant diseases in Alaska, both indigenous and introduced, are not well documented. Comprehensive plant disease surveys in agricultural and nonagricultural plant species are few, especially for plant viruses, although viral and other contagious diseases can have a significant negative impact on agricultural and nonagricultural crops adapted to arctic, subarctic, and alpine environments. Physiological aspects of plant adaptation and these environments also require more research.

approach and progress

1. *Cold-tolerant strawberries and rhubarb.* The introduction of cold-tolerant strawberry clones from USDA ARS National Clonal Germplasm Repository (NCGR) in Corvallis, Oregon, was transferred directly to a farmer's field, providing opportunity for participatory research and improved relationships with stakeholders. The unit provided petiole material from some of our *Rheum* accessions to the Matanuska-Susitna Borough for the development of an Agricultural Processing and Product Development Center for Rhubarb. The proposed program will allow interaction with the Cooperative Extension Service Home Economics Program at UAF.

2. *Medicinal plants.* Three medicinal plants native to circumpolar regions are being acquired and maintained: wormwood (*Artemisia* sp.), valerian (*Valeriana officinalis*), and devil's club (or Alaska ginseng) (*Oplopanax horridum*). There is an increased awareness and interest in herbal medicines in the US but a dearth of scientific information in the herbal database about the role of arctic and subarctic plant species, although Alaska Natives have used herbal remedies for thousands of years. One species in particular, devil's club, could be an important economic crop export. Related to ginseng, it has been found to contain saponins and ginsenosides (antimicrobial agents). Alaska contains probably the highest concentration of devil's club in the world (over 55,000 acres).

3. *Revegetation.* In collaboration with Dr. Dot Helm of SNRAS, we designed experiments to observe the effects of the biotic component of soil inocula on seedling growth, transplant survival, and establishment of *Shepherdia canadensis* (russet buffaloberry). We have also conducted an experiment with Dr. Helm to observe the effects of fulvic and humic acid frac-

tions on the germination of buffaloberry, a revegetation species important to the mining industry in Alaska. It is used to revegetate hard rock mine and coal mine sites.

4. **Plant regeneration.** We have regenerated crops that have proven difficult to regenerate in the lower 48 states. In the case of *Brassica oleracea* (broccoli), what takes two years to produce seed in the Lower 48 can produce seed in one year in Alaska. We are now screening many of the crops that are important to Alaska agriculture and our local stakeholders (lettuce, potatoes, cole crops).

5. **Virus detection.** Barley yellow dwarf virus-MAV was detected in Alaska for the first time. Using polymerase chain reaction, BYDV-MAV was detected in an estimated 1–5 percent of oat plants in a field; the disease was not identified when MAV-specific antiserum was used. Analysis of coat protein gene from 23 Alaska isolates confirmed uniqueness when compared to other isolates in the world that included the USA, China, and Sweden. The genetic difference in these unique MAV isolates most likely contributed to the failed serology tests, and stresses the importance of molecular diagnoses for disease detection.

6. **Rhubarb pest.** Aphids associated with rhubarb in Alaska were identified for the first time. The identification of a viral disease and aphids suggest that aphids might be involved in the spread of the disease.

impact

This project is an important part of the National Program 301 (Plant, Microbial, and Insect Genetic Resources, Genomics and Genetic Improvement), and contributes most of the efforts to the Plant Genetic Resource component of this program. Until now there has been no systematic effort by any US agency to preserve high-latitude and high-altitude plant germplasm. Although the values or benefits of preserving and studying these unique and environmentally isolated plant species is unknown, understanding high-latitude environments requires basic knowledge about the arctic, subarctic, and alpine plants that grow there. Locating this research in Alaska is vital because some high-latitude and high-altitude accessions are difficult or impossible to grow at relatively warm, short-day, low-latitude sites.

## Identification of resistance genes from potato cultivars

Peter Gay, Jenifer Huang McBeath

purpose

This study examined the presence of glutathione S-transferases (GSTs) and resistance (R1) genes in thirty-three potato cultivars. These two genes may play a very important role in disease resistance in potatoes. GSTs are a large family of multifunctional isozymes in plants and animals. They are well known for their involvement in drug metabolism and detoxification and in apoptosis (programmed cell death). The resistance gene plays an important role in the potato's defense mechanism against late blight and virus diseases.

approach

Thirty-three potato cultivars and breeding lines were collected from various potato farms in Alaska. Presence of

GSTs and R1 genes in these potatoes were examined using Polymerase Chain Reaction (PCR) amplification, primers and other molecular genetic techniques.

progress

Glutathione S-transferases were shown to be responsive to biotic and abiotic stresses. GSTs appear to have different functions in primary and secondary metabolism and cell signaling. They were shown to be capable of protecting plants from herbicide injury by conjugating the chloro-S-triazine atrozine. Stress-inducible GSTs prevent the degradation of hydroperoxides to cytotoxic aldehyde derivatives. GSTs use glutathione to reduce the organic hydroperoxides of fatty acids and nucleic acids to the corresponding monohydroxyalcohols, and they protect plants from oxidative injury. This functionality in GSTs has been demonstrated to be important in tolerance to cold and salt stresses.

PCR amplification of R1 and GST genes using primers based on *S. commersonii* R1 and GST were conducted on genomic DNA. Among the 33 potato cultivars tested, 3 had an amplification product for R1, 3 had amplification products for R1 and GST, and 3 cultivars had amplification products for R1 and GST, which are linked. We will explore the correlations between GST and R1 gene linkage in further research.

impact

This study elucidates the potential disease resistance of potato cultivars and breeding lines.

## Maintaining Alaska potato export status

Jenifer Huang McBeath, Mingyuan Cheng, Bixia Su

purpose

Alaska is the only place in the world that can export seed potatoes to Taiwan, and is the only US state that can export seed potatoes to China. Alaska is also one of five US states that can export tablestock potatoes to Taiwan. However, to attract buyers in Taiwan and China, Alaska potatoes must be free of all quarantine disease and pests stipulated by Taiwan and China, as well as many commercial diseases (diseases that affect marketability but do not require quarantine). This study assesses the quality of Alaska potatoes and was limited to a farm that intended to export seed potatoes to Taiwan and China. The project was funded by the State of Alaska.

approach

In summer 2004, a field disease survey and lab tests were conducted. The list of diseases and pests surveyed and lab tested including potato virus X (PVX), potato virus Y (PVY), potato virus A (PVA), potato virus M (PVM), potato leaf roll virus (PLRV), bacterial ring rot, late blight, potato witches' broom phytoplasma, aster yellow phytoplasms, root knot nematode, golden nematode, and potato rot nematode. Plant leaves, stems, and roots were examined for symptoms and signs of diseases and nematode infestations. Many samples (leaves, stems, roots, and soils) were collected at each seed lot for further examination and tests in the laboratory using microscopic, molecular, and immunological methods. Nematodes were extracted and examined from root and soil samples collected from each seed lot.



progress

A total of eight seed lots were examined. We found that all of the seed lots were completely free of the six virus diseases tested—PVX, PVY, PVA, PVM, PVS, and PLRV. Neither bacterial ring rot nor late blight was found on any of the potato plants examined. Potato witches' broom phytoplasma and aster yellow phytoplasma were also absent from the seed lots. Potato roots were found free of plant pathogenic nematodes. Except for a few free-living nematodes, no plant pathogenic nematodes were found in the soils collected.

impact

Under the World Trade Organization rules, agricultural products can only be exported after negotiation and signing of export protocols by trading countries. The export protocols can be revoked at any time if the importing countries find evidence that exporting countries have violated conditions stipulated in the agreements, such as the absence of diseases and pest problems. Our results provided the scientific evidence for the quality of Alaska potatoes on the examined farm and maintained Alaska's exporting status to Taiwan and China.

## Integrated pest management strategies for Alaska agriculture

Alberto Pantoja, Dennis Fielding, Jeffrey Conn, Loretta Winton, Steve Seefeldt

purpose

Since 1973, winter temperatures in Alaska have increased by 2–3°C, resulting in renewed interest in agricultural expansion in circumpolar regions and an increase in the incidence of pest insects and plant diseases. Information on biological properties of high-latitude pests (weeds, diseases, and insects), pest interaction with crops, and knowledge of best pest management practices for agricultural and natural areas in arctic/subarctic regions is lacking, poorly documented, or not well developed. More research is needed to improve management and to understand the biology of invasive plants, diseases, and insect pests in subarctic regions.

approach

Elevational transects have been completed on three river systems to determine the environmental factors governing distribution of white sweetclover (SC) on floodplains and to determine the relationships between cover and density of SC and diversity and abundance of other plant species. As steps to identify and quantify pathways for introduction of invasive plants to Alaska, stores in Alaska have been surveyed to determine sources and volumes of hay and straw brought into the state. Traditional and organic plantings of vegetables, potatoes, and rhubarb in Fairbanks and Palmer were monitored for the insect pests and their natural enemies.

progress/impact

Population densities of important pests were determined for each location; lady beetles, an important natural enemy of aphids, were identified. A complex of six species of leafhopper, ten species of aphids, and five Elateridae were found associated with potatoes. At least four aphid species were found in association with rhubarb.

Approximately 100 acres of land in Delta Junction was seeded to a mix of grass and forb species following USDA-Natural Resources Conservation Service recommendations for lands enrolled in the Conservation Reserve Program. This land will be used, among other things, to study the effects of different methods of brush control on weed and grasshopper populations. Baseline data has been collected this year.

An initial plant disease survey of Alaska's main agricultural areas in Palmer, Nenana, Fairbanks, and Delta Junction was completed. Overall, disease incidence was low, with negligible severity for all but three diseases. Lettuce drop was found to cause significant losses in commercial lettuce fields and variety performance trials near Palmer.

Potato leafroll virus was found at one location in interior Alaska. A presumptive peony disease has been found to prevent up to 75 percent of flower buds from developing into mature blooms in interior Alaska. Studies initiated to determine the causal agent(s) of the bud blast problem have not implicated fungal, viral, or bacterial diseases. Instead, two insect species appear to be associated with damaged peony buds at two locations in interior Alaska.

Alaska grasshoppers eschewed ryegrass turf as a place to deposit eggs, preferring instead bare ground, whereas grasshoppers of the same species from Idaho were less selective. Cultural practices such as establishment of turf along roadsides and field margins could reduce favorable egg-laying habitat and thus lessen the potential for outbreaks without resorting to chemical controls. Alaska grasshoppers exhibit very fast growth and development: the rapid growth was supported by more efficient use of digested food, rather than greater rates of food consumption or assimilation.

## β-1,6-glucanase isoenzyme profiles of *T. atroviride*

Mingyuan Cheng, Jenifer Huang McBeath

purpose

β-1,6-glucan is a minor component of the cell wall of plant pathogens and β-1,6-glucanase produced by *Trichoderma* may also play a role in its mycoparasitism of other fungi. This study examined the profiles of β-1,6-glucanase of *Trichoderma atroviride* with different carbon sources and pHs.

approach

*Trichoderma atroviride* was grown under different pH (2–10) in media amended with glucose, glycol chitosan, pustulan, and autoclaved mycelia *B. cinerea*, *P. capsici*, *R. solani*, and *S. sclerotiorum* as the sole carbon sources. Production over time of β-1,6-glucanase by *T. atroviride* was examined using biochemical techniques and statistical analysis.

progress

*Trichoderma atroviride* was found to produce multiple β-1,6-glucanases when it was grown with different carbon sources and under different pH conditions. The molecular weight of the various β-1,6-glucanases detected by SDS-PAGE ranged from 51 to 200 kDa. β-1,6-glucanase was detected from pH 2.0 to pH 7.0 and its specific activity peaked at pH 4.0. β-1,6-glucanase activity was highest on the second day after *T.*

*atroviride* was transferred from repression to induction conditions; it decreased the third day, and then increased again the fourth and fifth days to the second day's level.

impact

*Trichoderma atroviride* produces a coordinated biochemical response in the presence of different plant pathogens. Characterization of these enzymatic responses has revealed an induced and constitutive response by *T. atroviride*. Understanding  $\beta$ -1,6-glucanase profiles produced by *T. atroviride* helps in understanding the mechanisms involved in the biological control of plant diseases.

## Biological control of Armillaria root rot

26 Jenifer Huang McBeath; Kelly Walker (AmPac Inc., Fresno, California); J. Reedly (Reedly Farm, Sanger, California)

purpose

Armillaria root rot is one of the most serious diseases on fruit trees. Methyl bromide soil fumigation has been the primary strategy for disease control. International restrictions on methyl bromide use make it necessary to seek alternatives. *Trichoderma atroviride* is biological control agent discovered and developed at SNRAS. This fungus is unique in its ability to inhibit growth or cause disease and death in a wide range of plant pathogens, including *Armillaria mellea*, causal agent of Armillaria root rot. This research assesses the feasibility of using Plant Helper, a commercial product containing *T. atroviride* as a main ingredient, developed by AmPac, a company in Fresno, California. (Dr. McBeath and UAF have a financial interest in *T. atroviride* as used in Plant Helper and other commercial products.)

approach

In mid-December 2003, an efficacy demonstration of *T. atroviride* was initiated on Reedly Farm, Sanger, California, on a plum orchard heavily infested with Armillaria root rot. Approximately 100 acres of the farm were prepared as the demonstration site. Plant Helper, containing  $10^7$  cfu/g of *T. atroviride* spores, was sprayed on the root of plum stocks before they were transplanted. Two rows of the transplants adjacent to the road were not treated. Observations were made on the health of the trees. At the end of one year, ten trees were selected at random from the treated and untreated trees and measured. The circumference of the tree trunk was taken at twelve inches above the crown. Data on leaf samples, harvested from the sample trees, were also collected.

progress

On trees treated with Plant Helper there was no more die-back of branches. Treated trees were taller (261.1 cm) than the untreated control (223.3 cm) and their trunks, with an average circumference of 18.52 cm, were thicker than the untreated control (16.71 cm). Treated tree leaves were longer (17.1 cm) and broader (3.8 cm) than the untreated (14.5 x 3.0 cm). Furthermore, the leaves of the treated trees were greener; leaves of the untreated were in various stages of senescence.

impact

Under the United Nations Environment Programme,

the Montreal Protocol on Substances that Deplete the Ozone Layer was adopted to phase out the use of methyl bromide soil fumigation. Finding alternatives is important, since methyl has been used to control many soil insects, diseases, nematodes, and weeds, as well as insects and other organisms present in stored or shipped commodities and related facilities. Methyl bromide is also highly toxic to humans; exposure increases risks for melanoma and non-melanoma skin cancers, eye cataracts, and weakened immune systems. Our demonstration results indicate that *T. atroviride* may be used as an alternative to methyl bromide soil fumigation in the control of Armillaria root rot on fruit trees.

## Characteristics of an endo- $\beta$ -1,3-glucanase associated with biocontrol activity of *Trichoderma atroviride*

Mingyuan Cheng, Jenifer Huang McBeath

purpose

Pathogenesis-related (PR) proteins are a structurally diverse group of plant proteins that are toxic to invading fungal pathogens. They are widely distributed in plants in trace amounts but are produced in much greater concentration following stress or an attack by pathogens. Different plant organs may produce different sets of PR proteins (Agrios GN, 1997. *Plant Pathology*. Academic Press. 635 pp.). Chitin and  $\beta$ -1,3-glucan are two main components of the cell wall of plant pathogenic fungi. There are two types of  $\beta$ -1,3-glucanase involved in the biological control of plant diseases.  $\beta$ -1,3-glucanase is also found in plants as a PR protein that induces host resistance to pathogens. Here we study the characteristics of  $\beta$ -1,3-glucanase produced by *Trichoderma atroviride*.

approach

*Trichoderma atroviride* was grown in medium amended with autoclaved mycelia of *Phytophthora capsici* to induce  $\beta$ -1,3-glucanase production. The  $\beta$ -1,3-glucanase produced was purified through filtration and DEAE, Phenyl sepharose, and chromatofocusing chromatography methods. Determined for purified  $\beta$ -1,3-glucanase were its molecular weight, optimal enzyme activities, optimal temperature, and pH and antifungal activities.

progress

A 77 kDa endo- $\beta$ -1,3-glucanase produced by *T. atroviride* was purified. The purified endo- $\beta$ -1,3-glucanase showed strong antifungal activity by inhibiting spore germination of *Botrytis cinerea*. The endo- $\beta$ -1,3-glucanase only was active on substrate containing  $\beta$ -1,3 linkages. Again the polymers with the highest activity were laminarin and glucan. Endo- $\beta$ -1,3-glucanase remained active at a wide temperature range, even at low temperatures (6°C). The optimal temperature for this  $\beta$ -1,3-glucanase was 45°C, and the optimal pH was 4.0. The Km value of this endo- $\beta$ -1,3-glucanase was 6.2 mg/ml, which is higher than the reported  $\beta$ -1,3-glucanases. The sequence of endo- $\beta$ -1,3-glucanase produced by *T. atroviride* differs greatly from other endo- $\beta$ -1,3-glucanase. It more closely resembles that of a  $\beta$ -1,3-glucanase with only one N-terminal amino acid difference.

impact

*Trichoderma atroviride* produces a coordinated biochemical response in the presence of different plant pathogens. Characterization of these enzymatic responses has revealed an induced and constitutive response by *T. atroviride*. Elucidation of the characterization and antifungal activities of  $\beta$ -1,3-glucanase of *T. atroviride* can provide a better understanding of the mechanisms involved in the biological control of plant diseases.

## Effects of heavy metal on the growth of *Trichoderma atroviride*

Jenifer Huang McBeath, Bixia Su

purpose

*Trichoderma atroviride* has been found to promote the growth of plants under normal conditions. *T. atroviride* is a very robust fungus and has high tolerance to common fungicides and/or herbicides. This study examined the tolerance of *T. atroviride* to heavy metals and its potential use to promote plant growth in heavy metal-contaminated soils.

approach

Growth responses of *T. atroviride* to aluminum ( $\text{AlCl}_3$ ), cadmium ( $\text{CdCl}_2$ ), cobalt ( $\text{CoCl}_2$ ), copper ( $\text{CuSO}_4$ ), lead [ $\text{Pb}(\text{NO}_3)_2$ ], manganese ( $\text{MnSO}_4$ ), mercury ( $\text{HgCl}_2$ ), nickel ( $\text{NiCl}_2$ ), and zinc ( $\text{ZnSO}_4$ ) were conducted under shake culture and hand shake conditions. After 17 days, fungal mass of *T. atroviride* was harvested, dried, and weighed.

progress

At the concentration of 100 mg/L, and shake culture condition, the mycelium dry weight of *T. atroviride* to  $\text{CdCl}_2$  and  $\text{CoCl}_2$  was more than three times that of the control. The growth response of *T. atroviride* to  $\text{MnSO}_4$  and  $\text{CuSO}_4$  also surpassed the control. Under  $\text{NiCl}_2$ ,  $\text{AlCl}_3$ , and  $\text{ZnSO}_4$ , *T. atroviride* growth is comparable to the control. *T. atroviride* grew less well under  $\text{Pb}(\text{NO}_3)_2$  and  $\text{HgCl}_2$ . When grown under hand-shake conditions, the response of *T. atroviride* to various heavy metals was almost the complete reverse of those under shake culture conditions.

impact

Chemical and heavy metal contamination are prevalent in many areas in the United States. Heavy metals, such as cobalt, cadmium, and mercury can be toxic to plants and seriously affect their growth. Results of our study indicate that *T. atroviride* may be used to promote plant growth and health in heavy-metal-contaminated soils.

## Regulation of $\beta$ -N-acetyl-D-glucosaminidase in *Trichoderma atroviride* by plant pathogens

Mingyuan Cheng, Jenifer Huang McBeath

purpose

*Trichoderma atroviride* is a unique biological control agent capable of controlling a wide range of plant diseases. *T. atroviride* uses plant pathogenic fungi as its food source.

In the presence of plant pathogenic fungi, *T. atroviride* will gear up its production of a large numbers of enzymes, some of which degrade the cell wall of the plant pathogens, which leads

to their death.  $\beta$ -N-acetyl-D-glucosamine is one of the basic building blocks of fungal cell walls. Here we study the reponse of *T. atroviride* to inductions of  $\beta$ -N-acetyl-D-glucosaminidase, a group of main fungal cell wall degradation enzymes.

approach

The four economically important plant pathogens selected for this study were: *Botrytis cinerea* (grey mold of many crops), *Phytophthora capsici* (root, stem, and fruit rot of chili peppers), *Rhizoctonia solani* (various diseases on many crops), and *Sclerotinia sclerotiorum* (white mold on many crops). *T. atroviride* was grown in the presence of these fungi. Biochemistry techniques, such as SDA-PAGE and native PAGE gel electrophoresis, were used in enzyme purification.

progress

Results of the enzyme induction experiments revealed that *T. atroviride* produced two  $\beta$ -N-acetyl-D-glucosaminidases. One is about 93 kDa (molecular weight) and the other is about 73 kDa. The 73 kDa  $\beta$ -N-acetyl-D-glucosaminidase was produced only when *T. atroviride* was grown in the presence of *S. sclerotiorum*. *T. atroviride* produced the 93 kDa  $\beta$ -N-acetyl-D-glucosaminidase when it was grown with other plant pathogenic fungi and their autoclaved (heat killed) mycelia. Culture filtrates of *S. sclerotiorum* regulated production of the 73 kDa  $\beta$ -N-acetyl-D-glucosaminidase while culture filtrates of *B. cinerea* had no effect on  $\beta$ -N-acetyl-D-glucosaminidase gene expression. Metabolites from the *S. sclerotiorum* culture filtrate were released into the media and regulated expression of the 73 kDa  $\beta$ -N-acetyl-D-glucosaminidase. Expression of the 73 kDa  $\beta$ -N-acetyl-D-glucosaminidase occurred before physical contact of *T. atroviride* with *S. sclerotiorum*.

impact

*Trichoderma atroviride* produces a coordinated biochemical response in the presence of different plant pathogens. Characterization of these enzymatic responses has revealed an induced and constitutive response by *T. atroviride*. Results of this study contribute to our fundamental understanding of mechanisms involved in the biological control of plant diseases.

## High-Latitude Soils

### Soil landscape relationships in the Luquillo Mountains, Puerto Rico

C.L. Ping (SNRAS); C.A. Stiles (Univ. of Wisconsin); G. Gonzalez (USDA)

purpose

This study investigates the soil landscape relationships along a topographic transect in the cloud forest of Luquillo Mountains in Puerto Rico. Baseline soil data is needed for better understanding of ecosystem dynamics. This study is in cooperation with the USDA Forest Service International Institute of Tropical Forestry in Puerto Rico and the University of Wisconsin Madison.

approach

Soil characteristics of an altitudinal gradient in eastern

Puerto Rico were investigated. Soil study sites were selected according to the area's major forest types and soil pits were excavated outside of the ecological monitoring plots. Soil morphological, chemical, and physical properties are to be characterized.

#### progress

The setting, within 20 km of the coast, is considered an orographic toposequence due to the interaction of strong easterly trade winds and the Luquillo Mountains. All soils formed in andesite residuum, colluvium, or alluvium, depending on landscape position. The soils in the highest altitude cloud forest (1012 msl; MAP>300cm) were highly enriched in aluminum and iron, depleted in silicon and base cations (calcium, potassium, magnesium, sodium) and dark and acid topsoil. The very friable, smeary nature of the surface horizons, coupled with very high aluminum contents that differed from parent material composition, suggest that these soils are volcanic ash.

#### impact

The input of volcanic ash into the soils of the cloud forest was not recognized before. This finding is applicable to specific management considerations and can further understanding of nutrient cycling in these volcanic ash-derived topsoils.

## Biogeochemistry of soils associated with cryptogamic crusts on frost boils in arctic Alaska

G.J. Michaelson, C.L. Ping

#### purpose

Our goal is to determine the amount and direction of chemical changes that are occurring in different soil substrates over the relatively short temporal and spatial dimensions atop the nonsorted circles as soil vegetative cover is achieved on surfaces that are relatively recently disturbed. The study sites are associated with the National Science Foundation Biocomplexity Study.

#### approach

Soils studied were from frost boils at nine sites across arctic Alaska; most sites were adjacent to established grid sites of the biocomplexity study. Samples were taken at incremental depths under a 15 cm x 15 cm area by slicing from an excavation that exposed one side of the sample area. Surface soils were sampled to a 10 cm depth and increments varied from 0.5 to 2 cm, depending on the nature of the surface and site vegetation. Thin cyanobacteria crust surfaces were sampled at 0.5 cm and other crusts or barren areas at 1 or 2 cm, depending on apparent crust thickness. Vegetation mats were sampled at thickness of the mat, which varied from 1 to 4 cm. After the first sample increment representing the surface or organic horizon (for vegetation mats), samples were taken at 2-cm increments down to a 10-cm depth.

#### progress

Cryptobiotic crusts composed of lichens, small mosses, liverworts and algae species are of considerable importance for stabilizing the barren soils and for nitrogen fixation. Studies of crust taxonomy and characterization of the soil properties have begun. Soil mineral substrates and their chemical character have

important influences on the nature of bare-surface soils and soils under cryptobiotic crusts. Crusts developed on soils with calcium-rich (nonacidic) substrates, such as those found on the coastal plain, accumulate calcium salts at the crust surface and in vegetated areas. The bare areas of the boil show even distribution of calcium near the surface consistent with more active mixing of seasonal frost processes. Areas with significant sodium in soil substrates (i.e., coastal areas or other areas with marine sediments) show salt redistribution effects with frost boil formation. This redistribution of salts could be contributing to persistence of the surface vegetation pattern in which sodium accumulates in the bare boil centers and calcium is segregated under crusts developed on the boil edges and in inter-boil areas.

#### impact

This study is the first to examine nutrient dynamics in cryptogamic crust in the Arctic. Perhaps the most important impacts of crust and vegetation mat establishment result from the accumulation of organic carbon, nitrogen, acidity, and nutrients in the soil system affecting soil fertility. An important direct and immediate result of soil organic matter cycling in crusts is the release of soil acidity (protons). In soils from more temperate regions these processes work primarily from the surface down or a static horizontal layering of soil horizons, but for systems associated with nonsorted circles, surface effects are mixed to depth (down as far as the top of the permafrost table), and they affect the physiochemical dynamics of the whole active layer over a longer time.

## Soils associated with pattern ground in arctic Alaska and Canada

Chien-Lu Ping, Gary Michaelson

#### purpose

The project objective was to characterize soils associated with pattern ground, especially nonsorted circles in arctic Alaska and Canada.

#### approach

Soils were studied and sampled alongside the NSF Biocomplexity vegetation plots in arctic Alaska and Canada.

#### progress

We conducted soil nutrient dynamic studies along the transect of frost boil-interboil microassociations on five biocomplexity vegetation plots in arctic Alaska, four plots on Banks Island, and five plots on Prince Patrick Island, Northwest Territory, Canada. We took soils characterization samples on all study sites, and partially completed soil characterization data. Preliminary results indicate that all soils associated with vegetation plots on Banks Island are carbonate saturated, and thus have high pHs. All soils studied are highly cryoturbated and organic matter or organic-rich mineral surface soils were frost-churned down to upper permafrost. The organic carbon stores are evenly divided between the active layers and the upper permafrost.

#### impact

Soil characterization data provide the baseline soil data to the vegetation study group and also to the modelers. The total

organic carbon stores in soils of the arctic islands are higher than expected. This will increase the contribution of carbon from the Arctic to the current global terrestrial carbon budget estimates. Results from the soil morphological study and chemical analysis suggest that cryoturbation mainly due to frost heave plays a controlling role in carbon sequestration in arctic tundra soils.

## Black spruce forest soils in boreal regions of Alaska

C.L. Ping, E.C. Packee, N.D. Zaman

### purpose

We examined black spruce forest soils for their characterization, organic carbon pool, and relationship to boreal forest management.

### approach

This study is a joint USDA Hatch and McIntyre-Stennis project, so the study sites were selected with the cooperation of the Forest Growth and Productivity Program of the Alaska Agricultural and Forestry Experiment Station. One category of soils sampled were those associated with Permanent Sample Plots. The other category involved soils in burned and unburned black spruce forest stands, which were pair sampled. We studied soils associated with black spruce along both north-south and east-west transects, and characterized their morphological, physical, and chemical properties.

### progress

Soil studies associated with the Forest Growth and Yield Program in interior Alaska found black spruce forests growing on a wide variety of landscape positions from somewhat excessively drained sand dunes and well-drained ridge tops to poorly drained lowlands. Organic horizon (soil layer) thickness ranged from 4-18 cm. on well-drained sites to >30 cm on poorly drained sites. Soil pH increased with depth: from 4.0 to 6.0 in organic horizons (O), 4.0 to 6.0 in humus-rich surface mineral horizons (A), 5.0 to 7.0 in weathered mineral horizons (B), and 7.0 to 8.0 in substratum that has very little weathering (C horizons). Total soil carbon decreased sharply with depth from about 30-50 percent in O horizons to <1.0 percent in BC and C horizons. Wildfire is a common and frequent disturbance feature in black spruce forests in the western boreal region; thus, charcoal was found throughout the soil profiles with a concentration in surface and subsurface horizons.

### impact

Volcanic ash has been newly recognized as result of this study as a critical element in maintaining forest productivity on eastern Tanana Valley uplands, because this ash layer holds more available water than the underlying sands.

We also found that charcoal and charred material resulting from forest fire often leads to overestimation of soil organic matter and yields a wide carbon-to-nitrogen ratio. This leads to overestimation of nitrogen need of the ecosystem.

## Carbon cycling in three mature black spruce (*Picea mariana* [mill.] B.s.p) forests in interior Alaska

Jason Vogel, David Valentine, Steve Sparrow

### purpose

We sought to evaluate the relationships between climate and ecosystem carbon balance. In a warming climate, the temperature sensitivity of organic matter decomposition will accelerate soil carbon loss via microbial respiration from cold boreal soils. Increased decomposition may also increase nutrient availability, plant productivity, and organic inputs to soils. The difference between plant growth and decomposition will determine whether a black spruce ecosystem contributes to or removes carbon from the atmosphere. A net removal (growth>respiration) will decrease the amount of atmospheric greenhouse gases; a net loss (respiration>growth) will increase atmospheric greenhouse gases.

### approach

We studied the relationship between decomposition, aboveground plant growth, total soil respiration, root respiration, and heterotrophic respiration near Fairbanks, Alaska. We compared our results to those of other researchers in Alaska and in central Canada who used similar methods. For our local study, we chose three similarly structured black spruce-feathermoss forests that varied in aspect, elevation, and depth to permafrost. These characteristics drive complex differences in annual temperature at the soil surface and through the soil profile. A soil temperature gradient was also examined at the regional scale (encompassing Alaska and Canada sites). We hypothesized that ecosystem CO<sub>2</sub> uptake (plant growth) and loss (total soil and heterotrophic respiration) both would increase with soil temperature, but that in warmer soil temperatures plant growth would exceed heterotrophic respiration. In other words, the warmer ecosystems would store greater amounts of carbon because of greater plant growth.

### progress

Plant growth and decomposition both generally increased with soil temperature, but there was no discernible increase in ecosystem carbon storage. Rather, with increased soil temperature carbon was simply reallocated by black spruce from belowground process to aboveground growth with no net gain or loss of ecosystem carbon. The results also suggest that soil moisture may affect ecosystem carbon allocation.

### impact

For the forest type we studied, this research suggests that the predicted warmer and wetter boreal climate will result in 1) increased black spruce growth and 2) less carbon stored in the forest floor. This suggests one benefit for Alaska: increased black spruce growth could make it a marketable species. However, this benefit will not offset atmospheric carbon buildup because ecosystem carbon storage remains unchanged with warming. Other research suggests that mineral soil carbon balance may be somewhat independent of patterns in both surface soil carbon and forest growth, and that low-productivity forests with substantial soil carbon may not increase in growth enough to offset carbon losses.

## Controls over water-soluble organic carbon characteristics and fluxes along climate and stand productivity gradients in interior Alaska

Evan Kane, David Valentine, Gary Michaelson, John Fox, Chien-Lu Ping

purpose

Many streams in Alaska are tea-colored because of dissolved organic acids that derive from the partial decay of soil organic matter. This project evaluates whether soluble organic carbon losses from soils represent a major component of carbon export from soils when compared to other export mechanisms, such as soil respiration.

approach

To examine the factors controlling water-soluble organic carbon (WSOC) fluxes, we estimated WSOC fluxes based on measured concentrations along four replicate gradients in upland black spruce productivity (*Picea mariana* [Mill.] B.S.P.) and soil temperature in interior Alaska and compared them to concurrent measurements of soil CO<sub>2</sub> efflux.

progress

As of fall 2004, we had measured WSOC concentrations in organic and mineral soil horizons (n=9) at all 12 sites, in early spring, summer, and late fall. We separated WSOC into four fractions using ion exchange resins (XAD8): humic acid, fulvic acid, hydrophilic neutrals, and low molecular weight fulvic acids.

In colder, low-productivity stands the proportions of relatively bioavailable organic fractions (hydrophilic organic matter and low molecular weight acids) were highest in WSOC; in warmer, high-productivity stands the more degraded products of microbial activity (fulvic acids) were highest in WSOC.

Concentrations of WSOC ranged from 4.9–22.7 g carbon m<sup>-2</sup> in organic horizons (soil layers) and from 1.4–8.4 g carbon m<sup>-2</sup> in mineral horizons. Annual WSOC fluxes increased with annual soil CO<sub>2</sub> effluxes across all sites, with higher fluxes occurring in warmer, more productive stands.

Although annual WSOC flux was relatively small compared to total soil CO<sub>2</sub> efflux across all sites (2–6 percent), its relative contribution was highest in warmer, more productive stands.

This paper was revised in *Soil Biology and Biochemistry* in summer 2005.

impact

Understanding the factors that control WSOC fluxes from boreal forest soils is important because small changes in carbon cycling can change the sign of the forest carbon balance.

These data suggest that accounting for water-soluble organic carbon is necessary to determine accurately how climate change will affect boreal forest soil organic carbon balance.

## Fire impacts on boreal forest soil carbon bioavailability

Sarah Masco, David Valentine, Steve Sparrow

purpose

We sought to evaluate whether and how wildfire changes the quality of organic matter remaining at the soil surface following wildfire.

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[www.uaf.edu/snras/](http://www.uaf.edu/snras/)

approach

Soil samples were obtained from the lower two sub-horizons (F and H layers) of the organic surface horizon (the surface layer of decomposing organic matter). Subsamples were incubated at three temperatures for six months. Respiration rates, total amounts of respired CO<sub>2</sub>, and temperature sensitivity of respiration rates were determined, then compared with chemical analyses of the soil organic matter, which was determined via pyrolysis gas chromatography/mass spectroscopy (py-GC/MS).

progress

Incubated soil organic matter from burned sites initially respired more slowly than soil organic matter from unburned control sites, but for most of the incubations the respiration rates were indistinguishable. Initial differences in respiration rate and temperature sensitivity did not correlate well with bulk soil organic components determined through py-GC/MS or through fiber analysis. Burned soils had higher net nitrogen (N) mineralization rates than unburned soils. This could have resulted from more rapid gross N mineralization in burned soils or from more rapid gross N immobilization (higher N demand) in the unburned soils. We interpret these results as suggesting that the only major difference between burned and unburned organic soils is the presence in the unburned soils of a rapid turnover pool from recently dead roots that is not present in the unburned soils. In 2004, Ms. Masco completed her thesis and sent it to her advisory committee for review.

impact

This thesis sheds light on the mechanisms that are not responsible for the patterns of respiration observed in the Frostfire experiment. Fire did not directly cause changes in the quality of bulk organic soil carbon, and differences in heterotrophic respiration observed in the field likely arose from other changes. This is significant because it ultimately helps us predict how soil carbon balance will respond to fire. Our results suggest that none of the change we saw resulted from some fire effect on the organic matter, but resulted instead from the lack of new carbon inputs from live plants.

## Soil carbon stabilization along climate and stand productivity gradients in black spruce forests of interior Alaska

Evan Kane, David Valentine (SNRAS); Ted Schuur, Koushik Dutta (Univ. of Florida)

purpose

How do soil carbon chemistry and carbon accumulation vary with forest productivity? This research aims to answer that deceptively simple question. Specifically, we are looking at the relationship between the stability (resistance to microbial degradation) of soil organic carbon (SOC) and how rapidly and densely nearby trees are growing.

approach

To determine how the complex interplay between stand production, nutrient mineralization, and soil temperature affects soil carbon stabilization, we investigated total SOC along four replicate gradients in black-spruce productivity and climate in interior Alaska.

Because turnover of soil pools is faster in warmer, more productive sites, we hypothesized:

1) total SOC decreases as stand productivity and soil temperature increase because productivity depends on nutrients released with soil organic matter turnover (which also increases with temperature), the net result being that

2) SOC content in more stable soil pools is proportional to the amount of actively cycling SOC in surface soil pools.

progress

Within organic soil across all sites, total SOC harbored in mineral soil horizons decreased by 4.4 g carbon m<sup>-2</sup> for every degree-day increase in heat sum. Furthermore, as stand productivity and soil temperature increased, the proportion of relatively labile light fraction soil organic matter decreased significantly. Mean residence times of SOC in dense fraction mineral soil ranged from 282–672 years. The oldest SOC occurred in the coolest sites, which also harbored the most carbon and had the lowest rates of stand production. This paper is currently in press, in the *Canadian Journal of Forest Research*.

impact

The amount of SOC in stable, slow turnover pools is likely to change in response to climate warming because processes mediating soil carbon balance (net primary production and decomposition) vary with environmental conditions. This is important to consider in boreal forests, which contain one of the world’s largest stocks of SOC. In this study we found that the interactions between increased stand productivity, organic matter accumulation, and soil heat sum have altered the quality and quantity of different soil organic matter pools through differences in decomposition environment and plant carbon inputs; this occurred even though total SOC appeared insensitive to temperature in some cases. These data suggest that organic matter decomposition responds to temperature within discrete soil pools, and not just total soil carbon stocks, and should be examined to project the effects on soil carbon balance of changing climate and primary production.

**Soil respiration following wildfire in lowland interior Alaska forests**

Tim Quintal, Evan Kane, David Valentine

purpose

Since 1999 we have measured a consistent decline in total soil respiration, as well as in heterotrophic (not plant-associated) respiration, in interior Alaska forests after wildfire. Because other reports in the literature suggested that the pattern would be different in lowland areas—perhaps owing to permafrost dynamics—we decided to extend our soil respiration measurement program to areas burned during the 2001 Survey Line fire on the south bank of the Tanana River.

approach

Following the Survey Line Wildfire in 2001, we tracked growing season soil respiration in burned and unburned lowland black spruce stands near the Tanana River in the Bonanza Creek Experimental Forest. We used static chambers of a more robust design than in the Frostfire project, and also tracked soil temperatures and moisture contents in tandem with the respiration measurements.

progress

Results were similar to those of the Frostfire project: a large and immediate decline in respiration from burned soils that persisted through 2004. We also routinely measured root-free (heterotrophic) respiration in the unburned stands. Respiration rates in burned soil—which had few or no live roots—were 30 percent lower than unburned heterotrophic respiration rates measured in root-exclusion collars in 2004. These results reinforce the pattern found in the Frostfire project: fire reduces CO<sub>2</sub> evolution rates both through elimination of root respiration and through slowing of heterotrophic respiration.

impact

In response to the Kyoto Protocol, carbon credit markets have been established in the United States and throughout the world. The Alaska legislature has been considering bills that would authorize investigation of carbon credits in boreal forests and elsewhere as potential sources of revenue for state coffers. Our results will assist such efforts by shedding light on key dynamics governing carbon balance following the major disturbance type in interior Alaska.

**Soil respiration following wildfire in upland interior Alaska forests (Frostfire)**

David Valentine, Sarah Masco, Tim Quintal, Jason Vogel

purpose

We seek to quantify the impact of the most important disturbance type (wildfire) on the largest pool of terrestrial carbon (soils) in upland black spruce and mixed hardwood forest types.

approach

We tracked soil respiration in black spruce and mixed hardwood stands before and since a 1999 experimental wildfire (the Frostfire project) at the Caribou-Poker Creeks Research Watershed.

progress

We found that soil respiration decreased by ~50 percent in mixed hardwood stands and by ~15 percent in black spruce dominated stands in which photosynthesis by feathermosses partially offsets soil respiration. That initial decline coincided with the cessation of respiration by roots that no longer receive photosynthate from their burned above-ground parts.

Because faster decomposition rates would be favored by the warmer and wetter environment brought about by the combustion of the canopy and blackening of the soil, I had expected that the post-fire respiration rates would increase after the initial decline. However, the soil respiration differences between burned and unburned soils persisted, and in 2001 were at least as large as they were in 1999. Heterotrophic respiration rates (measured in soils with roots excluded in 2003) were lower in burned than in unburned soils. In 2001 I also assessed decomposition rates of a standard substrate (tongue depressors fabricated out of paper birch wood), and found that decomposition rates were higher in burned than in unburned sites. Thus, the continued differences in respiration—despite the more favorable conditions for decomposition in the burned

sites—result from slowed heterotrophic respiration.

In her thesis, MS candidate Sarah Masco found that unburned soils initially showed higher laboratory respiration potentials than burned soils, but successive measurements over the course of six months showed that difference did not persist. This suggests that there may be a pool of high-quality organic matter that is depleted rapidly in the absence of new inputs (e.g., root exudates and turnover), but that the overall quality of the forest floor organic matter has not been altered by fire.

We continued measurements through the 2004 growing season. Aspen seedlings and bluejoint grass have become dense and tall, necessitating clipping of all biomass within each of the respiration chambers. 2004 was the final year of respiration measurement for this study.

impact

Taken together, these results imply that the decline in heterotrophic respiration following fire may be tightly coupled to the loss of root turnover; while the respiration rates of the remaining soil organic carbon are relatively unchanged by fire. These results are key to projecting the effects of increasing wildfire on carbon balance in upland spruce and hardwood ecosystems in interior Alaska.

## Management of Ecosystems

### Alaskans represent the US in the GLOBE Arctic POPs Project

Elena Sparrow (AFES/SNRAS); Tania Spurkland, Mark Lyke (Polaris K-12 School, Anchorage, AK); Carla Lam (Kodiak High School, Kodiak, AK); Georgia Rodgers, Michael Wilkinson, Dave Wilkinson (Polaris high school students); Emily Barnard, Matt Deal, Andrew Lam, Tony Nelson (Kodiak high school students)

purpose

This Global Learning and Observations to Benefit the Environment (GLOBE) project aimed to: 1) increase the knowledge of persistent organic pollutants (POPs) in the Arctic and of earth and environmental science in participating schools; 2) investigate the distribution and levels of new POPs, such as brominated flame retardants (polybrominated diphenyl ethers or PBDEs) in the Arctic; and 3) contribute to the documentation and public awareness of new POPs in the Arctic.

approach

A three-year study on arctic POPs was conducted by scientists from the Norwegian Institute for Air Research (NILU) and the United States, high school students, teachers, principals, and GLOBE coordinators from seven countries in the Circumpolar North: Canada, Finland, Iceland, Norway, Russia, Sweden, and the United States. Alaska GLOBE students, teachers, and the Alaska GLOBE Program, through the UAF GLOBE Partnership, actively participated and represented the United States in this multinational and multiyear arctic research endeavor. The two Alaska high schools were Kodiak High School and Polaris K-12 School in Anchorage.

In 2001 the first GLOBE Arctic POPs Workshop was hosted by the Alaska GLOBE UAF Partnership, the Center for Global Change, and the School of Natural Resources and Agricultural Sciences. This Training for Trainers Workshop in Fairbanks, Alaska, focused on GLOBE basic protocols and the new GLOBE Arctic POPs fish protocols: measuring fish length, weight, maturity; sampling of fish tissues (liver from cod, muscle tissue from salmonids, otoliths, and scales); use of proper equipment and materials; documentation on data sheets and using a camera; sample preservation, packing, and shipping procedures to Norway. Fish samples collected by high school students were analyzed at NILU and results were sent back to the students for use in their studies.

progress

Results of the study indicated that PBDEs are present in the arctic environment. Samples from Alaska fish had the lowest amounts of PBDE and polychlorinated biphenyls (PCB) compared to those in the other arctic countries. Students participated with teachers, country coordinators, and scientists in subsequent GLOBE Arctic POPs workshops held in Akyureri, Iceland in 2002; Pajala and Kiruna, Sweden in 2003; and in Lofoten, Norway in 2004. Alaska students gave presentations locally, statewide, and internationally on their findings in this project and in other GLOBE-related studies, such as phenology and atmosphere investigations.

impact

Students became aware of what POPs are, how they are transported to the Arctic, and their health effects. They learned how to conduct scientific investigations, and more than 200 Alaska high school students participated. It has brought out the importance of collaborative work among peoples, the vital role of students and teachers in research and education programs like GLOBE, and the concept that what happens locally can have global implications. This project has also resulted in many presentations and student papers, and the widening of participants' horizons through learning about and traveling to other countries, meeting new people, and gaining a better understanding of different cultures. Both scientific collaboration and cultural and literature exchange were facilitated by the project.

## climate research and global change

### Arctic Climate Impact Assessment (ACIA) scientific document

Glenn Juday, Valerie Barber, Stephen Sparrow, Carol Lewis, Scott Rupp, John Yarie, Paul Duffy, Martin Wilmking

purpose

This project examined the influence of climate and climate change on agriculture and forestry in the far north. It identified the key controls of climate, and the history, risks, and opportunities of climate change and climate variability for natural and managed forest and agricultural systems.

approach

Extensive peer-review comments (more than 500) were comprehensively addressed and filed, and the resulting changes were incorporated into the chapter in the ACIA scientific doc-



ument on forests, land management, and agriculture. A new section on forest biodiversity was added to the chapter on biodiversity.

#### progress

Temperatures across most of the northern boreal region have warmed significantly in the last thirty years. Generally the current levels of warmth have not been experienced since at least the Medieval Warm Period of 1000 years ago, and even much earlier in some locations. Clear evidence of the effects of this warming is present, including decreasing tree growth in dry subregions and increasing growth in cool and moist subregions, large outbreaks of forest-damaging insects such as autumn moth, spruce bark beetle, and spruce budworm, and a trend of increasing forest fires. Warming has increased the success of cold-limited crops, and improved the success of afforestation in cold-climate-limited places such as Iceland.

#### impact

The ACIA overview document was published by Cambridge University Press in 2004. Results are being used by several major policy making groups and a large number of resource management organizations. The ACIA received extensive international media coverage, including an international scientific symposium in Iceland.

### **CARMA – CircumArctic Rangifer Monitoring and Assessment network**

Gary Kofinas, Greg Finstad, Brad Griffith, Robert White (UAF); Don Russell (Canadian Wildlife Service/Environment Canada) with other country partners

#### purpose

CARMA was established in November 2004 to monitor and assess the effects of global change on the human-*Rangifer* system of the circumarctic through geographic and interdisciplinary cooperation. The CARMA network formed in response to the Arctic Council's call to monitor arctic biodiversity in the face of dramatic global changes, and as part of a series of networks being implemented by the Biodiversity Working Group of Conservation of Arctic Flora and Fauna. CARMA is also a project of the International Arctic Science Committee and an initiative of the International Polar Year.

#### approach

CARMA involves 35 partners, representing all arctic countries (see [www.rangifer.net/CARMA](http://www.rangifer.net/CARMA)). Initial work of CARMA is focused on wild reindeer/caribou. Monitoring and assessment are undertaken regionally and coordinated by leaders in each country. Monitoring and assessment are undertaken at three scales of analysis: community-based monitoring; field-base biological research; and remote sensing, including subsistence harvesting patterns, NDVI analysis of green-up as related to caribou reproductive success, caribou energetic budgets, and availability of caribou to hunters.

#### progress

We are implementing the program by developing common monitoring protocols, building a circumarctic database and web-based reporting system, and completing a synthesis through retrospective analyses of select regional case studies.

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[www.uaf.edu/snras/](http://www.uaf.edu/snras/)

#### impact

CARMA is identified as a lead initiative of the International Polar Year, and has the potential to leave an important legacy in international research and cooperation. SNRAS and the Institute of Arctic Biology at UAF, with Environment Canada, have assumed the lead role in the program as network coordinators.

### **Carbon cropping the boreal forest of Alaska: landscape modeling**

J. Yarie

#### purpose

The CENTURY and DAYCENT ecosystem models were calibrated for analyzing carbon capture dynamics of Alaska forests. These two models are tools for analyzing carbon dynamics in interior Alaska forests.

#### approach

Past, current, and future climate regimes were used to develop carbon balance estimates for interior Alaska using CENTURY and DAYCENT.

#### progress

CENTURY was run to model carbon dynamics with climate data from 1950 to 1980 and from 1980 to 2000. A comparison of carbon dynamics was completed for hardwood, white spruce, and black spruce forest types.

#### impact

We now have estimates of the effect of changing climate dynamics over the past two decades on carbon capture by interior Alaska forests. The CENTURY model has predicted that the quantity of carbon capture in hardwoods has shown a significant decline, the quantity of carbon capture in white spruce ecosystems has increased, and the quantity of carbon capture in black spruce ecosystems has shown little change. When the area estimates for the forests types across the taiga forests of Alaska is combined with the above dynamics, it can be suggested that over the past 20 years there has been a substantial decline in carbon capture.

### **Collaborative research: an integrated approach to understanding the role of climate-vegetation-fire interactions in boreal forests responses to climatic change**

T. Scott Rupp, Mark Olson (SNRAS); Linda Brubaker, Patricia Anderson (Univ. of Washington); Feng Sheng Hu (Univ. of Illinois)

#### purpose

Scientists trying to predict responses of northern landscapes to climatic change need to know the extent to which the distribution of the boreal forest is driven solely by climatic factors or by feedbacks among climate, vegetation, and fire. Palynological records from central Alaska reveal a perfect natural experiment to explore this issue. During the early Holocene, white spruce expanded rapidly into Alaska from northwest Canada, reaching its western limit in central Alaska approximately 9000 years ago. Within 500–1000 years,

spruce populations declined or disappeared across a 1 million-km<sup>2</sup> area. Spruce did not recolonize the region until 2000 years later.

#### approach

An integrated data-model approach will be applied to understand the mechanisms that caused a complex shift in spruce treeline in central Alaska during the early to mid-Holocene.

#### progress

This project is nearing completion and numerous model simulations have been conducted or are planned for the final year of the project. A manuscript describing our conceptual approach was submitted to Mitigation and Adaptation Strategies for Global Change in October 2004. The manuscript will appear in a 2005 special issue resulting from the International Boreal Forest Research Association conference held in Fairbanks in May 2004. Two additional manuscripts are in preparation and will be submitted to peer-reviewed journals in fall 2005.

#### impact

Improved understanding of boreal forest-tundra dynamics in Alaska is important for understanding processes and mechanisms controlling circumpolar ecosystem responses to climate change. The research also provides an example of insights that can be derived from explicitly linking paleo-data and modern ecological modeling. This approach can be used as a template for other northern areas or adapted for more temperate regions.

### **Collaborative research: modeling the role of high-latitude terrestrial ecosystems in the Arctic System: A retrospective analysis of Alaska as a regional system**

A. David McGuire, T. Scott Rupp, David Verbyla (SNRAS); Donald Walker (IAB); Gordon Bonan, Amanda Lynch, James Maslanik, Wanli Wu (Univ. of Colorado); Jerry Mellilo (Marine Biological Laboratory, Woods Hole); Steve Running, John Kimball (Univ. of Montana); Charles Vorosmarty, Richard Lammers, Steve Frohling (Univ. of New Hampshire)

#### purpose

This study analyses the performance of three climate models when applied to Alaska, providing a synthesis mechanism for field-based and modeling research in the Arctic; results will be communicated for directing future research on the Arctic System. State-of-the-art data set development will provide coherent data sets for other researchers. Model evaluation will establish credibility for applications of models to the pan-Arctic in future climate change scenarios.

#### approach

The performance of a regional climate model, an ecosystem modeling framework, and a large-scale hydrological model were evaluated. The focus on Alaska allowed assessment of how well the models close regional water and energy budgets, simulate exchange of CO<sub>2</sub> with the atmosphere, and evaluate linkages between atmosphere, land, and ocean.

#### progress

This study has been completed. Manuscript preparation for a project special issue in Earth Interactions is underway and will be submitted in fall 2005.

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[www.uaf.edu/snras/](http://www.uaf.edu/snras/)

#### impact

Analyses by the Intergovernmental Panel on Climate Change project that the buildup of greenhouse gases in the atmosphere is likely to lead to increases in mean annual temperature of between 1.0 and 3.0 degrees C by 2100, with increases greater at high latitudes. The responses of high-latitude terrestrial ecosystems to global change have important consequences for the Arctic System that are associated with (a) water and energy exchange with the atmosphere, (b) the exchange of radiatively active gases with the atmosphere, and (c) the delivery of fresh water to the Arctic Ocean.

### **Community-based ecological monitoring in arctic Canada and Alaska**

Gary Kofinas

#### purpose

In the face of rapid global change, community-based ecological monitoring emerges as an important strategy for integrating local and science-based knowledge to assist resource users and decision makers on ways to respond to change. The Arctic Borderlands Ecological Knowledge Co-op is a monitoring program focused on the range of the internationally migratory Porcupine Caribou Herd and its near-shore environment. Climate change, industrial development, and contaminants are monitored. Seven communities in Alaska and Canada participate in the program, along with US Fish & Wildlife Service, Environment Canada, the Wildlife Management Advisory Council of the North Slope Yukon, Yukon Renewable Resources Department, and others. The objective of the collaborative monitoring program is to understand what is changing and why (see [www.taiga.net/coop](http://www.taiga.net/coop)).

#### approach

The monitoring program uses annual interviews with active subsistence users in each participating community, using a standard questionnaire developed in collaboration with communities. Interviews document local observations on fish, caribou, weather, berries, and other ecological and social aspects of community homelands. Special attention is given to documenting unusual observations, changes in trends, and local interpretations of changing conditions. The program uses a database of spatially referenced local observations. Science-based indicators of change are posted on the web for public access, and together with local knowledge, serve as the basis for discussions at annual gatherings of agency managers, researchers, resource users, and community leaders.

#### progress

The cooperative serves as an early warning signal of change, providing researchers with insights not available through remotely sensed and plot-based data. Current work is focused on developing links between Alaska's two LTER programs and the co-op's community based monitoring to understand changes in ecosystem services and human responses to those changes, by means of a ten-year trend analysis of local knowledge and science-based indicators, and by building the program to include greater participation of Alaska Native communities.

impact

The co-op serves as a model for nascent-stage community based monitoring programs, and for the National Science Foundation's SEARCH (Study of Environmental Arctic Change) and other International Polar Year observation system initiatives. Several planning and co-management groups of the region are drawing on the co-op's findings to assess land-use alternatives.

### Evaluation of the MODIS vegetation indices in the Arctic Coastal Plain

Matt Macander, Dave Verbyla

purpose

We assessed the utility of two remotely sensed vegetation indices in the Arctic, where clouds, water, snow, or barren ground can be sources of significant remote-sensing error.

approach

We used a higher resolution earth cover map to sample MODIS (Moderate Resolution Imaging Spectrometer) pixels that had a mixture of vegetation, water, and barren ground. We then compared the two MODIS vegetation indices across a gradient of mixed pixels ranging from pure vegetation to pure nonvegetated pixels.

progress

In mixed vegetation/nonvegetation pixels, the MODIS Normalized Difference Vegetation Index performed poorly compared to the MODIS Enhanced Vegetation Index. The Enhanced Vegetation Index had a less variable response to proportion of vegetation within a pixel and was also less sensitive to the type of nonvegetation (water versus barren ground).

impact

Based on spectral mixture modeling, we show that conversion of ice to water could dramatically change values of the Normalized Difference Vegetation Index. For arctic vegetation remote sensing, we recommend using the Enhanced Vegetation Index to minimize this type of problem.

### Fire-mediated changes in the Arctic System: Interactions of changing climate and human activities

F. Stuart Chapin (IAB); III, T. Scott Rupp (SNRAS); A. David McGuire (IAB)

purpose and approach

Increasing fire suppression has changed human-fire interactions from a positive feedback to a negative one, in which people attempt to reduce fire frequency. This change has implications for the climate system at high latitudes, because it could reduce the strength of fire-induced negative feedback to climate warming. The proposed research program will document the changing role of fire, particularly as affected by human activities, on the Arctic-Boreal Climate System and its human residents. To add an understanding of human effects on the fire regime, a regional analysis of past and present human-fire interactions is underway. The analysis of past and current patterns of human-fire interactions will stratify first by country

(US vs. Canada) and then by predominant cultural influence (indigenous communities along rivers vs. western communities along road systems). Regional patterns of variation associated with climate and vegetation will then be assessed.

progress

Modeling scenarios have been assembled looking at the impacts of gold miners on fire regime and are being used to develop a manuscript for submission in fall 2005. Additional scenarios have been assembled for the final year of this project culminating in multiple manuscript submissions.

impact

Research effects will extend well beyond immediate results. This is the first consideration of the overall consequences of human activities on climate feedbacks at high latitudes, including both global warming and local land-cover change induced by changes in fire regime. It will enable us to compare the magnitude of climate feedbacks between arctic and boreal regions and between trace-gas fluxes and water/energy exchange. If, as is hypothesized, enhancing boreal fire is the only large negative feedback to high-latitude warming, this research is the first step in determining whether fire manipulation is a plausible mechanism to reduce the magnitude of high-latitude warming.

### Phenology integrated research and education

Elena B. Sparrow, Michael White (Utah State Univ., Logan, UT), Leslie Gordon (Gordon Consulting, Neskowin, OR)

purpose

The project goal was to support, further develop, and promote the use of existing plant phenology protocols in engaging pre-college students in scientific research and conducting research to 1) determine the impact of climate change on vegetation phenology; 2) determine the patterns of vegetation phenology in observationally underrepresented parts of the world, such as dry areas and semi-arid regions; and 3) compare remote sensing algorithms and processing techniques with phenology data gathered through the Global Learning and Observations to Benefit the Environment (GLOBE) program.

approach

The budburst protocol was added to the plant phenology measurements (protocols) of green-up and green-down that were developed here at SNRAS. Grade K-12 teachers learned and practiced these GLOBE protocols during professional development workshops. They in turn taught their students to use the phenology protocols to collect data for their own studies and for use by others, both scientists and students. These phenology field data are reported and archived on the GLOBE site.

progress

GLOBE students from 84 schools in 12 countries have made over 60,000 phenology measurements at their schools and have reported annual dates for bud burst, green-up, leaf growth, and green-down for selected trees, shrubs, and grasses. Students in Alaska have collected nearly half that data and research to date has focused on the Alaska data. Data analysis is in progress. GLOBE schools in dry areas and semi-arid regions

are being recruited to participate in the study for determining patterns of vegetation phenology.

#### impact

Global plant phenology data resulting from the use of GLOBE standardized ground-based observation methodologies, are currently available to scientists. Elementary, middle and high school students have engaged in plant phenology research as a way of learning science. One sixth-grade female student, mentored by the senior author, conducted a phenology investigation and presented her findings at the 2004 Fairbanks District Science Fair. She won top awards that included a University of Alaska scholarship. In Alaska, the phenology protocols and learning activities continue to be used by teachers and students who participate in different science education programs funded by the National Science Foundation (NSF), such as the Schoolyard Long-Term Ecological Research Project, the Global Change Education Using Western Science and Native Observations Project, the Alaska EPSCoR Rural Research Partnership, and the NSF/NASA-funded Alaska GLOBE program.

### **A reindeer herder's perspective on climate change: A case study**

Kumi Rattenbury (IGERT); Greg Finstad (SNRAS); Knut Kielland (IAB); Bill Schneider (Oral History)

#### purpose

This interdisciplinary study examines how caribou, weather conditions, and climate change affect reindeer herding on the Seward Peninsula, Alaska. Seward Peninsula reindeer herders have lost thousands of reindeer to caribou now wintering in the region. Delayed freeze-up, warm or severe weather events in midwinter, and early breakup conditions may prevent herd access and exacerbate losses.

#### approach

The research focuses on a case study with one herder, including interviews, weather monitoring, and GIS analysis of reindeer and caribou distribution.

#### progress

Weather data for 2004 was collected from stations placed at critical locations on the range where management decisions were made by the herder. Surveys and interviews with the herder were conducted in conjunction with the weather data collection.

#### impact

Integrated research involving local knowledge and observations are crucial for understanding how climate change will affect resource use decisions and in turn, land-based livelihoods.

### **Resilience and Adaptation Program / IGERT**

Gary Kofinas, Terry Chapin, David McGuire (IAB); Glenn Juday, Joshua Greenberg, Scott Rupp (SNRAS); Craig Gerlach (Anthropology), Mark Herrmann (School of Management); other UAF faculty

#### purpose

The University of Alaska Fairbanks offers a graduate training program in Resilience and Adaptation (RAP) to train scholars, policy makers, and managers to address issues of regional

sustainability in an integrated fashion. RAP prepares students to address a major challenge facing humanity: to sustain the desirable features of Earth's ecosystems and society at a time of rapid changes in all of the major forces that shape their structure and functioning. The Resilience and Adaptation Graduate Program is sponsored by the National Science Foundation (NSF) through the Integrated Graduate Education Research Traineeship (IGERT) program. As directed by NSF, IGERT programs are intended to change the culture of graduate education in the United States by encouraging interdisciplinary research by PhD students. This goal is motivated by the belief that questions at the intersection of two or more disciplines are the most critical to the future of our society. The IGERT at UAF meets this objective by focusing on issues of sustainability through the study of social-ecological resilience and adaptation.

#### approach

Students are supported with an IGERT fellowship during their studies, and are expected to integrate social and natural science as a part of their dissertation research. Students take core classes—Regional Sustainability, Adaptive Management, Integrated Modeling of Social and Natural Science, and the Resilience Seminar. All courses are team taught by faculty with expertise in anthropology, natural resource management, ecology, and economics. Students participate in summer internships after their first year of studies to gain experience and insight outside their home disciplines. RAP hosts guest scholars, visiting lecturers, and sponsors special programs that build a community for interdisciplinary enquiry.

#### progress

In 2004–05, 24 graduate students were enrolled in RAP, with 22 at the PhD level. SNRAS has assumed a lead role in RAP through faculty participation and the involvement of interdisciplinary PhD and NRM graduate students. Examples of current research topics of SNRAS graduate students in RAP include:

- Sustainability and the effectiveness of co-management for Alaska marine mammals
- Motivation of businesses that participate in an Alaska green certification program
- Ecological and economic dimensions of Alaska's non-timber forest products
- An integrated assessment of lodgepole pine in Alaska
- Planning for growth of national parks by gateway communities in Alaska

#### impact

2004–05 was the third year of the five-year IGERT grant. It has strengthened inter-departmental cooperation across campus and generated a greater drive to consider sustainability in the Alaska context. Other related programs on campus include the Chancellor's Campus Initiative on Sustainability and new undergraduate courses on sustainability.

## fire-related studies

### **Development of a computer model for management of fuels, human-fire interactions, and wildland fires in the boreal forest of Alaska**

T. Scott Rupp, Daniel Mann, Paul Duffy, Tom Kurkowski (SNRAS); Randi Jandt (BLM Alaska Fire Service); Larry Vanderlinden (US Fish & Wildlife Service); Layne Adams (US Geological Survey Alaska Biological Science Center); Bruce Dale (Alaska Department of Fish & Game)

#### purpose

Interior Alaska contains 140 million burnable acres and the largest national parks and wildlife refuges in the country. On average, wildland fires burn one million acres in interior Alaska each year and threaten the lives, property, and timber resources of Alaska's sparse but growing population. Wildland fires threaten human values, but they also are crucial for the maintenance of forest ecosystems. To better manage wildland fire in Alaska for the mutual benefit of humans and natural ecosystems, we undertook the development of tools for creating fire management plans.

#### approach

Under development is a computer model to assist land managers who design and implement fire-management plans in the boreal forest of interior Alaska. This model will integrate fuel buildup, vegetation, climate, and fire-management policy with real geography over time scales of years, decades, and centuries.

#### progress

MS student Tom Kurkowski graduated in summer 2005 and PhD student Paul Duffy plans to complete his research and graduate in spring 2006. Duffy's first thesis chapter was published in *Ecological Applications*. A manuscript looking at the effects of changing fire regimes on caribou winter grazing habitat was accepted by *Ecological Applications* in December 2004.

#### impact

The model will produce mapped depictions of changes in wildland fuels, fire risk, and vegetation under multiple future scenarios of fire management, climate change, and human development. It will serve as an integrative and adaptive planning tool for land managers designing fire-management plans that can safeguard both human and natural values.

### **Fire in Alaska: A History of Organized Fire Suppression and Management in the Last Frontier**

Susan Todd, Holly Jewkes

#### purpose

This project documents the history of fire management in Alaska, since its inception in the early 1900s through 2004. The manuscript, written for a lay audience, recounts how difficult it was for early firefighters to recognize lightning as a source of ignition and fire as a natural part of the boreal forest ecosystem. It discusses the resourcefulness of fire control agencies in this remote location and the many technological

and organizational innovations they made to meet unique challenges. The document includes summaries of the ecological benefits of fire and data on the number of fires and acreage burned by cause from 1940 to 2004

#### approach

A review of relevant literature and agency archives on fire management was completed. A manuscript for publication as an AFES bulletin on the history of fire fighting and fire management in Alaska was prepared.

#### progress

In 2004 the manuscript summarizing this research was in the final stages of editing and has been submitted for publication in 2005.

#### impact

The Commissioner of the Alaska Department of Natural Resources requested a copy of the fire management manuscript and asked for permission to quote from it at legislative hearings on the 2004 record-breaking fire season. A state senator heard the commissioner's testimony and asked if he and his colleagues could have copies of the report. This indicates that there is interest on the part of politicians and other stakeholders in learning more about the history of fire suppression and management in the state. Much of the archival data included in this report has not been available previously.

### **Fuel load analysis and fire risk assessment for the Municipality of Anchorage**

T. Scott Rupp, David Valentine, Dan Cheyette (SNRAS); Sue Rodman (Anchorage Fire Department)

#### purpose and approach

The objectives of the project are to inventory the fuels present in Anchorage's wildland-urban interface, create custom fuel models that accurately describe the fuels inventoried, model the expected fire behavior were a wildfire to occur in the wildland-urban interface under current forest conditions, and identify fuel conditions that should, according to our model, lessen the extent and/or intensity of the predicted fire.

#### progress

This project has been completed. The fuels inventory was completed and delivered to the Anchorage Fire Department (AFD) in summer 2004. Final custom fuel models were completed and tested and incorporated into AFD's fuel management program. MS student Dan Cheyette defended his thesis in summer 2004 and graduated in spring 2005.

#### impact

Research has demonstrated that fuel management practices will reduce the predicted fire behavior and/or severity. The goal of this research is to model the expected fire behavior in the Anchorage wildland-urban interface and to identify fuel inputs that can be proactively managed so as to minimize Anchorage's risk and exposure to any such fire. This research should immediately benefit Anchorage fire managers, who can use the results for that purpose.

## Landscape fragmentation and forest fuel accumulation: effects of fragment size, age, and climate

William Gould, Grizelle Gonzalez (International Institute of Tropical Forestry, USDA Forest Service); Andrew Hudak (Rocky Mountain Research Station, USDA Forest Service); Teresa N. Hollingsworth, Marilyn Walker (USDA Forest Service BECRU)

purpose

This study examines the fuel load accumulation of forests and how it is affected by fragment size, stand age, and climatic differences.

approach

One hundred twenty transects were visited in interior Alaska, 120 transects in northern Minnesota, 240 in Idaho, and 240 in Puerto Rico. We measured live and dead fuel loads across these transects. Across a subset of the transects, we set up decomposition experiments.

progress

All transects have been visited and data analysis is underway.

impact

This study will shed light on how fragmentation affects fuel accumulation and decomposition across a large climatic gradient.

## forests

### Divergence in growth of trees at treeline

Martin Wilmsking, Glenn Juday (SNRAS); Rosanne D'Arrigo (Columbia Univ.)

purpose

Treeline white spruce in Alaska are generally assumed to increase in growth with warmer temperatures, but we found that many are actually decreasing, and that a change in the relationship of growth to temperature happened in the mid-twentieth century. The purpose of this study was to examine tree-ring growth records widely distributed across the circumpolar north to see whether the divergent responses of both increasing and decreasing growth at treeline following recent warming were widespread.

approach

Individual tree growth records were calibrated to climate for 938 trees at eight sites across the far north. Correlation scores of growth with the best climate predictors were compared between the periods before recent warming (1921–1960) and after warming (1961–2000).

progress

Tree growth at all seven sites that experienced increasing temperatures in the late twentieth century diverged into two distinct populations. One group increased in growth with warmth as before, but one began to decrease in growth after warming or no longer respond predictably to temperatures. This recent, widespread divergence in growth response appears to be unique over at least the past three centuries.

impact

Because recent warmth has reduced the growth of some

trees and increased others, past temperatures will be reconstructed inaccurately from overall site-based chronologies that assume a constant tree growth response to temperature, and overall tree growth in the future under scenarios of climate will be misestimated. Correct values can be obtained if individual tree growth records are examined and selected for a consistent response, rather than averaged for the site without verification of consistency.

### Effects of moisture limitations on forest ecosystem dynamics in interior Alaska: comparison of field studies and modeling results

J. Yarie

purpose

I sought to better understand the role of precipitation distribution in forest growth in interior Alaska. In the field this is currently being studied on both upland and floodplain sites associated with the Bonanza Creek Long Term Ecological Research program

approach

Seasonal covers that will drain rainfall off of experimental plots were constructed in upland and floodplain mid-successional forest types in interior Alaska. The effect of limiting summer rainfall on tree growth is being monitored. The CENTURY ecosystem model is being used to investigate moisture dynamics. Modeling results will be compared with field data.

progress

Based on average yearly tree basal area growth over the past decade, no effects of rainfall elimination were found in upland locations; however, tree growth was significantly reduced in floodplain locations. Modeling studies are completed. Comparisons with field data will be completed in 2005.

impact

Study results will improve understanding of the effect of precipitation distribution on vegetative growth and contributes to improved prediction of climate change effects on forest dynamics.

### Forest Management Community Types

Edmond C. Packee, Sr.

purpose

This is an effort to provide an open-ended system of community types that can be expanded as new information becomes available. A Forest Management Community Type is a landscape description that includes overstory plant community, understory plant community, and soils units. The types are used to help make management decisions. There has been no comprehensive effort to develop these types for Alaska, although local characterizations of some or all of the community characteristics are available for some management units, some local areas, and at some agencies. Each community type describes what is there now and does not by itself imply a potential successional condition (climax or seral). Emphasis is on the forest, so the overstory unit is the forest cover type. Forest cover types developed for North America inadequately describe, the cover types of the Northern Forest of Alaska.

approach

The effort begins with identifying and describing the forest cover types present in the Northern Forest. Using existing Permanent Sample Plots (PSPs), other forest growth and yield plots, and published and unpublished community and soils information, understory communities are identified and described. Data will be entered into a spreadsheet and sorted using the appropriate computer program. Initially, only a catalogue of community types will be produced.

progress

During 2004 the program, with emphasis on forest cover types, was initiated at the verbal request of the Alaska State Forester. Potential forest cover types were identified.

impact

Forest Management Community Types facilitate management decisions. Unit descriptions allow managers to extrapolate the results of management practices from one specific unit to similar units. For example, based on observations during the 2004 fire season in eastern Alaska, it was learned that the white spruce forest cover type on aeolian (sand dune) landforms burned hot and that fireline construction on such units is unlikely to achieve objectives.

### **Growth of Alaska birch**

Glenn Juday, Valerie Barber, Rob Solomon, Kimberley Maher

purpose

Alaska birch (*Betula neoalaskana*) is the dominant tree in about 14 percent of the boreal forest of Alaska. Our previous work found that three out of four sampled stands of productive and commercially valuable birch grew less in warm summers and more in cool summers. The goal of this project was to find out if this response occurred in other stands.

approach

Ring widths from Alaska birch in three additional stands were measured and de-trended to remove the effect of age and geometric bias, and then correlated with monthly temperatures at Fairbanks. The best climate prediction of growth was developed.

progress

Birch ring-widths are difficult to accurately distinguish and measure, but several dozen trees were measured. Growth in two of the three sampled stands was highly negatively correlated to temperature (growth was less in warm summers, greater in cool summers), and was very weakly positive in one stand. Estimates of future growth of birch on these sites, derived from these empirical relationships with past temperature, has been developed for climate scenarios for the twenty-first century.

impact

Twenty-first century climate scenarios for two of the three stands produce climates in which they would not survive, because predicted rates of growth would approach zero. Warming of 3°C over the 1906–2003 recorded data at one site would eliminate birch there. The summer of 2004 experienced more than 1°C warmer temperature than the previous record. Such stands of birch appear not to be sustainable under recent climate trends.

## **Log decomposition in interior Alaska**

J. Yarie

purpose

In natural forest ecosystems, decomposing logs represent a significant input of carbon, organic matter, and nutrients into the forest floor. This study documents the decomposition dynamics of logs within interior Alaska.

approach

A series of logs are being positioned on the forest floor to observe long-term decomposition. Fifteen 4-meter logs are placed on the forest floor in six replicate stands for each major upland and floodplain vegetation type, and will be resampled during the next 100 years. Sampling of the logs that have been in place for 10 years was started in 2004 and will be completed in 2007.

progress

Currently all time zero, two, and five-year samples have been collected. Chemical analysis is continuing on the collected samples and should be completed by the end of 2005. Additional sites that represent floodplain black spruce sites and burned white and black spruce sites in both upland and floodplain locations are being established.

impact

At this time it is not clear what effect coarse woody debris has on the carbon dynamics of the taiga forest in interior Alaska. The results of this study will help to develop a clear picture of log decomposition dynamics on the carbon balance of forests in interior Alaska.

## **Permanent Sample Plots (PSPs) for stand characterization**

Edmond C. Packee, Sr.

purpose

Permanent Sample Plots (PSPs) characterize stand and community species composition, structure (tree height, diameter, cubic-foot volume, basal area, and number per acre), top height of forest canopy and understory shrub species, tree regeneration, tree mortality, cover class of all species, and soils. Remeasurement at five-year intervals monitors change in these characteristics. Stands representative of different age classes, productivity, and communities are selected for PSP establishment so that community dynamics such as tree growth and succession can be applied to similar stand conditions across the landscape.

approach

Three fixed-area, 0.1-acre PSPs are established per site within pure and mixed stands of native species. Present emphasis is on natural stands. Small size and replication allow estimation of stand variability. Data collected at time of establishment and at each remeasurement include landscape information (landform, topographic position, aspect, slope, presence of permafrost, drainage class, thickness of organic horizon, rooting depth, and upper horizon soil texture). Each tree receives a numbered aluminum tag for future remeasurement. For each plot, plant species are identified and cover class is estimated. Tree data collected include species, height, diameter at breast height (4.5

feet), crown position, crown condition, and stem defects; tree regeneration is also assessed.

progress

To date, since inception of the program in 1995, 534 PSPs have been established in groups of three, equaling 178 stands. Five-year remeasurement was completed for 42 PSPs (14 stands) and 10-year remeasurement for 12 PSPs (4 stands). PSP data are included in four MS theses and are providing support for one PhD dissertation. Soil description and sampling to USDA Natural Resources Conservation Service standards were initiated in 2002 in interior Alaska. Seven PSPs (two stands and part of third) were damaged by 2004 fires; these are not lost, but will provide ecological and forest recovery information.

40 impact

PSP data are used to define and characterize vegetation community types, model and predict forest stand succession and growth trajectories, truth satellite imagery interpretations, assess wildlife habitat, and assess forest health conditions. PSPs also provide stand data, including basic inventory data, growth and mortality information, and stand condition data. that are essential for developing forest management plans, timber management plans, and thus, sustainable multiple-use forest management plans.

### **Regional variability and biodiversity of black spruce communities in interior Alaska: linking vegetation, carbon, and fire**

Teresa N. Hollingsworth, Marilyn D. Walker (USDA Forest Service BECRU); F.S. Chapin III (IAB); E.A.G. Schuur (Univ. of Florida)

purpose

This study examines local and regional patterns of variability in plant composition and diversity in black spruce communities in interior Alaska. It assesses the important environmental controls driving the species composition of these communities at both local and regional regional scales and links vegetation composition to soil carbon patterns and patterns of fire history.

approach

Various environmental, stand, and compositional data were collected from 150 black spruce stands that span from the Alaska Range to the Brooks Range. Soil and fire history indices from each site also were collected.

progress

Three theses chapters have been written, two of which are in manuscript form to be submitted.

impact

This study sheds new light on the environmental controls of plant communities that are strongly linked to soil mineral pH on the landscape scale. The study links species composition to soil carbon patterns, and quantifies two fire-history components that are important to current vegetation composition: a ground fire component and a tree fire component. This has implications for vegetation classification, fire and fuel loads management, and carbon sequestration in black spruce forests in interior Alaska.

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[www.uaf.edu/snras/](http://www.uaf.edu/snras/)

### **Relationship of tree growth to environmental and fertility factors for thirty-five years in interior Alaska**

J. Yarie, K. Van Cleve

purpose

Fertilization and thinning studies were initiated in age groups that represented young, middle, and old age classes for major forest types in interior Alaska in the late 1960s. Both climatic and tree growth monitoring of these stands has continued through 2004. These records represent a long-term record of tree growth and climate data from an age sequence of forest stands.

approach

Fertilization and thinning studies started in the late 1960s are annually monitored. to produce a long-term data set related to tree growth and the effects of fertilization and thinning on a number of age classes of the common forest types found in interior Alaska.

progress

Five manuscripts are currently in the final stages of preparation. These papers will detail the 35-year results of eight separate studies and include the 15-year results of the Bonanza Creek Long Term Ecological Research sites.

impact

The completion of the five manuscripts will yield a significant long-term perspective on forest growth dynamics within interior Alaska.

### **Stream temperature response to timber harvest activities in interior Alaska**

John D. Fox, Jr.

purpose

This study looks at summer stream temperature and winter ice thickness regimes in response to changes in riparian vegetation, timber harvest, and ice-bridge construction.

approach

Several simple to complex models are being used to explore the many interacting variables that can influence summer stream temperature and winter ice thickness.

progress

A comprehensive annotated literature review has been compiled on ice thickness and ice bridges. Freeze-thaw models contributed to a general recommendation that water depth be greater than two meters for ice-bridge sites and that upwelling areas be avoided. Literature review, modeling work, and stream water temperature data indicate a strong association between air and water temperatures for mid-sized to large streams and, for small streams exposed to direct solar radiation, a systematic temperature increase longitudinally from headwaters to mouth.

impact

I provided information on sun angles and effective buffer widths to the Science & Technology Committee of the Alaska Department of Natural Resources Division of Forestry for their



review of Region II, southcentral Alaska riparian standards. Techniques and models developed that relate to ice thickness may contribute to assessment of climate change effects on seasonal frost depths, snow depths, and seasonal soil moisture, as well as ice bridge design.

## invasive species and revegetation

### **Ectomycorrhizae on disturbed lands in southcentral and interior Alaska: a comparison of regional similarities and differences**

Dot Helm

purpose

41 Most woody plant species need ectomycorrhizal fungi (fungi that help plants absorb nutrients and moisture from soil and receive carbon as an energy source from plants), that may not be found on nursery or greenhouse transplants used in revegetation. We compare ectomycorrhizal communities in early successional sites across a latitudinal gradient in Alaska to evaluate similarities among ectomycorrhizae for assessing the potential for a common revegetation strategy.

approach

Roots and surrounding soil or soil/litter cores are collected. Morphotypes of root-fungi combinations are described and compared among early successional sites.

progress

In 2004 I collected a few more roots and surrounding soil on the hillside at Exit Glacier. Laboratory analysis is still in progress. Differences to date may be related more to plant species than to latitude.

impact

Successful revegetation using woody species in Alaska usually requires formation of ectomycorrhizae. Inoculation with fungal propagules may facilitate this process, but it is unknown whether soil inoculum characteristics vary across latitudes.

### **Extent of *Melilotus alba* on Alaska's major roads**

Tricia L. Wurtz (USDA Forest Service, BECRU); Blaine Spellman

purpose

We are documenting the distribution of sweetclover, or *Melilotus alba*, along Alaska's road system. The effects of invasive species on native organisms and ecosystems is increasingly recognized as a critical conservation issue. Invasive species may change ecosystems in fundamental ways. *Melilotus* spp. is an invasive species of concern in Alaska.

approach

A strip-plot sampling method is being used at ten-mile intervals and at every river and stream crossing.

progress

Surveys of the Elliott, Dalton, Parks, Glenn, and Richardson highways were completed in 2005.

impact

*Melilotus* is rapidly spreading along roadsides around the state, and has recently been found in Denali National Park and

other lands of high conservation significance. More notably, however, *Melilotus* has aggressively colonized the floodplain of the Stikine River in southeast Alaska, and has recently been found on the floodplains of the Matanuska River in southcentral Alaska and the Nenana River in the Interior. This plant may be invading the floodplains of other Alaska rivers at places where they intersect with roads.

### **Natural regeneration of white spruce**

Glenn Juday, Scott Sink

purpose

This is a long-term study of white spruce that have regenerated naturally following the 1983 Rosie Creek Fire. Data from 2004 are the sixteenth year of measurement in the study. This is the longest and most detailed look at the exact amount of tree regeneration and what conditions are associated with successful natural tree regeneration in boreal Alaska.

approach

All seedling white spruce in a 100m by 100m plot in the Bonanza Creek Experimental Forest LTER, Reserve West plot, were mapped and measured at the end of the 2004 growing season. Growth of a subsample was measured weekly.

progress

Mean height growth of 1983 seed crop seedlings in 2004 (23.9 cm) was substantially greater (23 percent) than the previous year, amounting to the second-greatest height growth in the 21 years since the fire. Heavy precipitation in July 2003 (fourth-highest monthly total in 100 years of record at Fairbanks, wettest July in 100 years of record) did not promote 2003 height growth. Instead, the stored moisture contributed to excellent 2004 white spruce height growth despite the warmest and one of the driest summers in the 100-year Fairbanks record in 2004. For the 1983, 1987, and 1990 seed crops, the number of seedlings taller than 100cm amounted to 84 percent, 41 percent, and 8 percent, respectively, and the mean total height was 224, 94, and 48 cm, respectively. Seedlings taller than 100cm in the early years of regeneration have overtopped shrubs and herbs and have good potential to become part of the canopy if they are not overtopped in turn by hardwood trees.

impact

Data from this study provide the probability statistics that trees will reach specific height benchmarks in a given year, and show the very great advantage of immediate seed crops following forest disturbance. Previous results suggest that the 2005 height growth may be severely reduced because of the heat and dryness of summer 2004 weather. There is not a typical year of seedling height growth that follows a standard curve from year to year; growth is highly variable depending on weather, especially in the critical early years following seedling establishment.

### **New Crops Opportunity: inoculated woody seedlings: a new Alaska crop for Alaska revegetation**

Dot Helm (SNRAS); David Ianson (USDA/ARS)

purpose

The objective is to determine if soil inoculum used by local producers to grow mycorrhizal-inoculated seedlings in the greenhouse must be from the same latitude as the final planting site, as would be the case with seeds.

approach

We collected seeds and soil inoculum from three latitudes, grew seedlings indoors with several inoculum treatments, planted them, and then harvested over two years. Treatments are compared based on plant height and mycorrhizal formation.

progress

The latitude of origin of the soil inoculum did not affect the height growth of the plants in the first two years, but the source of the soil used did affect growth.

impact

Better understanding of latitudinal variation in mycorrhizal inoculum and plant interactions will allow growers to produce a value-added product to compete with large greenhouses outside Alaska that now grow woody plants for Alaska revegetation.

## wildlife studies

### Caribou genetics and management

M.A. Cronin (SNRAS); M.D. MacNeil (USDA); J.C. Patton (Texas A&M Univ.); S. Haskell, W.B. Ballard, R.M. Nielson (Texas Tech Univ.); T.L. McDonald (West, Inc.); L.E. Noel, M. Butcher (Entrix, Inc.); W. Streever (BP Exploration, Inc.)

purpose

This project is an assessment of caribou (*Rangifer tarandus*) demography, including interactions among herds, and an assessment of effects related to oil field development.

approach

To assess herd interactions, genetic variation will be determined. Field work, including observations of caribou distribution and behavior in and around northern Alaska oil fields, has been done to assess potential effects.

progress

During 2004 three manuscripts were prepared and submitted for publication on aspects of our study.

Genetic variation of caribou at 18 microsatellite DNA loci and the cytochrome-b gene of mitochondrial DNA (mtDNA) was quantified in 11 herds of 3 North American subspecies: Alaska barren ground caribou (*R. t. granti*), Canadian barren ground caribou (*R. t. groenlandicus*), and woodland caribou (*R. t. caribou*). Phylogenetic analysis of 1,194 nucleotides of cytochrome-b sequence resulted in a clade of 52 genotypes in *R. t. granti*, *R. t. groenlandicus*, and in one herd of *R. t. caribou*, a subspecies that also showed a clade of 7 genotypes. Between these clades the mtDNA sequence divergence is approximately 1 percent. Within them divergence is 0.3 to 0.6 percent. The subspecies do not have monophyletic mtDNA, but do have different frequencies of mtDNA genotypes.

Microsatellite allele frequencies also are differentiated between the woodland (*R. t. caribou*) and barren ground (*R. t.*

*granti* and *R. t. groenlandicus*) subspecies. An exception is the George River herd in Labrador. Although classified as *R. t. caribou*, it has mtDNA and microsatellite allele frequencies intermediate between the other *R. t. caribou* and *R. t. groenlandicus* herds.

Within subspecies, in four geographically separate areas in Canada, there is relatively low differentiation of microsatellite allele frequencies and mtDNA genotypes among herds of *R. t. groenlandicus*, and relatively high differentiation of microsatellite alleles and mtDNA genotypes among herds of *R. t. caribou*. The extent of differentiation of mtDNA genotype frequencies and microsatellite allele frequencies within and among each subspecies reflects past and present gene flow among herds.

For arctic Alaska, past research has suggested that during the calving period, caribou generally avoid areas within 2 km of oilfield roads with traffic. However, avoidance is not absolute, and caribou may habituate to human activity and infrastructure such as buildings, roads, and well pads. We conducted road-based surveys of caribou in oilfields on Alaska's Arctic Coastal Plain during the late calving and post-calving periods of June 2000–2002. Caribou appeared to habituate to active oilfield infrastructure after the calving period in 2000, during the late-calving period in 2001, and prior to before our sampling period in 2002. Timing of annual rehabilitation was positively correlated with timing of spring snowmelt.

Elevated oil field pipelines may alter caribou movements. Using time-lapse videography, we quantified caribou crossing of the Badami pipeline and habitat use at three river crossings. The results indicate that pipelines elevated >1.5 m above the tundra did not cause changes in caribou habitat use or block movements to and from coastal insect relief habitats.

impact

On Alaska's North Slope, understanding caribou demography is an integral part of the multiple-use management of oil and gas and wildlife. Land and wildlife managers can use this study to develop more effective and flexible calving-period-specific mitigation measures for industry.

### Fish and wildlife endangered species systematics and taxonomy

M.A. Cronin

purpose

Taxonomy is increasingly important as units below the species level (e.g., subspecies and populations) are used for conservation and management. The process of identifying such units is arbitrary and subjective. For naming intra-specific groups, I am attempting to incorporate rigorous definitions of terms and use of appropriate data and analyses.

approach

The best scientific approach is to use all appropriate literature and insist on rigorous objectivity in defining and naming intra-specific groups for conservation and management.

progress

For intra-species groups of animals defined with genetic criteria, many new terms have come into use, including subspecies, evolutionarily significant units, evolutionary units,

management units, metapopulations, distinct population segments, populations, and subpopulations. These terms have redundant meanings and can lead to confusion for biologists, managers, and policy makers. I propose that for wildlife management we can simplify intra-species terminology and use only the terms subspecies, populations, and subpopulations. These three terms have roots in evolutionary and population biology and can incorporate genetic, demographic, and geographic considerations. During 2004 I wrote a draft manuscript, subsequently submitted to the *Wildlife Society Bulletin*.

impact

As the subjective and arbitrary naming of intra-specific groups is recognized and corrected, the spurious nature of many conservation efforts and Endangered Species Act listings will be open to correction with good science.

### Grizzly bear genetics

M.A. Cronin (SNRAS); R. Shideler (Alaska Dept. of Fish & Game); L. Waits (Univ. of Idaho), R.J. Nelson (Univ. of Victoria)

purpose

This project is an assessment of grizzly bear demography in the area of the Alaska North Slope oil fields.

approach

Molecular genetics technology is used to quantify the family relationships of bears, numbers of bears contributing to breeding, and comparison of bears at Prudhoe Bay with bears in adjacent areas.

progress

The lab work and data analysis were completed during 2004. A manuscript was submitted to the journal *Ursus* in 2004, and subsequently published in 2005.

impact

The project provided a good review of the factors influencing the demography of grizzly bears in Prudhoe Bay oil field areas: immigration and emigration, mortality, recruitment, reproductive rates, and access to anthropogenic food.

### Polar bear genetics

M.A. Cronin (SNRAS); S.A. Amstrup (USGS); K. Scribner (Michigan State Univ.)

purpose

This project aims to improve understanding of polar bear demographics.

approach

Molecular genetics is used to assess the level of differentiation of bears in the Beaufort Sea and Chukchi Sea in northern Alaska.

progress

Existing lab data has been analyzed in 2004, and subsequently incorporated into a manuscript submitted in 2005 to the *Canadian Journal of Zoology*.

impact

This study shows the bears in the two study areas are not

genetically differentiated, which may reflect immigration, emigration, or both, that is of importance to wildlife management.

## Natural Resources Use & Allocation fisheries

### Converting Alaska fish byproducts into value added ingredients and products

Peter Bechtel, Cinthia Bower (USDA/ARS)

*Note: This project has several components, all involving the utilization of fish processing byproducts.*

purpose

The total Alaska harvest in 2003 of pollock, cod, and salmon was estimated at 2.1 million metric tons and the fishing industry annually produces over one million metric tons of byproduct and waste. Although this material has potential value as a protein and natural products source, much of it is not utilized. This project seeks to characterize the various fish processing byproducts and existing secondary products and to develop new and higher-valued ingredients for use in animal (agriculture and aquatic) feeds. Greater utilization of this material will also reduce problems of waste disposal.

approach and progress

**Livestock Feed and Pet Diet studies:** Research conducted with Drs. McKeith, Ellis, and Fahey of the University of Illinois is titled "Nutritional value of fish oil on reproductive performance in gilts and sows and effects of fish protein hydrolysates on immune indices in geriatric dog" (SCA 5341-31410-002-06S). One use of proteins and peptides from fish processing byproducts is as feed ingredients for early weaning pigs. The initial study indicated that young pigs fed the spray-dried animal plasma grew faster; however, dietary treatment had no effect on gain:feed ratio, suggesting that most of the reduction in overall growth rate with some fish-meal-based diets resulted from reduced feed intake rather than any reduced efficiency of nutrient utilization. A digestibility study and a growth performance study were included in a second trial, using different levels of the best performing hydrolysate ingredients. This trial was stopped after a number of the animals became ill. A subsequent trial has progressed as planned and will be completed in September 2006. Other trials involving the use of salmon oil were designed to determine the effect of fish oil on reproductive performance postweaning and its components in gilts and subsequent growth of piglets after birth through weaning. Data will be analyzed when trials are completed.

Dr. Fahey at the University of Illinois is also exploring the uses of the fish byproducts in pet diets. A broad range ingredients made from fish processing byproducts were evaluated as part of an MS thesis by Juliana Folador. From Folador's work, a trial was initiated using selected ingredients (fish meal, milt meal, and pink salmon hydrolysate) in a high-quality dog diet to evaluate how they affect tract nutrient digestibilities and immune indices. The trial, using senior dogs at the University of Illinois companion animal facilities, will be completed in September 2006 and the data analyzed.

**Protein and Oil Component:** This research was conducted with Drs. Sathivel and Oliveira of the UAF Fishery Industrial Technology Center. [Properties of Protein Hydrolysates and lipids extracted from fish processing byproducts (SCA 5341-31410-002-07S)] Although fish byproducts are rich in proteins and oils that could be used as food and feed ingredients and in industrial applications, much of this material is not utilized.

1. *Sterol compounds.* Cholesterol levels in the muscle of many fish species are known, but data on other sterol compounds is limited. Depending on the species, high levels of lipid are found in the head and liver. There is little data on the content of sterols in fish processing byproducts, and the sterols fraction from most cold-water fish byproducts has not been characterized. For this study, five replicate samples of liver were obtained from pollock, cod, rock fish and flat fish, arrowtooth flounder, black cod, dog fish, and heads from these species. Pink, red, and chum salmon samples also were collected. All tissue samples are analyzed in duplicate for protein, ash, moisture, and lipid content. Most of the several available methods for determining sterols in seafood are not readily applicable to modern gas chromatographic conditions. For this research, a modification of the Kovacs method was developed and standardized. Data is being analyzed for presentation and publication in 2006.

2. *Modified fish byproduct proteins.* Protein from fish processing byproducts can be modified by enzymatic hydrolysis to improve their quality and functional characteristics. Utilizing proteolytic enzymes, fish protein hydrolysates can be prepared with the peptides having new and/or improved properties. Antioxidant properties of fish protein hydrolysates produced from herring byproducts have been reported; however, information is needed on these properties for pollock and salmon byproducts, and on optimization of antioxidant activity, and application of these hydrolysates in reducing oxidation of fish products. The three tissues chosen for this study (pollock trim, pollock skin, and salmon heads) were collected and hydrolyzed. Soluble aqueous fractions were obtained after centrifugation and are being further fractionated using a membrane filtration unit with a 10,000 MW membrane cutoff. The three fractions (total soluble fraction and the two fractions separated by the 10,000 MW membrane) are being freeze dried and their physical and chemical properties determined, including antioxidant properties, solubility, emulsifying capacity, emulsifying stability, fat adsorption capacity, water holding capacity, color, water activity, bulk density, molecular weight, proximate, amino acid, and mineral compositions. This component of the study will be completed in September 2006. The antioxidant properties of a selected sample will then be further analyzed when added to salmon mince in a storage stability study.

3. *Protein extraction.* Although protein from fish byproducts is utilized to make fish meal or discarded in Alaska, the potential exists to extract protein having superior physical properties and a higher market value. (a) Reports describing a new method of extracting protein with excellent physical properties from fish muscle have appeared in the literature. The method solubilizes protein using high pH followed by isoelectric pre-

cipitation of the protein. A study was initiated to evaluate this method for protein extraction from Alaska fish byproducts. It was used to extract protein from pollock heads, whole fish, viscera, and frames and from pink salmon heads and viscera collected from commercial processing lines. The byproducts were frozen until the protein was solubilized at pH 11. The insoluble protein fraction was separated from the soluble protein fraction, which was then precipitated at pH 5.5. The precipitated soluble protein was freeze dried, then yields were determined and samples analyzed for proximate composition, mineral and amino acid contents, lipid oxidation, FAMES, solubility, emulsion stability and fat adsorption properties, and SDS-PAGE electrophoresis. Protein powders with good functional characteristics and nutritional characteristics were made from pollock head and frame and salmon heads. These soluble protein powders have potential uses as food and feed ingredients.

(b) This study evaluated protein extraction at high pH followed by isoelectric precipitation. This method was used to extract protein from pollock heads, whole fish, viscera, and frames, and pink salmon heads and viscera collected from commercial processing lines. Protein powders with good functional characteristics and nutritional characteristics were made from pollock head and frame and salmon heads. These soluble protein powders have potential uses as food and feed ingredients.

4. *Enhancing soy-based fish diets.* Pollock viscera and salmon gonad meal contain biologically-active, non-nutrient components that stimulate growth of trout fed diets based on soybean meal. Generally soy-based diets do not result in growth performance equal to diets based on fish meal. This research seeks to enhance the performance of soy-based diets by adding meals made from selected fish byproduct components. The study was a trout feeding trial in which meals made from different byproducts, including salmon gonad and pollock viscera, were used with a soy protein diet. The study validated the project goal of developing high-value feed additives from seafood processing waste, although further work to refine and characterize the products is needed.

5. *Milt meal.* Meals made from milt have often been referred to as spawn powder. Large volumes of milt are available in Alaska from pollock and salmon processing, most of which is utilized in the production of fish meal or discarded. Development of an industrial scale extraction method for the production of high-quality milt meal from both pollock and salmon was developed. The products of the new extraction method have been characterized. Salmon milt meal contains biologically active components that stimulate growth of salmonids fed diets based on soybean meal. Because of its relatively high concentrations of nucleic acids and other components, there are a number of potential uses for this meal.

6. *Fish skin.* Fish skins from the Alaska fish processing industry are not used currently to make gelatin, in part because gelatins from cold water fish skin are liquid at room temperature. Gelatin was extracted from Alaska pollock and pink salmon for potential use in biomedical applications, such as bioadhesives and microspheres for drug delivery. Gelatins were cross-linked using glutaraldehyde and genipin, a gardenia ex-

tract. The cross-linking reaction was evaluated using dynamic rheology. Glutaraldehyde proved to be a more effective cross-linker for pollock gelatin than genipin. After five days of cross-linking, porcine gelatin had much higher gel strengths than pollock gelatin. This study indicated the potential of modifying the properties of cold water fish gelatins to enhance their utilization.

7. *Salmon liver meal.* Salmon livers have both relatively high lipid content and, in the case of female salmon, relatively high concentrations of vitellogenin, a lipoprotein, and cholesterol. In Alaska, salmon livers and other viscera are not utilized in the production of human food and are often discarded. An industrial scale method was developed for processing these livers into meals, which were then characterized. These meals had high cholesterol concentrations that will be helpful in dietary formulations for shrimp and possibly as a feed augmentation ingredient for younger fish.

8. *Alaska pollock and salmon oils in shrimp diets.* Because standard fish oil sources are projected not to meet increasing demand, identification of alternatives can have significant commercial importance. An eight-week feeding trial indicated that pollock and salmon oils can replace menhaden oil in shrimp diets. Three shrimp growth diets were manufactured incorporating each of these oils in complete replacement of menhaden oil, which served as a control. After eight weeks, shrimp fed the control and experimental diets exhibited similar excellent growth, feed efficiency, and survival. This finding will be useful to aquaculture feed manufacturers who are looking for high-quality replacements for standard sources of fish oil.

9. *Attractant properties of hydrolysates from Alaska byproduct for shrimp.* Protein hydrolysate meals made from byproducts of the Alaska fishing industry exhibited positive attractant properties in diets for shrimp. A series of diets containing the prepared protein hydrolysate ingredients were formulated in a bland diet made from soybean meal; wheat was used as a control. For all hydrolysates except one, the shrimp's voluntary consumption rates were significantly higher than the control. For most of the hydrolysates, the consumption rate was similar to that of menhaden fishmeal used in shrimp feeds. This finding is useful to feed manufacturers who are looking for alternatives to traditional sources of fish meal.

10. *Attractant properties of fish stickwater fractions for rainbow trout.* Stickwater derived from processing fish byproducts into fish meal contains all the soluble small molecules derived from the heads, viscera, flesh and skeletons of processed fish and may function as a palatability enhancer and an attractant in fish diets. Methodologies were developed for drying stickwaters that could potentially be scaled to an industrial level. Stickwater fractions were tested as additives to high soybean-meal diets for rainbow trout that are known to lower feed intake by reducing feed palatability. None of the stickwater fractions improved feed intake or fish growth, in contrast to findings with fish hydrolysates.

11. *Fish skin films from cold-water fish gelatins.* Currently in Alaska fish skins are either used to make fish meal or discarded. This study was designed to evaluate unique permeability

and tensile properties of films with potential food applications made from cold-water fish gelatins. Also evaluated was the feasibility of using ultrasound to extract gelatin from dried pollock skins.

This study identified unique permeability properties of the fish gelatin films with potential application to food products and it furthered the development of technologies to increase the yield of gelatin from dried skins.

12. *Other commercial species.* We have evaluated the chemical and nutritional properties of byproducts including heads, frames, viscera and skin from some of the major species of fish harvested in Alaska; however little known about the properties of byproducts from other species that are commercially harvested. In this study we evaluated the properties of the oils and protein for black cod heads and frames and pacific ocean perch byproducts. The oil extracted from black cod byproducts was unique when compared to most other cold water fish and contained lower levels of polyunsaturated fatty acids. The protein from the byproducts of these two species was of high quality. This study identified unique properties of oil rendered for black cod byproducts.

#### impact

Large land-based fish processors currently convert most waste and byproduct into low-value, high-ash meal. Meal production is considered a cost of doing business and has not yet become recognized as a significant revenue source. Information gained from the above studies may lead to greater utilization of fish byproducts and increased revenues. Also, much of the waste from smaller processors is disposed using the grind and dump method. Regulatory changes, including those requiring 100 percent utilization of cod and pollock, make the development of best-use end products urgent.

### Regional economic impact assessment of the Alaska snow crab fishery

Joshua Greenberg, Hans Geier (SNRAS); Mark Herrmann, Charles Hamel (SOM)

#### purpose

This impact assesment estimates the economic effect of the Alaska snow crab fleet on communities in Alaska and Washington, and informs fishery managers of potential economic impacts associated with changes in snow crab fishery policy.

#### approach

An input-output model of the snow crab harvesting sector was constructed for Alaska and Washington communities using IMPLAN. This model was then linked to an international supply and demand equilibrium model for Alaska and Canada snow crab, which was estimated using the three-stage least squares (3SLS) econometric method.

#### progress

We completed the project in 2004. Despite severe data limitations, our regional models present the single best source to date for the linkages between opilio harvesting and other industries present in Kodiak, Unalaska/Dutch Harbor, Seattle, and St. Paul. The estimated combined effects of a doubling of

2002 snow crab harvests resulted in \$34,360,282 in economic activity spread throughout Kodiak, Unalaska, King County, and St. Paul.

impact

The constructed models should be beneficial to future analyses of how post-ITQ management changes affect Alaska communities and the Alaska sector of the industry. While it is evident that difficulties in obtaining data have compromised the level of confidence that can be placed on the accuracy of our predicted harvesting impacts, it is nonetheless satisfying that the results behave reasonably and that in the absence of economic information pertaining to Alaska's crab fisheries, the approach presented in this study, if taken cautiously, can be useful until the same or similar framework is furnished with a more robust data set.

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## forests and trees

### Alaska birch sap properties

Kimberley Maher, Glenn Juday, John Fox (SNRAS); Jan Dawe (Alaska Boreal Forest Council)

purpose

This study assessed volume, timing, chemistry, sugar concentrations, and components of sap from Alaska birch to help producers understand and market their product.

approach

Alaska birch sap was analyzed for carbohydrates using high performance liquid chromatography (HPLC) and Monosaccharide and Disaccharide Analysis. Ion content was determined using a Thermo Elemental IRIS direct current plasma (DCP) spectrometer.

progress

The sugars in birch sap at the end of the season are primarily glucose and fructose, which have much lower melting points than sucrose, which makes the sap more susceptible to scorching during the syruping process. As a result, sap from the early portion of the *Betula neoalaskana* sap season, with a relatively high sucrose content, is less prone to scorching than sap from the end of the season, when virtually no sucrose is present.

impact

If harvested sap is used to manufacture multiple commercial products, including birch syrup and bottled birch tonic, sap from the beginning portion of the sap season with its higher sucrose content is better suited for syrup production; sap from the latter portion of the sap season with its higher cation content is better suited for commercial tonic production.

### Birch bark use in Alaska

Edmond C. Packee, Sr.

purpose

People of the circumboreal north historically used birch bark to make baskets, plates, and pails. Current emphasis is on the production of items for sale to tourists as art objects. More lucrative is the use of the bark as a supply of pharmaceuticals.

The purpose of this project has shifted to bark as a source of phytochemicals, especially, but not exclusively, to pharmaceuticals and health care products.

approach

The project is a cooperative effort with the University of Minnesota Duluth (UMD) Natural Resources Research Institute. Bark samples previously provided to the UMD were analyzed with specific emphasis on betulin and betulinic acid content. In 2004, more bark samples (5 sites in each of 3 regions—Kenai, Matanuska-Susitna Valley, Tanana Valley) were provided to UMD for future analyses.

progress

Bark chemical content of the first set of samples submitted to UMD indicate that three species of tree birch occur in the Northern Forest of Alaska: *Betula kenaica*, *B. neoalaskana*, and an unknown. Quantity of betulin and betulinic acid are higher in the Alaska samples than in eastern North American paper birch. The extraction techniques had to be modified for the Alaska birches. Taxonomic literature reports four tree species of birch in Alaska: *Betula papyrifera* only in Southeast Alaska; *B. neoalaskana* on the northern portion of the Kenai Peninsula and dominant throughout the rest of northern and southcentral Alaska; *B. kenaica* dominant on the southern two-thirds of the Kenai Peninsula and scattered throughout the rest of Alaska; and *B. occidentalis* found locally in northern and southcentral Alaska. A review of the taxonomic literature on the species of tree and shrub birch in Alaska was presented as an article in *Agroborealis*.

impact

Careful peeling of the bark does not scar the tree permanently, create serious disease or insect mortality, nor direct mortality; the remaining brown bark, after an unknown number of years, sloughs off revealing once again the white, peelable bark. The amounts of betulin and betulinic acid are of commercial quantity and greater than that found in Midwestern (Minnesota-Wisconsin) birch, which is marginally commercial.

### Black spruce growth and yield

Edmond C. Packee, Sr., Carolyn Rosner

purpose

Small black spruce has potential as a raw material for phytochemicals (high-value pharmaceuticals and ethanol). We are developing individual tree and stand volume tables, growth equations, and a community type classification.

approach

Stand productivity equations and individual tree volume data collection include total and breast-height age, stump height age, tree height, stand volume, and community characteristics. Trees for site index and individual tree volume are measured every four feet from a six-inch stump. Tree volume data will be used for wood volume, bark "volume," taper, cambial area, and stem biomass equations. Regression is used to develop the equations. (See reports on Permanent Sample Plots (PSPs) and Northern Forest Productivity.) This study is a natural resources management MS thesis effort.

progress

A natural resources management MS thesis was completed in August 2004. Volume equations based on 885 trees were finalized. For site index (a measure of potential productivity) two distinct types of stands, upland and lowland, were identified. A paper for publication addressing polymorphic site index equations is in preparation and data for 20 stands selected for PSPs (60 PSPs) have been entered into the PSP compendium.

impact

Site index curves are used to measure productive capability of sites. Volume tables are essential for calculating allowable harvests and biomass. Years-to-breast-height is essential for determining rotation ages.

## 47 Early height growth of white spruce

Edmond C. Packee, Sr.

purpose

How many years does it take white spruce to reach breast height (4.5 feet) in Alaska? Is early height growth affected by distance between trees or overstory competition? Objectives are to determine years required for planted, open-grown, and understory trees to reach breast height; tree height at 20 years; and effect of overstory competition on seedling and sapling height growth.

approach

For free-to-grow-white spruce, Levels-of-Growing Stock (LOGS) plantations with five spacings (distance between trees) were established at Bonanza Creek (west of Fairbanks) and Red Fox (Tok); overstory competition is removed regularly. Height growth is measured annually through age 20, thereafter at five-year intervals. LOGS research heights were compared to operational plantation heights. To determine the impact of overstory competition, we measured the height of 25 trees in a stand for three conditions in eight white spruce plantations six to ten years old. The three conditions under which the trees grew were: a) free-to-grow, b) aspen overstory, and c) birch overstory.

progress

Senior thesis data addressing the impact of overstory competition on height growth involving 600 trees and LOGS study data were reviewed for potential publication as a paper. Additional data from other Alaska studies are being sought. Paper birch and aspen affect white spruce height growth about equally, reducing it about 25 percent.

impact

Data improves the ability to predict the age at which planted white spruce reach breast height and free-to-grow status. The data will improve modeling of early growth trajectories for yield forecasts and response to ecological changes.

## The ecology of post-fire morel mushrooms

Tricia L. Wurtz (USDA Forest Service, BECRU); Jane Smith (USDA Forest Service); Nancy Weber, Dave Pilz (Oregon State University); Richard Winder (Pacific Forestry Centre)

purpose

We are documenting the morel mushroom productivity of burned sites in interior Alaska.

.....  
[www.uaf.edu/snras/](http://www.uaf.edu/snras/)

approach

Pilz et al. developed a strip-plot sampling method.

progress

We documented the morel productivity of the Boundary Fire in 2004.

impact

Widespread commercial harvesting of edible mushrooms began in the (US) Pacific Northwest about 15 years ago. In 1992, approximately 1.8 million kg of wild mushrooms were sold there, with 590,000 kg of that being morels. Experts in the commercial harvest of nontimber forest products predict that trade in such products from Alaska forests will increase substantially in the coming years. Forest managers need basic information about these products in order to properly manage this forest use.

## Espacement effect on early diameter of white spruce stems

Edmond C. Packee, Sr.

purpose

Growing space and age affect diameter growth of trees. The effect of espacement, distance between planted seedlings, on early diameter growth of white spruce is not well documented.

approach

Two Levels-of-Growing-Stock plantations, established May 1986 west of Fairbanks with five spacings, were measured beginning in spring 2001 to obtain fifteen-year breast-height diameters. Regression analysis is used to determine if statistically significant differences occur between the two plantations and between spacings.

progress

Annual remeasurements were made in 2002, 2003, and 2004. Regression analysis on the first measurement demonstrated that significant differences exist between the two plantations; the warmer, drier, southerly slope had smaller diameters (mean diameter range: 22-37 mm) than the cooler, moister, easterly slope (mean diameter range: 35-55 mm).

impact

Knowing diameter-espacement relationships addresses economics (planting costs), early wood quality (e.g., juvenile wood, knot size), and early growth (essential for forest stand prediction models)—information essential for forest management.

## Gall aphids on Alaska white spruce

Edmond C. Packee, Sr.

purpose

Gall-forming aphids, not true aphids, on planted white spruce can be a serious forest health and landscape problem because they stunt growth, curl twigs, delay budburst, and cause small, brown abnormalities on branches. We are seeking to identify the causal agent(s) and determine infestation levels as related to espacement and overstory shading in interior Alaska.

approach

Two Levels-of-Growing-Stock plantations with five spacings at Bonanza Creek west of Fairbanks were used. Each

sample tree was divided into a lower and upper crown section (below and above breast height, respectively) and assigned an infestation level. Infestation levels for the 8x8-foot espacement were compared with those on trees planted at the same time with overstory shade. Analysis of Variance and “t” test were used to analyze data.

#### progress

Galls were noted at the Red Fox (Tok) Levels-of-Growing-Stock plantations. Based on empty galls from Bonanza Creek, a specialist identified the causal agent as either *Pineus similis* Gill. or *Adelges abietis* L. Aphid activity in 2003 and 2004 was essentially nonexistent at both locations. Aphid activity will again be checked in 2005.

## 48 impact

Results may influence nursery practices, seedling treatment, or planted seedling espacement.

### Individual tree volume equations

Edmond C. Packee, Sr., Thomas Malone

#### purpose

Accurate individual tree volume equations are essential for marketing forest fiber; the importance of accurate equations for ecological uses is often overlooked. Tree volume equations can be used for determining biomass, carbon sequestration, and biodiversity functions and processes. For Northern Forest species, existing equations are questionable; no equations exist for black spruce, tamarack, or balsam poplar. Our goal is to develop new, single-stem, cubic-foot volume equations to replace existing equations for the major commercial species (white spruce, paper birch, aspen).

#### approach

We measure felled-tree diameters at four-foot intervals, calculate volumes for individual sections and then the tree, and use regression to develop single-stem individual tree volume, bark thickness, taper, and cambial area equations. For their MS theses, Tom Malone is using the white spruce, paper birch, and aspen equations, and Carolyn Rosner used black spruce equations.

#### progress

A literature review continues. Data sets to date include: 2,024 white spruce, 1,050 black spruce, 136 aspen, 274 birch, >250 balsam poplar/black cottonwood. Draft white spruce and black spruce equations have been developed. Before proceeding further, testing white spruce volume and bark equations for accuracy and regional differences will be initiated; additional bark thickness data are needed and will be obtained during the first half of 2005.

#### impact

Improved equations will contribute to improved management practices, including growth and yield forecasts, forest fiber product sales, ecological modeling, and wildlife habitat manipulation.

### Levels-of-Growing-Stock (LOGS) studies

Edmond C. Packee, Sr.

#### purpose

Levels-of-Growing-Stock plantations are designed to determine the effect of initial espacement (distance between planted seedlings) or spacing (pre-commercial thinning) on crop tree growth (diameter, height, branch size, natural pruning, and wood quality). Initial emphasis has been on espacement because it affects plantation establishment costs and can provide spacing targets.

#### approach

LOGS plantations were established at Bonanza Creek near Fairbanks in May 1986 (white spruce and tamarack—the latter was abandoned because of insect-caused mortality) and at Red Fox (Tok) in August 1992 (white spruce, black spruce, tamarack, lodgepole pine). Espacements are 4x4, 6x6, 8x8, 10x10, and 12x12 feet. Plots (0.1 acre) are remeasured annually for the first 20 or 25 years.

#### progress

The Bonanza Creek white spruce and the Red Fox LOGS plantations were cleaned and remeasured for height (18-yr and 12-yr, respectively); diameter was remeasured at Bonanza Creek. Tamarack mortality occurs in groups and appears to be related to soil characteristics.

#### impact

Information from LOGS plantations will help resource managers optimize operational planting costs and reduce stand maintenance costs, and will provide early growth information essential to stand management and ecological studies.

### Managing forests to market carbon credits: How does fire fit?

Evan Kane, David Valentine, Tim Quintal

#### purpose

It is not yet clear whether fire suppression may diminish or enhance carbon storage in boreal forest soils. A crucial first step in managing for increased carbon sequestration is to determine the lasting effect of fire cycle variations on soil carbon accumulation. This study seeks to assess the historic relationship between fire frequency and soil carbon storage. It will analyze forest soil carbon contents in areas adjacent to lakes in which fire histories have already been determined through carbon-14 dating of charcoal found in sediment cores. Fire suppression in boreal forests would only be indicated if there is a substantially negative relationship between historic fire frequency and carbon accumulation rates.

#### approach

To determine the implications of fire as a source of carbon to slowly turned over pools, burn residues (black carbon) will be quantified in the surface mineral soil. Mineral soil contains the products of past fires, at different landscape positions that exhibit high, medium, and low stand productivity levels (i.e., probabilities of burning severely). These sites consist of twelve black spruce stands along four replicate gradients in climate and stand production across interior Alaska. Organic matter



fractions and charcoal macrofossils have been quantified along the gradients, and changes in their composition (such as hydrogen to carbon, oxygen to carbon, and  $\delta^{13}C$ , the relative content of a rare heavy isotope of carbon) have been used to shed light on the degree of black carbon incorporation into bulk soils and density separates.

progress

The relative vulnerability of different kinds of organic matter to microbial attack is difficult to assess. Dividing the soil organic carbon into categories based on their densities (mass per volume) using a very dense liquid (sodium polytungstate) is one approach to doing this that has worked fairly well: the dense fraction typically decomposes more slowly than the light fraction. However, this is complicated by the fact that charcoal, known to be very hard for microbes to attack, breaks the rule: it is relatively light, and winds up in the light fraction. Thus we are developing and testing ways of determining the charcoal content explicitly, which will then allow us to compare soil carbon fractions (including charcoal) with fire frequencies already derived from analyses of nearby lake sediments.

Since char material is significantly less hydrated and oxidized than other soil organic matter (SOM) fractions, these ratios may indicate the relative degree of char incorporation into discrete soil fractions. Warmer, more productive black spruce stands contained light fraction SOM that was less hydrated and less oxidized than did cooler, low-productivity stands. This may indicate that warmer and more productive stands harbor more black carbon. Future steps include a wet chemical procedure and a thermal oxidation treatment to quantify black carbon (as defined by Kuhlbusch) in bulk soils along the climate and productivity gradients.

impact

One of the few options available to manage black spruce forests of interior Alaska for carbon emissions trading is through some form of fire management. However, it is not yet known how charcoal accumulation varies with stand production or landscape position. Also unknown is the net impact of fire on carbon stabilization via charcoal production. When completed, this project will provide evidence about how long-term fire history (assessed via lake coring) compares with both carbon accumulation and the proportion of carbon in the form of char material. This information would help provide a sound basis upon which to make decisions concerning fire suppression. If the long-term storage of carbon in charcoal at least partially offsets releases during and following burning, then managers would have some justification for maintaining wildfire in forests for other values.

**Phytochemicals from the Northern Forest**

Edmond C. Packee, Sr.

purpose

Alaska's Northern Forest consists of high-value fiber, but much is in small-sized trees having little traditional value. Phytochemicals, chemicals derived from the forest, have potential high value as pharmaceuticals, human food components, industrial chemicals, and biofuels. The objective of this study is

to determine potential (type, quality, and quantity) of chemicals contained in Northern Forest species, extractive processes, and potential markets.

approach

The effort primarily involves review of the literature and contact with various scientists and entrepreneurs. The Alaska Northern Forest Cooperative workshop in fall 2004 addressed, in part, phytochemicals from birch. The planned workshop for 2005 will address forest chemicals and biomass energy.

progress

Tree components (bark, wood, foliage, reproductive tissue) have different chemical properties. Species, genetic, and environmental differences mandate qualitative and quantitative analyses of Alaska materials.

impact

The extent of uncommitted forest biomass available for phytochemicals is unknown. Preliminary evidence suggests that Alaska should seek funding for needed research and develop partnerships with private and public phytochemical organizations. Because of the high value of such phytochemicals as betulin and betulinic acid from birch bark and antioxidants from spruce, ethanol for energy might be reduced to a byproduct status and be produced at low cost.

**Potential suitability of lodgepole pine in interior Alaska**

Alina Cushing, Glenn Juday (SNRAS); John Alden

purpose

Lodgepole pine has been introduced into interior Alaska on small research plots, to southcentral Alaska as a small-scale reforestation species, and in operational afforestation and reforestation in Iceland and northern Sweden, respectively. This study evaluates past growth of lodgepole pine in Alaska and potential future growth in all three regions under climate change scenarios.

approach

Height and dbh measurements were taken at seven plantations in interior Alaska in the summers of 2003 and 2004 and added to an existing database of past measurements. Growth of the best performing lodgepole pine provenances over a twenty-year period was compared with that of two stands of native white spruce; one planted in a species trial together with lodgepole pine and other nonindigenous tree species, and the other naturally seeded after the Rosie Creek fire of 1983 near Fairbanks. The response of lodgepole pine to climate change in three high-latitude regions was predicted using tree-ring analyses. Cores were obtained from lodgepole pine trees at five sites in Alaska, six sites in Iceland, and two sites in Sweden. Climate change scenarios from five global circulation models were used.

progress

At twenty years of age, lodgepole pine had achieved greater height (24–61 percent), diameter (37–70 percent), and volume (66–95 percent) than white spruce. Lodgepole pine shows either a slightly negative response (reduced growth) or slightly to greatly positive response (increased growth) to climate warming in all three regions.

impact

Lodgepole pine clearly outperforms native white spruce in the juvenile stages of growth. Lodgepole pine appears well adapted to the present and modeled future environments of interior Alaska, Iceland, and northern Sweden, although global change variables other than temperature are not considered in this study, nor were risk factors such as disease and maladaptation to infrequent events.

### Site index of birch in Alaska

Edmond C. Packee, Sr., John D. Shaw

purpose

Site index is the major tool for quantifying forest stand productivity and provides access to other mensurational stand tables. Published site index curves for birch in Alaska are anamorphic and not well-suited for modeling. The objective is to develop new polymorphic site index equations and curves for birch (*Betula neoalaskana* and *B. kenaica*) with a standard breast height index age of 50 years.

approach

Standardized stem analysis procedures are used: age at stump and then at 4-foot intervals to top 4-foot section and then the top section; age, total diameter, and annual incremental radius were measured for each cross-section. Regression is used to develop equations and curves. Fifty-four stands from throughout Alaska) were previously sampled for a total of approximately 266 trees.

progress

Equations are distinctly polymorphic. During 2004, work on a draft paper for publication continued; initial curves from the MS thesis of co-author Mike Hoyt (deceased) are being reworked; final paper for submission expected in 2006.

impact

New curves will better define birch productivity on various sites. The index will improve stand treatment prescriptions, financial decisions, stand structure and growth predictions over time, and productivity correlations with environmental factors such as soils.

### Site index of black spruce in Alaska

Carolyn Rosner, Edmond C. Packee, Sr., John D. Shaw

purpose

Site index is the major tool for quantifying forest stand productivity and provides access to other mensurational stand tables. No site index curves existed for black spruce in Alaska; white spruce curves are used as a surrogate. The objective is to develop polymorphic site index equations and curves for black spruce with a standard breast height index age of 50 years.

approach

Standardized stem analysis procedures are used: age at stump and then at 4-foot intervals to top 4-foot section and then the top section; age, total diameter, and annual incremental radius were measured for each cross-section. Regression is used to develop equations and curves. Fifty-eight stands (33 interior and 25 southcentral) from Alaska were previously sampled for a total of 229 usable trees. Soil description and

sampling to USDA Natural Resources Conservation Service standards were initiated in 2002 in interior Alaska.

progress

Carolyn Rosner completed her MS thesis in August 2004. Final equations are distinctly polymorphic. Submission of a paper for publication expected in early 2006. Soil description analyses are the basis for Noreen Zaman's MS thesis, expected in fall 2005.

impact

Black spruce curves for Alaska are a vast improvement over the use of surrogate white spruce curves and will better define black spruce productivity on various sites in Alaska. Curves will improve stand treatment prescriptions, financial decisions, stand structure and growth predictions over time, and productivity correlations with environmental factors such as soils. Efforts to date show that black spruce in Alaska is not a wetland species but occurs on all landforms or site types, from poorly drained to well-drained and with or without permafrost.

### Site index of trembling aspen in Alaska

Edmond C. Packee, Sr., John D. Shaw

purpose

Site index is the major tool for quantifying forest stand productivity and provides access to other mensurational stand tables. Published site index curves for aspen in Alaska are anamorphic and not well suited for modeling. The objective is to develop new polymorphic site index equations and curves for aspen with a standard breast height index age of fifty years.

approach

Standardized stem analysis procedures are used: age at stump and then at 4-foot intervals to top 4-foot section and then the top section; age, total diameter, and annual incremental radius were measured for each cross-section. Regression is used to develop equations and curves. Sixty stands (39 interior and 21 southcentral) were previously sampled for a total of 244 trees.

progress

Equations are distinctly polymorphic. A paper drafted in 2003 is being revised for regional journal submission in 2005. Soil description and sampling to USDA Natural Resources Conservation Service standards was initiated in 2003 and continued in 2004.

impact

New curves will better define aspen productivity on various sites. It will improve stand treatment prescriptions, financial decisions, stand structure and growth predictions over time, and productivity correlations with environmental factors such as soils.

### Stand Density Indices (SDIs) for Alaska's Northern Forest

John D. Shaw, Edmond C. Packee, Sr.

purpose

SDI is a measure of stand stocking that indexes stand density to the number of trees per acre when mean diameter equals

10 inches. It is independent of age and site quality. The goal is to determine SDI maximum and self-thinning values for pure and mixed stands.

#### approach

We obtain basic data from existing plots (e.g., inventory, timber sale cruise, PSPs, LOGS) and collect supplemental data (stand basal area, tree diameters) from densely stocked stands. Finally, we calculate SDI values for pure and mixed species stands using the summation method.

#### progress

Other data sources have been obtained. The use of SDI with all-aged, mixed-species stands was successfully addressed and documented through a review of the literature. Maximum SDI values were identified as being weak or nonexistent for Northern Forest species in Alaska. Non-random sampling of identified high-density stands is planned to begin in mid 2005.

#### impact

SDI are used to determine and predict stand competition, wildlife habitat, understory vegetation quantity and density, fire management conditions, and stand treatments (e.g., spacing, thinning). It is an essential component of the FVS model (see Forest Vegetation Simulator, p. 54).

## UAF Sitka Forest Products Program

The long-term objective of the Forest Products Program is to help Alaska become competitive in the value-added forest products industry by providing specific technical, business, and marketing assistance. Proposals for new markets and new value-added products that are economic to produce must take into account such economic factors as high costs of labor and transportation. Program research can potentially increase the volume of wood products produced and marketed from Alaska forests. Since fall 2004, research assistant professor Valerie Barber has been the program's principal investigator. Barber, who is affiliated with the forest sciences department, is located in Sitka. Allen Brackley was the program's original principal investigator from spring 2001 through fall 2004.

## Yarn Swift Market Study and Test Marketing

Terry Lavallee, Kristie Sherrod (Bluster Bay Woodworks, Sitka, Alaska)

#### purpose

This is a market study for the Bluster Bay yarn swift. The aim was to successfully introduce a new, Alaska-made wood product into a high-end niche market. A yarn swift is an adjustable device with jointed arms, somewhat like an umbrella, that opens out to various circumferences to fit different sized yarn skeins. A detailed report on the product's marketing will serve as a model marketing plan for other high-quality, premium-priced products that can be made from Alaska wood for specialty markets.

#### progress

The project was nearly complete in 2004. The only logistical problem was locating a dependable supply of suitable Alas-

ka-grown wood for making the swifts. This problem should be alleviated by the US Forest Service cost-share grants for kilns and kiln-drying facilities in Alaska. There are now at least 23 kilns all over Alaska that have the potential to supply the finished wood needed for the yarn swifts. At present, the swifts are made out of non-Alaska woods that are consistently available. In this project's marketing phase, the product brochure designed and distributed as a result of responses to magazine advertisements was a resounding success. One in seven brochures resulted in a sale, which is unheard of in the mail-order business. Press releases and photographs sent to industries resulted in illustrated magazine articles about Bluster Bay swifts. Gross sales have exceeded all expectations and receipts total 224 percent of those originally anticipated.

#### impact

This study showed that an Alaska-made wood product can be successfully marketed, and could use Alaska wood when consistent supplies are available. Successful wood products made from Alaska could provide income for Alaska businesses and jobs for Alaskans.

## The New Markets study

Allen Brackley, Joe Roos (Center for International Trade in Forest Products [CINTRAFOR] - University of Washington)

#### purpose

This study sought consumer responses to the idea of using Alaska products, specifically those made from old-growth trees from the Tongass National Forest.

#### approach

During two trade shows, one in Anaheim, California, and one in Las Vegas, Nevada, approximately 181 consumers were polled. Based on answers to survey questions, it appears that willingness to use material harvested from the specified type of areas in Alaska may not be as overwhelmingly negative as some organizations are reporting.

#### impact

Alaska products made from old-growth trees may be marketable.

## International Lumber Marketing Project

Valerie Barber, Joe Roos (CINTRAFOR - University of Washington)

#### purpose

This was an investigation of marketing opportunities for Alaska wood products.

#### approach

Barber and Roos attended the Japan Home and Building Show in Tokyo in November 2004. During the show, more than 120 surveys were conducted to assess Japanese perspective on Alaska wood products.

#### progress

Final analysis of the data will be completed soon. A trip to China is planned for spring 2006 to look into potential markets for Alaska wood and to conduct further surveys.

## **In-Grade Testing of Alaska Species (Alaska cedar, Alaska hemlock, Sitka spruce, and white spruce)**

Ketchikan Wood Technology Center (KWTC)

purpose

This work was funded jointly by UAF-Sitka Forest Products, USDA Forest Service, and the State of Alaska to determine the physical and mechanical strengths of Alaska wood.

approach/progress

The research was conducted at KWTC under the guidance of Kevin Curtis, director, John Bannister, research manager, and Mike Hannan, facilities manager. Work has been completed.

impact

The study resulted in new design values for lumber produced in Alaska. Final results were submitted to the Western Wood Products Association and American Lumber Standards Committee and were accepted. New grading stamps have been issued. These new design values should result in new uses for Alaska lumber. The superior strength and clarity of the Alaska wood has the potential to increase lumber prices by 10-25 percent.

## **Western Hemlock and Yellow Cedar Small Clear Testing Projects (KWTC)**

Kevin Curtis (KWTC)

purpose

Small clear testing of lumber evaluates the physical and mechanical properties of small clear specimens. Due to the great variety of species, variability of the material, continually changing conditions of supply, factors affecting test results and ease of comparing variables, this need will always exist. Test results will be compared to In-Graded testing results. If highly correlated, small clear testing of woods could be used in place of In-Grade testing and would save time and money.

approach

The Forest Products Program funded the purchase of an Instron Test Frame. The testing equipment was installed at KWTC in 2004, and the software and data analysis packages necessary to use the equipment were developed there. Also purchased and installed were frame add-ons necessary to finish the testing required by the American Society for Testing and Materials (ASTM, International). Four-foot lumber samples were gathered, dried and conditioned to 12 percent moisture content for subsequent preparation of the bending and tension specimens required by ASTM. All required bending specimens were cut and jigs were constructed to cut the relatively complicated tension specimens. All necessary software and hardware are in place. ASTM is a nonprofit organization that provides a global forum for the development and publication of voluntary consensus standards for materials, products, systems, and services.

progress/impact

A few bending specimens have been tested. Procedures necessary to cut and prepare the tension specimens are completed. Wood used in this project was taken from the same lumber

used for the In Grade studies on Alaska yellow cedar and western hemlock. This will allow correlation of results from both studies. KWTC now has the capability of In-Grade testing of lumber as well as testing of small clear lumber in accordance with ASTM standards. If small clear testing can be correlated with In-Grade testing, much time and money will be saved. Testing and data analysis will be completed in 2005-06.

## **Drying Schedules**

Kevin Curtis (KWTC)

Drying schedules will be developed at KWTC for red alder and western hemlock lumber using a dehumidifying kiln. Preliminary grade yields will also be determined. Red alder is a previously underutilized species with great potential for furniture manufacture. The kiln will be ready for testing sometime in 2005. Utilizing wood harvested in Alaska for high-value products will be increased if furniture manufacturers have accurate information on yields and recognize the superior quality of Alaska wood.

## **The Medium Density Fiberboard (MDF) Plant Feasibility project**

Allen Brackley, Valerie Barber

purpose

Fiberboard can be produced from trees that have little or no commercial value as lumber and fiberboard products are cheaper than lumber products. This is a study to determine the feasibility of developing a medium density fiberboard plant in Southeast Alaska.

approach/progress

Len Gus Associates in Washington was selected to conduct the study. Gus will tour facilities in China and meet with furniture manufacturers, flooring manufacturers, importers of MDF, MDF manufacturers, furniture designers and materials specifiers, trade magazine editors, trade associations, and government officials in industrial zones. This report will be completed in 2005.

impact

If a fiberboard plant is feasible, and later constructed, it could provide a much needed outlet for southeast Alaska's timber forest products. The furniture industry in China is enormous and still growing. Sales worldwide in 2004 were US \$8.047 billion, up 33.83% in one year. China also imports furniture, amounting to US \$633 million in 2004, up 36% over 2003. Although Chinese and Japanese buyers are very concerned about new US tariffs and quotas, they have expressed interest in high-grade MDF from Alaska.

## **Physical and Chemical Properties of Alaskan Herb, Shrub, Tree Components**

Valerie Barber (Prior to May 2004, the principal investigator was Allen Brackley.)

purpose

The project goal is to obtain information related to the green moisture content and chemical properties of selected

herb, shrub, and plant components that can be used to make teas. Cooperating in the study is Erika Merklin of SuperNatural Teas in Haines, Alaska.

approach

During the project's first year, Ms. Merklin received equipment and assistance for a demonstration project. A dehumidifying kiln (normally used to dry wood) was provided for drying plants and plant parts used for tea. At least five different plants or plant parts will be studied. Green and dry weights, moisture content, and antioxidant capacities will be determined for each item, and kiln drying schedules will be determined. Due to logistical problems with setting up the kiln and processing unit, startup was delayed until May 2005. Next year's report will document results.

impact

The research using this equipment is expected to benefit nontimber forest product businesses. Alaska has a huge potential for producing nontimber forest products; certain nontimber forest products have a \$72 million annual unmet market demand in Alaska (Mater 2000). Basic research can contribute to development of this largely untapped potential.

## Wood Plastic Composite Project

Luftii Raad (UAF Engineering Department)

purpose

We sought to investigate the durability of composite boards made from spruce and plastic milk jugs.

approach

Wood and plastic composite material boards were made from spruce and plastic milk jugs. These were used to construct six raised garden beds in Fairbanks and six in Sitka. The boards went into the ground in October 2003 and are due to be taken out of the ground in fall 2005.

progress

The research plan has been completed. During 2005-2006, the control boards will be tested in accordance with standards of the American Society for Testing and Materials (ASTM, International).

impact

This research could lead to the development of products that utilize plastic waste and trees that are otherwise unsuitable for lumber.

## policy, use, and planning

### Alaska Northern Forest Cooperative

Edmond C. Packee, Sr.

purpose

Members of the cooperative exchange information among forest scientists, forest managers, and forest landowners in the Northern Forest of Alaska. The term "Northern Forest" includes the boreal forest or taiga extending across much of mainland Alaska but excludes the Coastal Spruce-Hemlock Forest.

approach

The cooperative has a technical focus; it is neither a political

nor an advocacy organization. It recognizes that nontechnical or traditional knowledge has value in forest management and that learning occurs by collaboration among scientists, landowners, and forest managers. The cooperative meets twice a year for business (spring and autumn) and sponsors at least one workshop or field trip each year separate from the business meetings.

progress

In 2004 two business meetings and one 2.5-day field trip with workshop were held. The first cooperative effort produced a CD-ROM disk compendium of research projects, although it only scratched the surface of ongoing programs in the state. The CD was distributed among active members and at a poster session at the joint national meeting of the Society of American Foresters and the Canadian Institute of Northern Forestry.

impact

Through collaboration and the dissemination of information, the level of forest management in the boreal forest of Alaska should increase on both public and private lands. Through the workshop, a working partnership was initiated with the University of Minnesota Duluth to address betulin (a phytochemical) production from the bark of Alaska paper birch species.

### Alaska residents statistics program

Peter J. Fix, Quinn Tracy

purpose

This study will assess travel and recreation patterns of Alaska residents, barriers to participation in outdoor recreation, desired recreation development (or lack thereof), and attitudes and values regarding natural resource management. The resulting information will be incorporated into the planning processes of several cooperating federal and state agencies: the US Department of Interior Bureau of Land Management, National Park Service, and Fish and Wildlife Service; The US Department of Agriculture Forest Service; and Alaska's Department of Transportation, Department of Natural Resources Division of Parks and Outdoor Recreation, and Department of Fish and Game.

approach

Information will be gathered using a mail survey. The state will be stratified into five regions and samples drawn from each region.

progress

During 2004 we developed the survey instrument and began pretesting.

impact

The study will assist participating agencies with their natural resource planning, result in a common dataset to be shared among the agencies, and provide baseline information to monitor trends.

## Carbon sequestration market opportunities in Alaska

Joshua Greenberg, Jennifer Duvall

### purpose

Carbon sequestration and carbon credit markets introduce an important opportunity for Alaska. There are potential revenue streams from selling credits for carbon sequestered in our lands and carbon sequestration may be a possible vehicle for rural economic development. This project is intended to evaluate options for state participation in carbon credit markets.

### approach

This study relies on an extensive review of the literature to understand carbon credit markets and opportunities for Alaska participation. Potential opportunities of particular promise for Alaska are to be further investigated to assess economic viability. This attenuated feasibility approach can be employed to identify opportunities for further consideration.

### progress

Initial evaluation of opportunities for Alaska's participation were examined in 2004, particularly offsetting diesel emissions from rural generators with wood or alternative energies. The calculations estimate that the rural diesel offset program could potentially earn 274,000 Verified Emissions Reductions annually, which the State of Alaska could sell to buyers to enhance its resource development revenue stream

### impact

The study provides important information to the state and its legislature about how a carbon credit market could work in Alaska.

## Forest Vegetation Simulator (FVS) model

Edmond C. Packee, Sr., John D. Shaw

### purpose

Forest managers use stand or individual tree models to forecast probable results of alternative silvicultural prescriptions. No such models are currently used on public and private lands in Alaska's Northern Forest. Our objectives are to select model(s) suitable for Alaska forests, determine data requirements, and begin using them for modeling stand response to potential treatments.

### approach

We selected the FVS model, which includes the Stand Visualization Simulator. Selection criteria included: quantitative and visual outputs, ability to handle wide range of silvicultural treatments, minimal data inputs, and user friendliness.

### progress

Other priorities took precedence over the project in 2004 resulting in no further progress. However, potential forest cover types, an essential component of FVS, were identified and plans are to begin documenting their presence in mid-2005.

### impact

FVS provides current and post-prescription quantitative and visual results of treatment prescriptions. These can provide the public with a clearer picture of silvicultural treatment

outcomes and improve and support State of Alaska Forest Land Use Plan harvest options.

## Lake level changes at Harding Lake

John D. Fox, Jr.

### purpose

Harding Lake is an important recreational lake in interior Alaska that has experienced periods of declining lake levels due to the divergence of a major feeder stream. This study focuses on reconstructing the lake's historic levels and lake level changes and creating a model useful in developing operational rules for a control structure on the divergent stream.

### approach

I am exploring historic lake levels by obtaining aerial photography, satellite imagery, and ground photographs of the lake and lake shore, and finding original survey meander corners. A water balance model of the lake will be used to explore lake level dynamics and responses to changes in surface inflow. A lake-level recorder measures the detailed lake fluctuations in response to dry periods and periods of rainfall.

### progress

I have obtained a number of dated aerial photographs and located meander corners established in 1921 and 1936. Additional historic ground photos and films have been reviewed. I have created an interactive model that captures the general dynamics of the lake water balance. I began study of the ice-push ridges on the north shore in an effort to locate a possible historical outlet to Harding Lake. Detailed lake-level monitoring was initiated in the summer of 2004. Preliminary analysis indicates that evaporation may be the only significant outflow from the lake and that ground-water outflow may be small, at least at current lake levels.

### impact

I continue to share collected information with members of management agencies and the newly formed Harding Lake Watershed Council. This information is being used by the Alaska Department of Fish & Game, the Natural Resources Conservation Service, and the Salcha-Delta Soil and Water Conservation District, which will participate in the design and planning of a control structure on the divergent stream. Legal issues have been resolved and progress on the diversion structure should continue contingent on available funds. Data collected in 2004 have allowed sorting out the confounding unknowns of lake evaporation and lake seepage outflow. This study is providing the basis for two senior thesis projects.

## A market survey of ecotourists in the Valdivian temperate forest ecoregion of Chile

Scott Harris, Glenn Juday

### purpose

This study compares the motivations of ecotourists in the Valdivian Temperate Forests ecoregion of southern Chile with the assumed motivations of participants according to accepted definitions of ecotourism.

Old Mill Building  
at Kennecott Mine,  
McCarthy, Alaska.  
—PHOTO BY STEVE C. TAYLOR



approach

A survey was used to determine if the experience and activity preferences of the market match what is being developed at local community-based ecotourism projects. Survey design was based on a literature review, and observations and key-informant interviews collected in the study area.

progress

Ecotourists show strong preferences for the types of accommodations and experiences that exist or are being developed at ecotourism project sites: hostels, camping, low-intensity nature-based activities, pristine environments, and simple marketing schemes. However, market demand for guide services may not meet expectations. Survey respondents who support ecotourism goals fall into a tightly defined cluster, the majority of whom are Chilean, not foreign visitors.

impact

Proponents of ecotourism development in this area have expectations that generally conform to the guidelines presented in the case study literature, and ecotourism can complement the improving, but currently weak, political capacity for conserving native forest biodiversity in this region.

**Visitor evaluation of interpretation at Wrangell St. Elias National Park and Preserve**

Peter J. Fix, Steve C. Taylor

purpose

This project assessed visitors' reasons for visiting Wrangell St. Elias National Park, their evaluation of interpretive services, and their preferences for management actions involving site development in the historic Kennecott Mill Town.

approach

A survey of randomly selected visitors was conducted during the summer of 2004. The survey consisted of questions regarding evaluation of interpretation, preferences for management actions, motivations for visiting the park, and trip characteristics.

progress

Data were gathered, compiled, and analyzed. A summary of key findings was presented to park staff along with an executive summary. The project report is in progress.

impact

Information from the study will assist park managers in determining the appropriate level of facility development and interpretive services in the Kennecott Mill Town and provide guidance in setting standards for management objectives.

**When laws affecting the environment conflict: focus on public lands**

Julie Lurman

purpose

This study aims to identify situations in which laws or policies with conflicting purposes or methodologies are in place, to analyze that legal conflict in order to understand how it manifested and what its practical consequences are, and perhaps to recommend changes.

approach

I examined how recent state predator control efforts on federal lands have been implemented without following mandatory procedures under both the Alaska National Interest Lands Conservation Act and the National Environmental Policy Act.

progress

Through an analysis of the applicable statutes and case law, procedural oversights have come to light. A manuscript has been prepared and will be ready for submission in September 2005.

impact

This analysis may keep federal land managers from running afoul of the law and risking expensive and time-consuming legal challenges.

# 2004 Publications

## Abstracts

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- Bonanza Creek regeneration in blade scarified patches. p. 57.
- Bonanza Creek hardwood removal from mature mixed stand. p. 62.
- Bonanza West south of Parks Highway aspen-white spruce thinning trial. p. 63.
- Bonanza West white spruce thinning trial. p. 64.
- Early height growth of Northern Forest tree species in Alaska. p. 58.
- Forest resource management community types. p. 15.



- Goldstream white spruce sapling spacing trial, Standard Creek Road. p. 66.
- Individual tree volume tables: Aspen. p. 72.
- Individual tree volume tables: Balsam poplar/black cottonwood. p. 73.
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- Individual tree volume tables: White spruce. p. 76
- Levels-Of-Growing-Stock (LOGS) plantations. p. 67
- Northern forest tree species and hybrids. p. 90.
- Permanent Sample Plots (PSPs) for stand characterization. p. 17.
- Site index of balsam poplar/black cottonwood in Alaska. p. 51.
- Site index of birch in Alaska. p. 52.
- Site index of black spruce in Alaska. 53.
- Site index of tamarack in Alaska. p. 54
- Site index of trembling aspen in Alaska. p.55
- Site index of white spruce in Alaska. p. 56
- Slash decomposition following thinning. p. 68.
- West Bonanza white spruce thinning and fertilizer interaction trial. p. 70.
- (Packee EC, Shaw JD) Forest Vegetation Simulator (FVS) and Stand Visualization Simulator (SVS) and growth and yield models. p. 87.
- (Packee EC, Shaw JD.) Stand Density Indices (SDI). p. 92.
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# Faculty

Current Faculty  
[www.uaf.edu/snras/faculty/](http://www.uaf.edu/snras/faculty/)



Valerie Barber  
Asst. Research Professor of Forest Sciences  
PhD, Univ. of Alaska Fairbanks, '02  
[fvab@uaf.edu](mailto:fvab@uaf.edu)



Joshua A. Greenberg  
Assoc. Prof. of Resource Economics  
PhD, Washington State Univ., '90  
[ffjag@uaf.edu](mailto:ffjag@uaf.edu)  
[www.uaf.edu/snras/faculty/greenberg.html](http://www.uaf.edu/snras/faculty/greenberg.html)



Kenneth A. Barrick  
Assoc. Professor of Geography  
PhD, Southern Illinois Univ., '83  
[ffkab@uaf.edu](mailto:ffkab@uaf.edu)  
[www.uaf.edu/snras/faculty/barrick.html](http://www.uaf.edu/snras/faculty/barrick.html)



Norman R. Harris  
Asst. Prof. of Range Management  
PhD, Oregon State University, '01  
[pfnrh@uaa.alaska.edu](mailto:pfnrh@uaa.alaska.edu)  
[www.uaf.edu/snras/faculty/harris.html](http://www.uaf.edu/snras/faculty/harris.html)



Matthew Cronin  
Research Assoc. Professor of Animal Genetics  
PhD, Yale University, '89  
[ffmac1@uaf.edu](mailto:ffmac1@uaf.edu)



Dorothy J. Helm  
Research Professor of Vegetation Ecology (ret.)  
PhD, Colorado State Univ., '81  
[pndjh@uaf.edu](mailto:pndjh@uaf.edu)  
[www.uaf.edu/snras/faculty/helm.html](http://www.uaf.edu/snras/faculty/helm.html)



Cary W. de Wit  
Asst. Professor of Geography  
PhD, Univ. of Kansas, '97  
[ffcwd@uaf.edu](mailto:ffcwd@uaf.edu)  
[www.faculty.uaf.edu/ffcwd/](http://www.faculty.uaf.edu/ffcwd/)  
[www.uaf.edu/snras/faculty/dewit.html](http://www.uaf.edu/snras/faculty/dewit.html)



Patricia S. Holloway  
Professor of Horticulture  
PhD, Univ. of Minnesota, '82  
[ffpsh@uaf.edu](mailto:ffpsh@uaf.edu)  
[www.uaf.edu/snras/faculty/holloway.html](http://www.uaf.edu/snras/faculty/holloway.html)



Gregory L. Finstad  
Instructor and Program Manager  
Reindeer Research Program  
BS, Univ. of Alaska Fairbanks, '81  
[ffglf@uaf.edu](mailto:ffglf@uaf.edu)  
[www.uaf.edu/snras/faculty/finstad.html](http://www.uaf.edu/snras/faculty/finstad.html)  
[www.reindeer.salrm.uaf.edu](http://www.reindeer.salrm.uaf.edu)



Stephen B. Jones  
Professor of Natural Resources Management  
PhD, State Univ. of New York Syracuse, '87  
[fychanc@uaf.edu](mailto:fychanc@uaf.edu)  
<http://www.uaf.edu/chancellor/>  
STEPHEN JONES, UAF PHOTO BY TODD PARIS.



Peter J. Fix  
Asst. Prof. of Outdoor Recreation Management  
PhD, Colorado State Univ., '02  
[ffpjf@uaf.edu](mailto:ffpjf@uaf.edu)  
[www.uaf.edu/snras/faculty/fix.html](http://www.uaf.edu/snras/faculty/fix.html)



Glenn P. Juday  
Professor of Forest Ecology  
PhD, Oregon State Univ., '76  
[g.juday@uaf.edu](mailto:g.juday@uaf.edu)  
[www.uaf.edu/snras/faculty/juday.html](http://www.uaf.edu/snras/faculty/juday.html)



John D. Fox, Jr.  
Assoc. Prof. of Forestry  
PhD, Univ. of Washington, '76  
[ffjdf@uaf.edu](mailto:ffjdf@uaf.edu)  
[www.uaf.edu/snras/faculty/fox.html](http://www.uaf.edu/snras/faculty/fox.html)



Meriam G. Karlsson  
Professor of Horticulture  
PhD, Michigan State University, '87  
[ffmgk@uaf.edu](mailto:ffmgk@uaf.edu)  
[www.uaf.edu/snras/faculty/karlsson.html](http://www.uaf.edu/snras/faculty/karlsson.html)



**Gary Kofinas**  
Asst. Professor of Resource Policy and Management  
PhD, Univ. of British Columbia  
gary.kofinas@uaf.edu  
www.uaf.edu/snras/faculty/ffgpk/



**Chien-Lu Ping**  
Prof. of Agronomy, Soil Scientist  
PhD, Washington State Univ., '73  
pfcpl@uaa.alaska.edu  
www.uaf.edu/snras/faculty/ping.html



**Carol E. Lewis**  
Dean, SALRM and Director, AFES  
Professor of Resources Management  
PhD, Georgetown Univ., '70  
MBA, Univ. of Alaska Fairbanks, '76  
ffcel@uaf.edu  
www.uaf.edu/snras/faculty/lewis.html



**T. Scott Rupp**  
Asst. Professor of Forestry  
PhD, Univ. of Alaska Fairbanks, '98  
scott.rupp@uaf.edu  
www.faculty.uaf.edu/ffsr/  
www.uaf.edu/snras/faculty/rupp.html



**Roseann Leiner**  
Assist. Professor of Horticulture  
Horticulture Extension Specialist  
PhD, Cornell, '99  
roseann.leiner@uaf.edu  
www.matsu.alaska.edu/pfrml/  
www.uaf.edu/snras/pass/faculty/leiner.html



**Mike Sfraga**  
Assist. Professor of Geography  
Director, Alaska Integrated Geography Program  
PhD, Univ. of Alaska, '97  
mike.sfraga@alaska.edu



**Julie Lurman**  
Asst. Professor of Natural Resources Law and Policy  
JD, Georgetown Univ. Law Center '03  
ffjl@uaf.edu  
www.uaf.edu/snras/faculty/lurman.html



**Milan P. Shipka**  
Assoc. Professor of Animal Science  
PhD, Utah State Univ., '96  
ffmps@uaf.edu  
www.uaf.edu/snras/school/mshipka/mshipka.htm  
www.uaf.edu/snras/faculty/shipka.html



**Jenifer H. McBeath**  
Professor of Plant Pathology  
PhD, Rutgers Univ. '74  
ffjhm@uaf.edu  
www.uaf.edu/snras/faculty/mcbeath.html



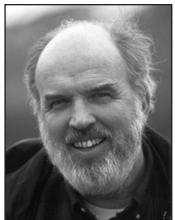
**Jeffrey Smeenk**  
Asst. Professor of Horticulture  
Horticulture Extension Specialist  
PhD, Michigan State Univ., '03  
jeff.smeenk@uaf.edu



**G. Allen Mitchell**  
Associate Director, AFES  
Professor of Agronomy  
PhD, Univ. of California, Riverside, '71  
pfgam@uaa.alaska.edu  
www.uaf.edu/snras/faculty/mitchell.html



**Elena B. Sparrow**  
Research Assoc. Prof. of Resource Management  
PhD, Colorado State Univ., '73  
ffeb@uaf.edu  
www.uaf.edu/snras/faculty/esparrow.html



**Edmond C. Packee**  
Professor of Forest Management  
PhD, Univ. of Minnesota, '76  
ffecp@uaf.edu  
www.uaf.edu/snras/faculty/packee.html



**Stephen D. Sparrow, Jr.**  
Associate Dean, SNRAS  
Professor of Agronomy  
PhD, Univ. of Minnesota, '81  
stephen.sparrow@uaf.edu  
www.uaf.edu/snras/faculty/ssparrow.html



**Sidney Stephens**  
Research Instructor, Global Change Program  
MEd, Univ. of Alaska Fairbanks, '86  
ffss1@uaf.edu  
[www.uaf.edu/snras/faculty/stephens.html](http://www.uaf.edu/snras/faculty/stephens.html)



**Susan Todd**  
Assoc. Prof. of Regional and Land Use  
Planning  
PhD, Univ. of Michigan, '95  
susan.todd@uaf.edu  
[www.uaf.edu/snras/faculty/todd.html](http://www.uaf.edu/snras/faculty/todd.html)



**David Valentine**  
Assoc. Prof. of Forest Soils  
PhD, Duke Univ., '90  
ffdwv@uaf.edu  
[www.faculty.uaf.edu/ffdwv/](http://www.faculty.uaf.edu/ffdwv/)  
[www.uaf.edu/snras/faculty/valentine.html](http://www.uaf.edu/snras/faculty/valentine.html)



**David L. Verbyla**  
Prof. of Geographic Information Systems  
PhD, Utah State Univ., '88  
dverbyla@lter.uaf.edu  
nrm.salrm.uaf.edu/~dverbyla/  
[www.uaf.edu/snras/faculty/verbyla.html](http://www.uaf.edu/snras/faculty/verbyla.html)



**Eva Wiklund**  
Research Assoc. Prof. of Animal Science  
PhD, Swedish Univ. of Ag. Sciences, '97  
ffemw2@uaf.edu



**John A. Yarie**  
Professor of Silviculture  
PhD, Univ. of British Columbia, '78  
jyarie@lter.uaf.edu  
[www.uaf.edu/snras/faculty/yarie.html](http://www.uaf.edu/snras/faculty/yarie.html)



**Mingchu Zhang**  
Assistant Professor of Agronomy  
PhD, Univ. of Alberta, '93  
ffmz@uaf.edu  
[www.uaf.edu/snras/faculty/zhang.html](http://www.uaf.edu/snras/faculty/zhang.html)

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## Boreal Ecology Cooperative Research Unit

[www.becru.uaf.edu](http://www.becru.uaf.edu)  
**Teresa Nettleton Hollingsworth**, Research Ecologist (LTER)  
fttkn@uaf.edu  
**Trish Wurtz**, Research Ecologist (LTER), trish.wurtz@uaf.edu  
**United States Department of Agriculture**

## Agricultural Research Service

[www.ars.usda.gov](http://www.ars.usda.gov)  
**Peter Bechtel**, Research Food Technologist, Bechtel@sfos.uaf.edu  
**Cynthia Bower**, Research Food Technologist,  
bower@sfos.uaf.edu  
**Jeff Conn**, Research Agronomist/Weed Scientist  
ffjsc1@uaf.edu  
**Dennis Fielding**, Research Entomologist, ffdjfl@uaf.edu  
**David Ianson**, Horticulturalist/Curator, pfhci@uaa.alaska.edu  
**Joseph Kuhl**, Research Geneticist, ffjck@uaf.edu  
**Alberto Pantoja**, Research Leader and Entomologist,  
ffap2@uaf.edu  
**Nancy Robertson**, Research Plant Pathologist,  
pfnlr@uaa.alaska.edu  
**Steven Seefeldt**, Research Agronomist, sseefeldt@pw.ars.usda.gov  
**Lori Winton**, Research Plant Pathologist, flmw@uaf.edu



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Sunflower at the Georgeson Botanical Garden. Sunflowers are among several agronomic and horticultural crops grown for variety trial studies over the last few decades at the Agricultural & Forestry Experiment Station (pp. 15-23).

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