AgroBorealis

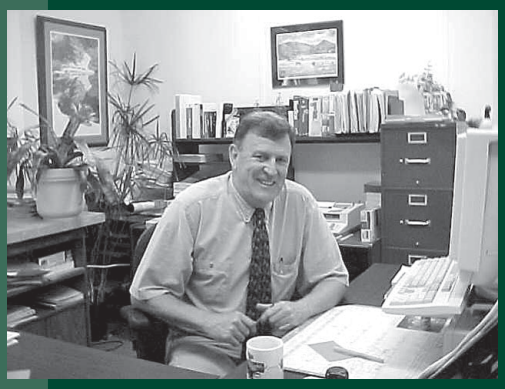
School of Agriculture & Land Resources Management
Agricultural & Forestry Experiment Station

Vol. 33, No. 2: The Annual Report Fall 2001

UNIVERSITY OF ALASKA FAIRBANKS

AFES Interim Director | Palmer Research Center | 533 E. Fireweed | Palmer, AK 99645

June 30, 2001



The Honorable Tony Knowles
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 Agriculture and Land Resources Management, University of Alaska Fairbanks, for the period ending December 31, 2000. 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 colleges 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.

Very respectfully,

G. Allen Mitchell

G. Allen Mitchell
Acting 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 well–being 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.

Experiment station scientists publish research in scientific journals, conference proceedings, books, and in experiment station bulletins, circulars, newsletters, 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 Agriculture and Land Resources Management (SALRM) 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.

EDITORIAL STAFF

AgroBorealis is published by the Agricultural and Forestry Experiment Station, University of Alaska Fairbanks. A written request will include you on the mailing list. The address is:

PUBLICATIONS, AFES
P.O. BOX 757200
FAIRBANKS, AK 99775–7200
e-mail: fynrpub@uaf.edu
or visit our web site at: http://www.lter.uaf.edu/salrm

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ISSN: 0002-1822

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UNIVERSITY OF ALASKA FAIRBANKS

SCHOOL OF AGRICULTURE & LAND RESOURCES MANAGEMENT
AGRICULTURAL & FORESTRY EXPERIMENT STATION

Faculty profiles

Harry R. Bader, Associate Professor of Natural Resources Law; Washington State University '84, B.A.; Harvard Law School '88, J.D. e-mail ffhrb@uaf.edu

Donald E. Carling, Professor of Horticulture; St. Cloud State University, Minnesota '67, B.A.; University of Missouri–Columbia '69, M.S., '75, Ph.D. e-mail pfdec@uaa.alaska.edu

Kenneth Barrick, Associate Professor of Geography; Shippenberg University of Pennsylvania '74, B.A., '78 M.S.; Southern Illinois University '82, M.S., '83, Ph.D. e-mail ffkab@uaf.edu

Cary W. de Wit, Assistant Professor of Geography; University of Kansas '84, B.S., '92, M.A., '97, Ph.D. e-mail ffcwd@uaf.edu

John D. Fox, Jr., Associate Professor of Land Resources; Trinity College '68, B.S.; University of Washington '70, M.S., '76, Ph.D. e-mail ffjdf@uaf.edu

Raymond G. Gavlak, Professor of Agronomy Extension; California State Polytechnic Institute '76, B.S.; Montana State University '82, M.S., ' 85, PhD. e-mail pfrgg@uaf.edu

Joshua A. Greenberg, Associate Professor of Resource Economics; University of Connecticut '82, B.S.; University of Alaska Fairbanks '84, M.S.; Washington State University '90, Ph.D. e-mail ffjag@uaf.edu

Dorothy J. Helm, Research Professor of Vegetation Ecology; University of Delaware '69, B.S.; University of Michigan '70, M.S.; Colorado State University '77, M.S., '81, Ph.D. e-mail pndjh@uaf.edu

Patricia S. Holloway, Associate Professor of Horticulture; Millersville University of Pennsylvania '73, B.A.; Washington State University '76, M.S.; University of Minnesota '82, Ph.D. e-mail ffpsh@uaf.edu

Glenn P. Juday, Professor of Forest Ecology; Purdue University '72, B.S.; Oregon State University '76, Ph.D. e-mail gjuday@lter.uaf.edu

Meriam G. Karlsson, Associate Professor of Horticulture; The Swedish University of Agricultural Sciences '79, B.S.; Michigan State University '84, M.S., '87, Ph.D. e-mail ffmgk@uaf.edu

Charles W. Knight, Associate Professor of Agronomy; Kansas State University '70, B.S., '71, M.S.; University of Alaska Fairbanks '88, Ph.D. e-mail ffcwk@uaf.edu

Carol E. Lewis, Interim Dean – School of Agriculture and Land Resources Management and Professor of Resources Management; University of Florida '62, B.S.; '64, M.S.; Georgetown University '70, Ph.D.; University of Alaska Fairbanks '76, M.B.A. e-mail ffcel@uaf.edu

Roseann Leiner, Assistant Professor of Horticulture/Horticulture Extension Specialist; Cornell, '81, B.S.; University of Alaska Fairbanks, '91, M.S.; Cornell, '99, Ph.D. e-mail pfrml@uaa.alaska.edu

Jenifer H. McBeath, Professor of Plant Pathology; National Taiwan University, '65, B.S.; University of California, Davis '70, M.S.; Rutgers University '74, Ph.D. e-mail ffjhm@uaf.edu

G. Allen Mitchell, Associate Dean – School of Agriculture and Land Resources Management, Acting Director – Agricultural and Forestry Experiment Station, and Professor of Agronomy; University of California, Riverside '71, B.S., '73, M.S., '77, Ph.D. e-mail pfgam@uaa.alaska.edu

Edmond C. Packee, Professor of Forest Management; University of Montana '62, B.S.; Yale University '63, M.F.; University of Minnesota '76, Ph.D. e-mail ffecp@uaf.edu

Chien–Lu Ping, Professor of Agronomy, Soil Scientist; Chung–Hsin University, Taiwan '65, B.S.; Washington State University '73, M.S., '76, Ph.D. e-mail pfclp@uaa.alaska.edu

Milan Shipka, Assistant Professor of Animal Science; University of Minnesota '83, B.S.; Iowa State University '90, M.S., '96, Ph.D. e-mail ffmps@uaf.edu

Elena B. Sparrow, Associate Professor of Resources Management; e-mail ffebs@uaf.edu

Stephen D. Sparrow, Jr., Professor of Agronomy; North Carolina State University '69, B.S.; Colorado State University '73, M.S.; University of Minnesota '81, Ph.D. e-mail stephen.sparrow@uaf.edu

Susan Todd, Assistant Professor of Regional and Land Use Planning; Bryn Mawr '75, B.A.; University of Michigan '79, M.R.P.; University of Michigan '95, Ph.D. e-mail susan.todd@uaf.edu

David Valentine, Assistant Professor of Forest Soils; Wittenberg '81. B.A.; Duke University '84, M.S.; '90, Ph.D. e-mail ffdwv@uaf.edu

David L. Verbyla, Associate Professor of Geographic Information Systems; Rutgers University '79, B.S.; Michigan State University '82, M.S.; Utah State University '88, Ph.D. e-mail dverbyla@lter.uaf.edu

John A. Yarie, Professor of Silviculture; West Virginia University '71, B.S.; University of Maine '74, M.S.; University of British Columbia '78, Ph.D. e-mail jyarie@lter.uaf.edu

Emeriti

Arthur L. Brundage, Professor of Animal Science

Robert A. Dieterich, Professor of Veterinary Science

Don H. Dinkel, Professor of Plant Physiology

James V. Drew, Dean of SALRM, Director of AFES, and Professor of Agronomy

Anthony F. Gasbarro, Associate Professor of Forestry Extension

Alan C. Epps, Professor of Natural Resources

Alan Jubenville, Professor of Resources Management

Leslie J. Klebesadel, Professor of Agronomy

Charles E. Logsdon, Professor of Plant Pathology

Jay D. McKendrick, Professor of Agronomy

William W. Mitchell, Professor of Agronomy

Bonita J. Neiland, Professor of Land Resources and Botany

Sigmund H. Restad, Assistant Director, Alaska AFES

Wayne C. Thomas, Professor of Economics

Keith Van Cleve, Professor of Forestry (Soils)

Robert B. Weeden, Professor of Resources Management

Research Achievements

Plant, Animal and Soil Sciences

Potato cultivar trials

Comparative yields of thirty-two cultivars of potatoes were tested in an irrigated field trial in 2000. These trials did not include a non-irrigated treatment. The 2000 growing season in Southcentral Alaska was a good one for potato production although yields were somewhat lower than in 1999. As in 1999, plants emerged before June 1. Later in the season there were many cloudy, misty days of the type conducive to late blight development, although for the second year in a row, no late blight was observed.

Average total yield of the thirty-two cultivars tested was 38.1 metric tons per hectare (MT/H) and the average US#1 yield was 31.6 MT/H. Top cultivars in total yield included Lemhi Russet (44.9 MT/H), Green Mountain (44.0 MT/H) and Chieftain (43.5 MT/H) whereas the cultivars with the highest US#1 yield included Green Mountain (39.5 MT/H), Andover (38.4 MT/H) and Chieftain (43.5 MT/H). Andover was the most productive of eight chipping varieties included in this study.

In another field trial, a continuation of a study run in 1998 and 1999, line selections and seed sources of Russet Norkotah were compared. A total of 20 treatments were tested, including lines from Colorado, Texas, and Montana, and sources from New York, Alberta and Alaska. Total yields ranged from 33.9–43.3 MT/H and US#1 yields ranged from 25.3–34.3 MT/H. The top yielding treatment was a line selection from Texas (TXNS 112) (34.3 MT/H US#1 and 42.6 MT/H total yield) with line selections and sources from Texas and New York yielding statistically similar amounts.

Data on potato varieties provides information to local commercial farmers and gardeners upon which to base variety selection decisions. Data on Russet Norkotah lines and sources illustrates, especially to commercial growers, the extent of variability between lines and identifies those capable of producing the greatest yield.

•Donald E. Carling

Production of reindeer range on the Seward Peninsula

Assessment of range resources is essential in range management. Our goal is to enhance understanding of the link between reindeer foraging strategies and animal production, by collecting data on production of each forage plant species in different habitats during the growing season. This information will be incorporated in future grazing management plans for reindeer ranges of the Seward Peninsula.

Ecosites were originally described and mapped by the Natural Resources Conservation Service (formerly the Soil Conservation Service), to be used in implementing range management plans for reindeer herds on the Seward Peninsula. During May-August, 2000 trends in production of reindeer forages were estimated in eight of these ecosites. Prior to greenup, we randomly established transects and replicate transects in discrete stands within each habitat type. During each sampling bout, we randomly chose locations along each transect. A sampling quadrat was laid down at each location and major reindeer forages were clipped and bagged for oven-drying and weighing. Following weighing, plants were analyzed for nitrogen, fiber, and mineral concentrations. Data loggers were placed in the vicinity of sampling sites prior to May 1st each year to monitor growing degree days (GDD) in conjunction with biomass estimation. Plant phenology was also recorded at each sampling bout.

During 2000, transects representing habitat types were sampled throughout the growing season (early June to mid August) to document changes in forage production of major forage plant species. Biomass was clipped at intervals throughout the summer. Four bouts of sampling were completed, providing a set of regression curves of biomass production of each forage plant species in each habitat versus growing-degree-days. We anticipate sampling additional habitats during 2001.

Most studies examining forage plant biomass production for free-ranging ungulates assess biomass at the peak of the growing season. Few studies document changing biomass production as the season progresses. Reindeer nutritional status is highly attuned to changes in forage plant availability and quality throughout the growing season, in particular during spring when females are lactating. Therefore, a onetime estimate of biomass production for the summer season is unlikely to represent true availability during the entire growing season.

We plan to continue this line of research for several growing seasons, to ultimately document seasonal biomass changes of forage plants in 15 major summer foraging habitats. This kind of information, along with the plant quality data already collected, will help us understand which habitats and forage plants may be critical for reindeer use at different times throughout spring and summer. If Western

Arctic caribou continue to migrate onto reindeer ranges, it may also help us designate refuge areas where reindeer can be held without compromising nutrition.

• *Greg Finstad and Maria Berger*

Reindeer radiotelemetry

The Reindeer Research Program in collaboration with the Natural Resources Conservation Service, USDA, and the Reindeer Herders Association used radiotelemetry to determine movement patterns and habitat usage of Seward Peninsula reindeer. This data will be used by reindeer herders and land managers to identify critical foraging habitats and long-term usage patterns in developing grazing management plans.

Also, the recent expansion of the Western Arctic Caribou Herd onto the reindeer ranges of the Seward Peninsula has caused management problems for herders. Reindeer that have been displaced or swept up by migrating caribou herds can be located and monitored through the use of radio collars.

Locations of satellite and conventional VHF collars were obtained by the NOAA satellite system and fixed wing aircraft. We map the locations with the ArcView (GIS) program and update collar locations on individual herd Web sites. The herder can then view current locations of reindeer on the Internet just prior to conducting herding activities.

Reindeer in six herds were equipped with satellite and VHF collars and their movements monitored during 2000 to determine home ranges, identify and evaluate preferred foraging areas, and establish seasonal movement patterns.

A more efficient management system is possible by integrating radiotelemetry with traditional herding methods. Reindeer herders can monitor their herds for seasonal habitat usage and unexpected movements, and can quickly make adjustments in herd location to use range resources more efficiently or to avoid migratory caribou. Tracking reindeer with satellite radiotelemetry enables researchers, land managers, and herders to obtain a consistent seasonal map of reindeer range utilization. Monitoring the behavior and survival of reindeer commingling with caribou may give us insight into ameliorating the current reindeer/caribou conflict.

• *Greg Finstad, Dave Swanson*

Evaluation of cervical tuberculin tests in reindeer previously sensitized to killed *Mycobacterium bovis*

The object of this study was to evaluate the single and comparative cervical tuberculosis tests, including estimates of test sensitivity and specificity, in reindeer that were sensitized to tuberculosis antigen.

Fifteen female reindeer, maintained by the Reindeer Research Program at the UAF campus, were tested negative for tuberculosis (TB) using the standard single cervical TB test. They were sensitized to TB antigen by an injection of killed *Mycobacterium bovis* organisms, and were then subjected (at 90 days and again at 210 days) to the standard TB tests for Cervids—the single cervical (SCT) and comparative cervical (CCT) tests.

The SCT is a screening test. Animals having a positive response to the SCT are given a CCT to determine whether the response was likely due to *M. bovis* or *M. avium*. The CCT measures increases in skin thickness at the sites where avian and bovine TB antigen are injected into the skin. The changes in skin thickness at the avian and bovine antigen injection sites are plotted against each other in a graph called a scattergram. The CCT results from the reindeer were plotted on the standard, approved Cervid scattergram and several alternate scattergrams. Sensitivity and specificity for the SCT and CCT were calculated.

Sensitivity is a measure of a test's ability to detect infection when it is present, while specificity measures the test's ability to correctly identify uninfected animals. The fewer false negatives or false positives associated with a test, the more useful that test are.

Results to date on TB testing of sensitized reindeer were not consistent with expected results. All ten deer that had been sensitized to *M. bovis* were expected to test positive to the SCT and CCT. While all ten responded to the SCT, the CCT correctly identified only eight of the ten sensitized reindeer as reactors at 90 days postsensitization and only six at 210 days postsensitization. The CCT response declined between 90 and 210 days after sensitization in three deer. Two changed from reactors to suspects and one changed from suspect to negative. One of the controls changed from SCT negative to SCT responder between 90 and 210 days after the test deer had been sensitized. This control deer was a CCT reactor at 210 days.

Sale and interstate movement of reindeer is dependent on negative TB test results. Routine TB tests on many reindeer have suggested that the false positive rates for the SCT and CCT in reindeer are higher than in other Cervids, particularly since there has never been a case of tuberculosis diagnosed in reindeer in the United States. Scientific review of the literature and additional data support this belief. False positive tests have caused the loss of sales and the destruction of valuable animals. This study has demonstrated that false negatives as well as false positives occurred in reindeer. It is the first phase of a project intended to evaluate the current tuberculosis testing regime for reindeer in the United States. This phase is not intended to provide the basis for changes in the testing regime for reindeer. It is designed to collect preliminary data and facilitate future research.

• *Mike Philo, Linda Carpenter, Bert Gore, and Greg Finstad*

Locally produced feed ingredients for use in captive reindeer diets

Commercially prepared reindeer diets are available for use by Alaska reindeer producers. However, the only commercial diets available for these producers contain over 60% imported feed ingredients. Although some ingredients used in reindeer diets must be imported (minerals and vitamins) the remainder of required nutrients should be supplied by Alaskan producers to reduce production costs. The objective of this project is to determine which locally grown feed ingredients and in what proportions can be used in reindeer diets in a nutritious and economic manner.

A diet containing mostly Alaskan grown ingredients consisting of 80% concentrate (dry-rolled barley based) and 20% ground brome hay and was formulated to contain 18% CP, .7% Ca, .5% P, and .7% K. This diet was used in a trial to evaluate palatability and baseline animal performance during 2000.

Although weight gain is an important indicator of diet quality, good reproductive performance of females and calf production is also essential for a successful commercial operation. Reproductive success and calf rate of gain were evaluated during 2000. Reindeer were fed ad libitum throughout the year and eight female reindeer were bred to a bull in September. All eight females dropped viable calves from April 25 to May 4. One adult female died in May due to a non-nutritional related illness. Body weights of females and calves were obtained monthly by holding reindeer in a squeeze chute mounted on a livestock scale.

Male calves gained .39 kg/day and body mass peaked in mid-October. Female calves gained .34 kg/day and body mass also peaked in mid-October. The calf growth rates observed in this study are similar to those found for free-ranging reindeer on the Seward Peninsula where male growth rates are 0.41 kg/day and female growth rates 0.36 kg/day.

We began nutritional analysis of several barley varieties to be used in future feeding studies. A filter bag method of analyzing forages developed was used to determine nutritional characteristics and in vitro true digestibility of five barley varieties. Rumen inoculum for the in vitro digestibility analysis was collected from two fistulated reindeer fed a commercial pelleted ration. Differences in nutritional characteristics of these barley varieties may lead to different responses in reindeer performance.

We now know reindeer will consume, gain weight, and be reproductively successful on a predominately barley-based diet. Utilization of barley grown in interior Alaska could make feeding of Alaskan reindeer economically feasible where the high cost of feed shipped from out-of-state sources has historically been prohibitive.

Results from these initial trials will be used to test diets containing different concentrate sources. Many varieties of barley have been successfully grown in Alaska but reindeer performance on diets containing different varieties is unknown.

• *Greg L. Finstad*

Monitoring climate and grazing conditions on the Seward Peninsula, Alaska

Reindeer on the Seward Peninsula currently exhibit high growth rates and body mass. Growth rates and body size of caribou and reindeer have been shown to be strongly influenced by snow depth, forage quality, and quantity. Yearly variation in forage is influenced by weather and grazing history. We have established weather stations, exclosures, and vegetation plots to monitor weather patterns, grazing intensity, phenology, and species composition of the vegetation communities used by reindeer and caribou. This data may be used to evaluate changes in climate and grazing patterns and the corresponding changes in vegetation and animal production.

Two weather stations, one located on the coast at Rocky Point and one located inland at Pargon Creek, collected hourly weather data during 2000. Precipitation, snow depth, temperature, relative humidity, wind speed, and direction data are available real time via a Web site maintained by the Natural Resource Conservation Service.

Two exclosures were erected in the central Seward Peninsula in 1998. The purpose of these exclosures is to determine the impact of caribou grazing on lichen productivity, biomass removal by caribou, nutrient cycling, and species composition. Vegetation plots were established in 2000 at the exclosure sites to determine the effect of climate change on phenology and species composition. Snow fences were erected and fertilizer applied to plots to imitate changes in climate.

Caribou from the Western Arctic Herd intensively grazed the areas around the exclosures during winter 2000. Assessing the impact of caribou grazing and environmental manipulation will be conducted during the 2001 field season. Additional years of data are needed to establish trends in climate and caribou grazing patterns.

The intensity of grazing and its effects on vegetation communities may be ameliorated or exacerbated by climatic conditions. Monitoring the interaction between climate and grazing will provide researchers, land managers, and reindeer herders with basic knowledge to understand and manage the effects of disturbance on Arctic systems.

• *Greg Finstad and Knut Kielland*

Reindeer research program educational outreach

The Reindeer Research Program implemented an educational outreach program in 1998, for grades K–8 in Fairbanks schools, to increase awareness of reindeer biology, research, and the reindeer industry in Alaska. We continued the program in 2000.

We begin our presentations with a slide show on the history of reindeer in Alaska, reindeer biology, and current herding practices. We incorporate props into the lecture to reinforce the hands-on approach. We include an informal question and answer session at the end of the lecture, followed by a visit with Elsa or Summit, our tamest halter-trained reindeer.

In 2000 we expanded our scope to include high schools. This required an essentially new presentation to be created that emphasized science. We revisited several elementary schools that participated in the program in previous years. The staff were gratified to see that many of the children remembered facts on reindeer biology and adaptations. We also presented the program at several elementary schools for the first time.

Many students have studied northern ungulates during the portion of the school curriculum dealing with Alaska animals. Our educational outreach program is designed to augment their curriculum by discussing the adaptations reindeer have that allow them to survive in their environment, and also discussing the reindeer industry in Alaska.

• *Rhonda Wadeson*

Computerized data collection

The Reindeer Research Program's (RRP) computerized data collection system is designed to provide reindeer herders with a complete and accurate life history record of their herds.

In summer and winter 2000 individual reindeer herds on the Seward Peninsula, Alaska were rounded up for censusing, antler harvest, vaccinations, and tagging. Staff from the RRP recorded demographic data for herd evaluation and support of research projects. Each reindeer was given a uniquely numbered ear tag when first handled, making possible a life history record. Data collected from some herds extends back to 1984. The data was entered into a customized database program, making it available to herders for management decisions.

At the end of the handling season a herd report was sent to each herder describing how many animals were handled, reproductive status of the herd, average weights, and numbers vaccinated.

This information allows herders to make management decisions such as the culling of nonproductive females, establishing appropriate sex ratios, and monitoring calving success and survival rate.

• *Pete Terzi and Greg Finstad*

Determining meat production of reindeer on the Seward Peninsula-Alaska

The objective of this study is to determine meat production of Seward Peninsula reindeer using carcass yield data.

Free-ranging reindeer on the Seward Peninsula are rounded up each winter for censusing, treatments, and slaughter. The majority of the slaughtering takes place in the field. In winter 2000 Reindeer Research Program (RRP) Staff attended these slaughterings. The total body weight and carcass weight were recorded, using portable Tru-Test weighbars, and compared to get a carcass yield percentage.

This project is in its early stages. RRP staff are taking the carcass yield percentages and determining the meat production for reindeer of different sexes and age classes. As the database grows, potential and realized meat production will also be determined for individual herds.

Currently there are three slaughter plants on the Seward Peninsula that will be operational in the near future. The carcass yield information will be used to assist the reindeer herder in determining how many animals, based on the size and sex ratio of the herd, will need to be slaughtered to maximize production of the slaughter plants. This information will not only allow the herder to optimize meat production profits but will also assist them in making herd management decisions.

• *Pete Terzi and Greg Finstad*

Perennial ornamental evaluations

Plant evaluations for 2000 at the Georgeson Botanical garden included 1000 woody and herbaceous perennial ornamentals. New recommended perennials for Interior Alaska that have shown superior hardiness include: *Spiraea miyabei, Delphinium* Centurion Sky Blue', *Sorbaria sorbifolia*, *Solidaster* 'Yellow Submarine', *Veronica* 'Baluriesen', *Centaurea americana*, and *Valeriana officinalis*. *Spiraea miyabei* is particularly valuable because it is a hardy, short-statured, and very ornamental shrub with a long blooming season. One perennial recommended previously, *Hesperis sibirica*, is being evaluated for degree of invasiveness since seeds self sow in the garden.

This research is useful for garden centers, greenhouse businesses, landscapers, and homeowners interested in hardy plant materials.

• *Pat Holloway and Grant Matheke*

Vegetable trials for Interior Alaska

Warm season vegetables grew poorly in 2000 due to very cold, overcast weather in August. 'Shogun' and 'Marathon' broccoli had the highest yields and were the best late-season varieties. Best midseason varieties were 'Eureka' and 'Arcadia'. The best new early season variety was 'Early Dividend'. Best yielding red cab-

bages were 'Sombrero Red' and 'Red Royale' and best green cabbage was 'Dynamo'. Other recommended vegetables include: 'Easter Egg' and 'Snow Queen' radishes, 'Merlot' and 'Bakita' red leaf lettuce, and 'Sangria' bib lettuce. All field tomato cultivars failed to mature, even the normally reliable 'Subarctic 25'.

This information is useful for home gardeners, market gardeners, and seed dealers interested in growing the best vegetables suited to subarctic conditions.

• *Grant Matheke and Pat Holloway*

Photoperiod pretreatments and flowering in cosmos

Cosmos bipinnatus 'Versailles Mix' and 'Sensations Mix' were pretreated with a 15-hr dark period for two weeks as seedlings in the greenhouse to determine if the pretreatment would promote earlier flowering and seasonal cut flower production. Dark-treated plants began flowering three weeks earlier than untreated plants. By July 12, the cumulative number of flowering stems was 40% greater, and number of flowers was 43% greater, in dark-treated plants than in the untreated control. By the end of the season, yields did not differ among treatments. The dark treatment promoted earlier flowering that may benefit producers of field-grown cut flowers.

The cosmos/photoperiod study will lengthen the commercial production season for producers of field-grown cut flowers.

• *Pat Holloway and Grant Matheke*

Growth of lingonberries on soils amended with fish waste and wood chips

Field cultivation of lingonberries (*Vaccinium vitis-idaea*) in soils amended with birch/spruce wood chips and/or uncomposted cannery fish waste showed that vegetative growth was inhibited by wood chips and was best on soils amended with fish waste alone. Nutrient levels, especially available N, increased significantly during the first growing season, and soil pH rose above 7. These changes were temporary and did not cause damage to young rooted microshoots. This research will benefit growers interested in field cultivation of lingonberries.

• *Pat Holloway, Vickie Talbot and Grant Matheke*

Light quality affects flowering of pansy

High-pressure sodium (HPS) lamps are commonly recommended and used in greenhouses and controlled environments. HPS lamps primarily provide light in the yellow and orange wavelengths of 560 to 620 nm. The light quality of incandescent bulbs, often used in desk lamps and home environments, increases from red (650 nm) to farred and longer wavelengths beyond the sensitivity of the human eye. The amount or intensity of light from incandescent bulbs is usually lower than from HPS. However, incandescent bulbs supplying intensities similar to HPS lamps are now available and plant growth can be compared without the differences of light intensity.

Pansy was grown from transplant to flowering at three light qualities. In addition to HPS and incandescent lamps, plants were grown at natural greenhouse light from April to June. The first open flower was observed after an average 56 days from seeding in the incandescent environment. Flowering was delayed 4 days at natural light and 24 days at HPS compared to incandescent lamps. Pansy is known to flower faster under long days with more than 12 hours of light than short days. For long day plants, light with farred wavelengths has been shown to be essential for flowering. The relationship between red (660 nm) and farred (730 nm) wavelengths (R/FR) is often used to summarize the spectral distribution or quality of a light source. The R/FR ratio is 2.8 for HPS, 0.7 for incandescent bulbs and approximately 1.2 for natural light. The frequent use of HPS lamps during the winter months at high latitudes or in controlled environments may not be the best choice for producing plants due to the limited amount of wavelengths beyond 700 nm.

• *Meriam Karlsson and Jeffrey Werner*

Flowering and stem elongation in black-eyed Susan

The initiation and development of flowers is correlated to stem elongation in some plants. Conditions supporting fast flowering simultaneously result in extension growth. 'Toto' is a cultivar of black-eyed Susan with a compact growth habit suitable for flowerbeds and containers. Flowering was recorded 98 days from seeding under natural greenhouse light conditions (March to June) or under high-pressure sodium (HPS) lamps. Plants under incandescent bulbs however, flowered 7 days faster. Plant height at flowering was 12 inches under incandescent light compared to 9 inches under HPS, and 8 inches under natural light.

Gibberellic acid (GA) is a natural plant growth substance involved in stem elongation. Prior to moving the plants to the three light qualities of HPS, incandescent, and natural light, plants were treated with GA in efforts to separate stem elongation from the flowering process. There was no difference in flowering between treated and untreated plants in the incandescent environment. The GA increased the rate of flowering in the HPS and natural light environments to within 2 days of flowering under incandescent light. Plants in HPS or natural light grew 6 inches taller after a GA treatment while height was similar for treated and untreated plants under incandescent lamps. Branching was limited for plants in incandescent light with an average of 5 flowers and buds.

Plants in natural light had 25 flowers and the largest number of branches. The flower number decreased from 25 to 18 in natural light after a GA treatment but increased from 5 to 25 in the incandescent environment. In HPS, GA increased flower number from 5 to 10. Production techniques such as growth regulators, temperature, and light conditions that result in more and faster flowering, can be expected to also promote stem elongation and overall plant height of 'Toto'.

• *Meriam Karlsson and Jeffrey Werner*

Greenhouse raspberry production

Cultural and pest management practices are identified for producing off-season raspberries in northern greenhouses during the winter and spring months. Techniques for managing pests include biological controls and beneficial insects. Commercially available bumblebees are used for pollination. Dormant plants can be kept in cold storage and brought out at staggered intervals for continuous production several months prior, up to, and beyond the normal growing season. 'Tulemeen' is a raspberry variety found to grow and produce exceptionally well under greenhouse conditions. The cold requirement for proper flowering of 'Tulemeen' is fulfilled with at least 1000 hours at 40°F. After transfer to a greenhouse at 60 to 65°F, ripe raspberries are expected approximately 100 days later.

Single cane plants are easier to handle and manage than traditional multi-cane raspberries in a greenhouse setting. Single cane plants can be potted and forced immediately, or kept in a cooler and brought out for later forcing. The productivity of single cane plants from California and Washington was evaluated. In general, the canes from Washington produced more and larger berries than the canes from California. Individual plants produced 14 oz of raspberries during a two-month production period. Individual raspberries produced on canes from California had weights up to 0.15 oz and raspberries on canes from Washington up to 0.2 oz. Greenhouse raspberry production offers opportunities as a high value, off-season crop without competing with any existing local small fruit production.

• *Meriam Karlsson and Jeffrey Werner*

Flowering forget-me-not

Flowering forget-me-not (*Myosotis* sp.) is of local interest and demand as a cut flower and as a flowering container plant. In addition to forget-me-not with blue flowers, local flower shops receive requests for white and pink flowers. The commercial availability is scarce and recommendations for flowering, production, and post-harvest handling are limited.

Eight varieties of forget-me-not, including selections with white and pink flowers, were evaluated for rate of development, flower display, and growth habit. Six weeks after seeding the temperature was dropped to 42°F. The temperature was increased to 60°F after eight weeks. Time required for flowering at 60°F varied from a few days to more than four weeks depending on variety and management of the plants. Pinching the plant at the beginning or end of the 42°F treatment resulted in faster flowering compared to plants left intact. In addition, the plants produced more branches and flowers when they were pinched either prior to or at the end of the cold treatment. The number of branches varied from three to four without a pinch and increased to between eight and twelve on pinched plants.

• *Meriam Karlsson and Jeffrey Werner*

Grain and oilseed crops variety trials

Spring grains, principally barley and oats, along with grass hay constitute a majority of the feed base for domestic livestock in interior Alaska. Straw from the grain fields is also valuable as a source of livestock bedding, mulch, and construction material. Performance tests are conducted at several locations each year to evaluate established varieties and new genetic materials from Alaska, Canada, Sweden, Norway, and Finland for adaptation to Alaska.

Replicated plots of small grains, oilseeds, and alternative crops were planted under dryland conditions at Fairbanks, Delta Junction, and Palmer, and under irrigation at Delta Junction. New varieties from foreign countries and genetic materials developed from barley breeding work in Alaska are compared to standard varieties for grain yield, early maturity, and resistance to lodging and diseases.

A new six-row feed barley, 'Finaska', was released in 2000. This new variety was extensively tested along with experimental lines originating from crosses involving 'Otal', the most popular feed barley variety in Alaska, and 'Thual', a hulless feed barley. Even though the growing season was wet and cool, irrigation significantly increased grain yields, especially for the later maturing varieties.

New crops and improved varieties are important for Alaskan farmers to remain competitive. Also, new varieties developed for Alaska are often beneficial to northern Canada and other circumpolar countries.

• *Charles Knight*

Constructed wetlands

Constructed wetlands are commonly used in more southern climates as biofilters for cleaning up stormwater runoff and sewage effluent. Many remote villages in the North have primitive wastewater treatment facilities or no facilities at all. Constructed wetlands offer a potentially low maintenance, cost effective means of treating wastewater in Alaska. However, for subarctic environments, no information is available concerning the type of vegetation to be used, the tolerance of indigenous plants to high

nutrient levels or heavy metal contamination, the efficiency of those plants in cleaning the water, the best means of propagating and establishing the selected wetland species, or the length of season during which the wetland would be effective. We evaluated five genera of plants indigenous to Alaska: *Typha latifolia, Menyanthes trifoliata, Carex rhynchophysa, Scirpus latifolia* and *Arctophila fulva*.

In a greenhouse study, plants were watered with solutions contaminated with cadmium, copper, lead, and zinc. Plant tolerance to each metal was evaluated, and the plants were harvested and analyzed for accumulation of metals. Also, an experimental wetland was constructed and vegetated with those plant genera. Wastewater effluent from a swine lagoon on the Fairbanks Experiment Farm was circulated through the constructed wetland and water quality was monitored before and after treatment.

The wetland has been operating effectively approximately three months each summer for the past three years. Almost all treated wastewater samples have met Alaska's wastewater treatment standards. This study has been completed and a Ph.D. dissertation and journal articles are currently being prepared to disseminate the information.

Since this project has been started, wetlands have been constructed and information from this research has been used in several areas in Alaska.

• *Charles Knight and David Maddux*

Tillage methods for cropland

In interior Alaska, preservation of soil moisture during spring tillage and planting is essential for successful crop production and reduced wind erosion. This study compares four methods of seedbed preparation, three levels of straw removal from the field, and four levels of nitrogen fertilization for spring barley production.

This six-acre tillage study has been continued at the same location near Delta Junction since 1983. Factors monitored include: barley yield, weed populations, soil organic matter content, soil aggregate stability, and soil fertility.

A single disking operation immediately prior to spring planting has been the most effective tillage practice. Under no-till, perennial grassy weeds become so competitive that those plots must be chemically fallowed about every five years. Fall tillage knocks down too much stubble, resulting in loss of snow cover and less soil moisture. Straw removal practices have not yet shown a significant effect on either soil properties or grain production, although we expect continuous removal of crop residues to eventually reduce soil organic matter content. The current recommendation is to apply 65 to 70 lb fertilizer N per acre.

Approximately 6,000 acres of spring barley are grown in interior Alaska each year. This study helps in establishing recommendations for barley, as well as best management practices for fallowing soil and growing other crops in Alaska.

• *Charles Knight and Stephen Sparrow*

Turfgrass care and survival

Turfgrass is very important for Alaska lawns, golf courses, parks, and recreation fields. The principal objectives of this study are to evaluate turfgrass species and varieties for growth and survival, to evaluate various fungicides for control of snowmold and other fungi, and to compare a seedbed of 100% sand to a mixture by volume of 85% sand and 15% peat.

We constructed a putting green and planted sections of it to 'Nugget' Kentucky bluegrass and 'Penncross' bentgrass. On these sections, we have been evaluating fungicides for effectiveness. We have also constructed raised-bed plots with either 100% sand or a sand/peat mixture. These plots are subdivided into 200 subplots. The subplots are planted to 25 types and/or mixtures of turfgrasses.

All grasses survived the first winter, but the application of fungicides was very beneficial for reducing fungal damage. During the first summer, grasses appeared to grow best on the pure sand seedbed, but nutrient deficiencies were apparent in all plots. Additional research needs to be done on fertilizer types and applications. Unfortunately, during the second winter, the study was destroyed by vandals on snow machines and only a few plots with 'Nugget' bluegrass survived. Further turfgrass research is being continued at the Palmer Research Center.

This research will be valuable to thousands of homeowners in Alaska as well as to golf course and recreational turf managers. Golf courses have become a multi-billion dollar industry in the United States and there are currently over a dozen golf courses in Alaska.

• *Charles Knight*

Leafy green vegetable trials

Head lettuce, cabbage, radicchio, and other leafy greens were planted in cultivar trials to observe yield and quality when grown in Alaska's cool soil temperatures and long hours of daylight.

Trials of head lettuce have been planted in the Mat-Su Valley since 1995. In 2000, fourteen cultivars were planted in May and June on two commercial farms. The selected cultivars included two that are commonly planted (Alpha and Premiere), standard type (Salinas), tipburn susceptible type (Calicel), and recent releases (Bayview, Jupiter, and Venus). Lettuce seedlings were transplanted into field plots after growing in a greenhouse for one month. When the majority of lettuce heads were firm, all the lettuce was harvested and assessed for head weight, size, and marketability (freedom from disease and defects).

At Palmer Research Center, trials of cabbage (12 cultivars), radicchio (9 cultivars), and leafy greens (9 cultivars) were planted in 2000. Cabbage seedlings were transplanted in early May. Radicchio and greens were seeded directly into field soil in June.

For lettuce, the average weight of marketable heads was 1.9 to 2.2 pounds. The average percent of marketable heads ranged from 83% (Cypress and Alpha II) to 21% (Calicel, a cultivar that often had tipburn, slime, white mold and split heads). The lettuce trials showed the problems of tipburn and disease when large frame cultivars are grown early in the season during the long days. For cabbage, most cultivars had an average weight of 2 pounds. The percent of marketable heads was lower than expected, probably due to plant competition for soil nutrients and water stress early in the season. The long season cultivar, Loughton, did not produce any marketable heads from any of the 80 plants. In the radicchio trial, all cultivars produced small heads less than six inches in diameter, possibly because they were seeded late, in June rather than May. In the greens trial, arugula grew well while mache was small.

Leafy green vegetables including head lettuce, cabbage, and specialty greens are grown on commercial farms in Alaska. Cultivar trials can demonstrate which cultivars are well-adapted to local growing conditions because differences in quality and yield are compared under the same growing conditions.

• *Roseann Leiner*

Baby lettuce and greens

Fresh green salads are healthful, popular, and convenient in salad bars and bags of salad mix. "Baby" lettuce and greens are produced by planting seeds in a thick band and harvesting young leaves after 3 to 5 weeks of growth. Baby lettuce and greens can contribute a variety of color and taste to salad mixes. The yield and quality of some available cultivars was assessed.

In 2000, 31 cultivars of lettuce were planted at a high density, usually at least 48 seeds per foot. When leaves were 4 to 6 inches tall, the leaves were cut above the growing point. For each cultivar, the number of plants and weight of leaves was recorded. In a separate trial, 12 cultivars of *Brassica* greens were grown.

Both lettuce and greens grew well when cultivated and harvested for baby leaves. For baby greens, Kyona mizuna had the highest average yield of 3.7 pounds per 10 feet of row in the first harvest and 2.5 pounds per 10 feet of row in the second harvest. In general, the yield of Asian greens (*Brassica rapa*), such as mizuna, mibuna, and tatsoi, was higher than the yield of mustard greens (*Brassica juncea*) and kale. Baby lettuce had similar yields and numerous shapes and colors of leaves. Yield may be less important than a variety of leaf color, shape, texture, and taste. Each cultivar can make an interesting addition to salad mixes.

Baby greens and lettuce are easy to grow. In a home garden, the leaves can be picked minutes before a meal for a fresh salad that appeals to the eye and palate. For commercial production, the quality of baby lettuce and greens will depend on careful harvest, handling, and transport because the young leaves are delicate. Local production of salad mixes has potential as a value-added product that is miles fresher than salad mix shipped from outside the state.

• *Roseann Leiner*

Growth rate of white mold

White mold is a disease of vegetables caused by the fungus *Sclerotinia sclerotiorum*. In Alaska, white mold can damage vegetables and flowers. Isolates of this fungus were collected from diseased vegetables and cultured to measure the growth rate at cool temperatures.

In 2000, over 200 isolates of the fungus *Sclerotinia sclerotiorum* were collected from lettuce with symptoms of white mold. The isolates were cultured in the laboratory and stored for experiments during the winter months when selected isolates were transferred onto potato dextrose agar, placed at several temperatures ranging from 39ºF to 72ºF, and measured for radial growth.

Isolates of *Sclerotinia sclerotiorum* grew rapidly as white mycelium. When growth reached the edge of a petri dish, small clumps (2-20 mm) of white mycelium develop into hard, black structures called sclerotia. Black sclerotia are characteristic of *Sclerotinia sclerotiorum* and can survive for years in soil. White mycelium and black sclerotia developed at all temperatures tested. At 72ºF, growth was rapid and occasionally irregular. At 39ºF, growth was slower but possible, demonstrating that white mold can develop in refrigeration as well as cool weather.

White mold disease, caused by the fungus *Sclerotinia sclerotiorum*, is found worldwide. White mold can cause yield losses in Alaska when sclerotia grow in cool moist soil and infect plants. Understanding the biology and diversity of white mold isolates from Alaska can help to develop effective control measures.

• *Roseann Leiner*

Molecular mechanism of biological control in *Trichoderma atroviride*: chitinolytic activities of *T. atroviride* under different environmental conditions

Trichoderma atroviride is a versatile biological control organism found in Alaska with strong disposition against a wide range of plant pathogens, even at low temperatures. Most commercial *Trichoderma* products require elevated temperatures to be active as

biocontrol agents, whereas Alaska strains are active at a wide temperature range. *T. atroviride* coiled around, penetrated into, and lysed the mycelia of *Botrytis cinerea, Coprinus psychromobidus, Fusarium nivale, F. solani, Phytophthora infestans, P. capcisi, P. cactorum, Pythium* spp*., Rhizoctonia solani, Sclerotinia borealis, S. sclerotiorum*, *Typhula* spp*.,* and *Verticillium dahlia*.

To help determine the role of chitinases in the mechanisms of mycoparasitism, chitinase activities of Alaskan *T. atroviride* isolates were determined in plate assays through the quantitative degradation of glycol chitin both in the presence and absence of plant pathogens. In addition, glycol chitin degradation plate assays were conducted under environmental differences with respect to light and temperature.

In general, Alaskan *Trichoderma* strains produced a burst of chitinase activity between 48 and 72 hours following plating. In addition, production of chitinase activity did not seem correlated to biological activity against plant pathogens and production of chitinolytic activity was dependant on environmental factors.

• *Jenifer H. McBeath*

Isolation and comparative characterization of an endochitinase gene from *Trichoderma atroviride*

The mechanisms of biological control of plant pathogens by antagonistic fungi have been a subject of many studies. Most of these studies have dealt with antagonistic organisms controlling soilborne pathogens under moderate to high temperature ranges in the soil. Development of biological control agents adapted to cold climates has been quite limited.

Trichoderma atroviride is a versatile mycoparasitic biological control organism found in Alaska, with strong dispositions against a wide range of plant pathogens, even at low temperatures and extreme environmental conditions. Because the 42 kD endochitinase of *Trichoderma harzianum* has been implicated as a component in the inhibition of plant pathogens, specific primers corresponding to the flanking region of the 42 kD endochitinase gene were used to amplify corresponding genes in several *Trichoderma* strains.

A 1.4 kilobase major amplification product was observed in most of the *Trichoderma* strains. Sequence analysis and comparison of the major amplification product revealed greater than 95% similarity to the published sequence of the 42 kD endochitinase gene from *T. atroviride* and single nucleotide differences in the endochitinase genes between strains were observed. Further studies are ongoing to determine if the observed single nucleotide differences may have an effect on the amino acid sequence resulting in potential conformational changes in the corresponding protein.

• *Jenifer H. McBeath*

Development of an autofluorescent marker system in *Trichoderma atroviride* for analysis of genes associated with biocontrol

Current knowledge of how *Trichoderma atroviride* controls fungal plant pathogens at the molecular level is incomplete and poorly understood. Once genes have been identified which are associated with biological control, further analysis is necessary to determine what role these genes may play in biological control. For this purpose, it is necessary to develop a transgenic system for expression of biological control associated genes. Since *T. atroviride* strains are highly resistant to antibiotics, another method of utilizing selectable markers is necessary for transgenic expression studies.

In this study, we have developed a marker system using a yellow genetic variant of the green fluorescent protein from the jellyfish *Aequorea victoria* for selecting transgenic *T. atroviride*. Two expression vectors were utilized carrying the *Neurospora crassa mtr* and the *Aspergillus nidulans gpd*A fungal specific promoters and the *A. nidulans trp*C terminator. A 0.8 kb insert containing an Enhanced Yellow Fluorescent Protein (EYFP) gene was engineered downstream from the promoters of two fungal expression vectors. Constructs were transformed into *T. atroviride* strain 901 using electroporation. Transformants were assessed for fluorescence and phenotypic variability with respect to phytopathogen inhibition.

Genes associated with biological control of pathogens may be inserted into each autofluorescent fungal expression vector to assess differences in biological control activity associated with enhanced expression. In addition, the engineered plasmids are highly suitable reporter vectors for visualization of *T. atroviride* in the rhizosphere.

• *Jenifer H. McBeath*

Efficacy tests of *T. atroviride* in controlling *Phytophthora infestans* on potato seed pieces

Phytophthora infestans is an extremely aggressive plant pathogen. It has a temperature range of 4ºC–26ºC. Under high relative humidity conditions, *P. infestans* can cause severe late blight disease on potato, tomato, eggplant, and other Solanaceae plants and result in heavy economic losses. Presently, management of late blight disease relies primarily on chemicals. Because none of the fungicides are curative, to achieve control, complete and repeated coverage of foliage with fungicide is needed prior to disease pressure. This practice is costly economically and environmentally. Furthermore, increasing evidence indicates that diseased seed tubers or pre-cut seed pieces play a significant role in the dissemination of *P.*

infestans. None of the fungicide treatments appeared to be effective in reducing tuber rot in storage or late blight spread in pre-cut seed pieces.

Laboratory, greenhouse and field trials to determine the effects of application of *T. atroviride*, with a temperature range of 4ºC–33ºC, on potato sprouts as seed treatments were conducted again in 2000. Simulations tested were seed pieces infection occurring during cutting. The experimental design was of a split-block fashion with three replicates. Treatment variables included *T. atroviride, T. atroviride* plus alder bark, Maxim MZ (chemical fungicide), alder bark control, *P. infestans* control, and blank control.

Experiments in the simulations were accomplished by inoculating the cut surface of healthy seed potatoes with *P. infestans* and then treating the inoculated seed pieces with *T. atroviride*. Results of these experiments demonstrated that *T. atroviride* is equal to and better than Maxim MZ. Similar to experiments conducted in 1999, no difference was found between inoculated seedpieces treatment with *T. atroviride* and the blank control as to the numbers of plants emerging. Furthermore, plant emergence from seed pieces treated with *T. atroviride* was faster and more uniform.

• Jenifer H. McBeath, W. Kirk and B. Niemira

Efficacy tests of *Trichoderma atroviride* in controlling damping off of cotton

Efficacy studies were conducted in a commercial cotton field in Tranquility, CA, to determine the affects of *T. atroviride* in the control of damping off disease and on the germination and growth of cotton. Plant Helper, (the trade name of *T. atroviride*), containing *T. atroviride* spore suspension at 10^6cfu/g, was applied on a commercial cotton farm.

The Plant Helper, at the rate of 15 lbs per acre, was applied as in furrow treatment at the time of planting. Two swaths of six (a total of twelve) half-mile long rows were treated in alternate with untreated controls. Plant samples were taken from treated and untreated plots two months after seeding. Measurements were made on plant height, fresh weight, and root length. Evaluations were also made on disease incidence and severity on the roots.

Pythium spp., *Rhizoctonia solani* and *Fusarium* spp. were found to be causal agents in the reduction of cotton germination and development. Statistic analyses performed were t-test, Tukey's Studentized Range Test, and Bonferroni t-test for the multiple comparisons. Statistically significant differences were found on all parameters measured between treated and untreated seedlings. Seedling density in cotton fields treated with Plant Helper was significantly higher than in the untreated control. Seedlings from plots treated with Plant Helper were significantly bigger with larger and healthier root systems.

• Jenifer H. McBeath, W. Mao, C. Nyugen, and Keith Eubanks

Efficacy tests of *Trichoderma atroviride* in controlling diseases on ginseng

Panex quinquefolius (American ginseng), cultivated as a high value specialty crop in Wisconsin, Minnesota, New York and many provinces in Canada, is widely used in natural herbal remedies. Plant diseases are the primary limitations to ginseng production and quality. Soil fumigation and routine application of chemical fungicides have been the primary strategies for disease control on ginseng.

Concerns about food safety and the environmental effects of fungicides have also led to increased restriction of their use. Resistance of pathogens to iprodione, metalaxyl, and other chemical fungicides makes disease control increasingly difficult. *Trichoderma atroviride*, a versatile beneficial fungus found in Alaska, has a strong disposition against a wide range of plant pathogens, including those that affect ginseng plants.

In 2000, efficacy studies were conducted in commercial ginseng gardens in Wausau, WI, to determine the affects of *T. atroviride* in the control of early season diseases (caused by *Pythium* spp.) and rusty root diseases on ginseng plants. The plots, on two-and-one-half acres of non-fumigated land, encompassed ten bays of seedbeds. *T. atroviride* (Plant Helper) and *T. viren* (SoilGard) were biological control treatments. Quadris and Diathane M-45 were applied during the growing season to all seedlings to suppress foliar diseases.

• Jenifer McBeath, T. Parent, K. Baurman, and R. Kreig

Development of premium quality Alaska seed potatoes

Geographic isolation and harsh winters provide Alaska an environment relatively free of diseases and pests. In Alaska, contaminated seed potatoes are the primary source of virus, bacterial ring rot, and late blight disease. The objectives of this project are to identify the source of the disease by conducting field disease survey and lab tests and by assisting producers in their efforts to produce premium quality seed potatoes, by providing them crucial information such as field survey and lab results. By incorporating the information in their management, many potato producers were able to produce seed potatoes free of viruses, bacterial ring rot and late blight diseases. This project is sponsored by the State of Alaska as a part of the Virus-Free Seed Poatato Program.

In the summer of 2000, more than 600,000 data points were collected from seed lots of 13 farms. We

found seven farms completely free of the six virus diseases tested for: potato virus X (PVX), potato virus Y (PVY), potato virus A (PVA), potato virus M (PVM), potato virus S (PVS), and potato leaf roll virus (PLRV). No late blight was found on any of the potato plants examined. Low incidences of bacterial ring rot (BRR) and bacterial soft rot were found in one tablestock potato farm in Palmer.

Another objective of this project is to evaluate the performance of Alaska seed potatoes grown under Taiwan's environmental conditions. In the field trials conducted at four locations in Taiwan, Alaska seed potatoes consistently outperformed those of seed potatoes (same variety) produced locally. Alaska seed potatoes also appeared to possess stronger resistance to diseases.

• Jenifer H. McBeath, Peter Gay, M. Ma and Takako Yokogy

Evaluation of lettuce varieties for tip burn, *Sclerotinia* basal rot and *Botrytis* grey mold disease resistance

Tip burn, a physiological disease caused by calcium deficiency, is one of the most important diseases on lettuce in Alaska. The rapid growth of lettuce due to the extremely long day-length during the growing season makes lettuce particularly prone to this disease. Basal rot caused by *Sclerotinia sclerotiorum* and grey mold caused by *Botrytis cinerea* can also be very severe under certain environmental conditions. Damage to lettuce production caused by these diseases has resulted in great economic losses to lettuce farmers each year. Treatments such as applications of calcium in the soil or top dressing were all found to be ineffective.

A lettuce variety trial was initiated in 1991, in collaboration with Mr. P. Sorreal (lettuce breeder, Harris Moran Co.) and vegetable farmers in Palmer. In 2000, Ms. P. Giauque and Mr. Ben VanderWeele, both lettuce and cabbage growers in Palmer, participated in the lettuce variety trials. Sixty-four lettuce varieties and breeding lines were evaluated in early and mid-July. Approximately 50 seedlings were planted for each lettuce line.

Disease occurrence of tip burn on lettuce was fairly severe. Several varieties and breeding lines were found to possess fairly good resistance to the disease. Infestation of *B. cinerea* and *S. sclerotiorum* was present this year. In one farm, severe infestation of *S. sclerotiorum* was observed on cabbages.

• Jenifer H. McBeath, Philip Sorreal, P. Giauque and Ben VanderWeele

Dairy research at northern latitudes

New Alaska guidelines for Confined Animal Feeding Operations (CAFO) are now in place. A key provision of those guidelines is management of amount, source, placement, form, and time of application of nutrients present in animal waste, in a manner that will minimize agricultural nonpoint pollution of surface and ground waters. This project will assist dairy producers through establishment of best management practices for forage and feed production, waste nutrient management, and extension activities related to dairy herd management.

Dairy waste application rate, source, and method and time of application studies on bromegrass and oats continued in 2000-2001 and were evaluated for yield and residual nutrient recovery. First-year nitrogen recovery efficiency (NRE) for bromegrass was 45% and 41%, respectively, for the 1X (10,000 gal/A) and 2X (20,000 gal/A) liquid manure applications compared to 48% and 60%, respectively, for equivalent fertilizer rates. The fate of unrecovered nitrogen should be clarified by second and third year data as well as results from the nitrogen mineralization work in progress.

Overall, second-year forage yields from plots receiving onetime liquid dairy waste application declined as residual nutrients were depleted; only the 2X liquid manure rate produced significantly more brome forage than the unfertilized control in the second year. Residual soil inorganic nitrogen under permanent grass was highest among treatments where liquid manure was applied; however, the residual nitrate remained primarily in the top six inches of soil and does not appear to pose a potential leaching problem. Soil nitrate distribution and nitrogen recovery under annual oats is still being evaluated.

Results from the time and method of manure application trial on bromegrass demonstrated that residual nutrients from 1999 applications benefited 2000 forage yield and quality when compared to control treatments, regardless of time or method of application. Overall trends for nutrient-use efficiency appear to support spring application where the manure is injected below the soil surface.

Outreach funding from this project was used to defray travel costs of assisting Alaska Dairy Producers in attending the Western Dairy Management Conference in Nevada. Representatives from six dairy farms participated in the scholarship opportunity and heard nationally recognized experts discuss dairy cow breeding and reproduction, nutrition, disease control, and other dairy herd management topics.

Results from this project are being made available to USDA-NRCS to assist them in developing CAFO nutrient management criteria specific for Alaska producers. The information will provide producers with a means of meeting water quality protection guidelines and assist them in reducing costs of dairy operations.

• Allen Mitchell, Ray Gavlak, Milan Shipka, Stephen Sparrow

Wet soils monitoring and hydric soils study in Alaska

This study develops a baseline data set of key soil properties through the annual cycle in wet soils across the boreal and arctic regions of Alaska, in order to adjust national definitions of hydric soils for northern environments. The study also assesses soils under various Alaska conditions as to the impact of climate and climate change on properties of wet soils in Alaska, and compares results with data being collected for soils from arctic to temperate regions in alpine and arctic environments.

Key soils in the arctic, interior, southcentral, and southeastern regions are equipped with automatic monitoring instrumentation that measures and records important soil climate parameters including sir and soil temperatures, soil moisture, reduction-oxidation potentials, precipitation, solar radiation, and wind throughout the entire year. Soils are monitored for change in conditions affecting biological activity in soils, such as oxygen, temperature, and moisture status.

Soil monitoring sites continued collecting data through the year including soil temperature, unfrozen water content, and oxidation-reduction potential for soils across Alaska. Soils at monitoring sites in arctic Alaska were examined at monthly intervals as thawing of the active layer progressed. During June, coastal plain sites were thawed to a depth ranging from 10 to 25 cm, for soils with organic layer thickness ranging from 20 to 0 cm, respectively. As the season progressed thaw depths increased from 30 to 50 cm for the same sites in August.

Both moist and wet nonacidic tundra types were reduced and had relatively anoxic conditions (deficient in free oxygen in soil air and water) to the point where free reduced iron (Fe II) was evident throughout the thawing soil from 5 cm deep to the frost table. By the latter part of July and in August soils within the ice wedge polygons under moist tundra micro high sites, were oxygenated with little or no Fe II. Soils of micro-low areas within the polygons remained anoxic. Soils under wet tundra remained anoxic through July and August with Fe II present to the surface under both micro-high and micro-low sites.

Arctic foothill site soils thawed deeper than coastal plain soils in both June and July. Foothill soils with no organic surface layers were thawed to a depth of 15 to 36 cm in June increasing to maximum of 45 cm in July and greater than 50 cm in August. Frost-scarred areas between tussocks, or in wind exposures where mineral soil is brought close to the surface by frost action, showed anoxic conditions and Fe II was present from 5 cm deep to the frost table throughout June, July, and August. Micro-sites with thick moss layers of 20 cm or more retained moisture in the thawing soil and were generally reduced with Fe II present at 5 to 10 cm above the frost for June through August. The boreal forest site at Coldfoot showed no signs of reduced Fe at anytime during the season samplings from June through August.

The definition and identification of hydric soils has been impacted along with wetland delineation in northern ecosystems. Conditions that result in soil biochemical and morphological properties vary from temperate to cold regions. This project allows connections to be made between actual observed conditions in the northern regions and soil properties that are used in determination of both hydric soils and wetlands. These actual on-site observations provide a regional database to support wetland and hydric soil delineation for northern ecosystems and determine the regional differences as they may exist. Based on four years of monitoring, soil temperatures at 50 cm in most arctic soils are below 5˚C, thus the definition of biological zero at 5˚C does not fit the arctic environment.

• *Chien-Lu Ping, Gary Michaelson, Ron Paetzold and Vladimir Romanovsky*

Winter carbon flux and soil organic matter in arctic tundra

Soil respiration and carbon dioxide evolution continues during the cold-season under the controls of soil organic substrates, temperatures, and unfrozen water contents. Soil microorganisms shift to more water-soluble substrates to support respiration as temperatures drop below freezing. In order to understand winter CO_2 flux from soils, it is necessary to understand these substrate stocks that are available in the soil to support cold-season respiration. The purpose of our study is to characterize and quantify soil water-soluble organic matter and determine if these stocks relate to cold-temperature respiration observed in soils from arctic ecosystems.

Soil incubation trials were conducted in the laboratory using 88 soils collected from six field flux-study sites. These sites represent the major arctic Alaska ecosystems, from the coastal plain in the north to the transition to boreal forest in the south. Rates of respiration at –2°C were compared to soil stocks of both total and water-soluble organic carbon present. Water-soluble organic substrates were characterized for each soil and soil stocks were characterized at each site and compared across ecosystems.

Results of –2°C incubations for all soils indicated that there is indeed a good correlation between water-soluble organic carbon stocks and respiration rate in organic surface layer soils, and for higher respiring organic-enriched mineral soils. Soils in permafrost layers had increased water-soluble organic carbon substrate levels and higher respiration rates. The highest respiration rate was found in an organic enriched soil from the permafrost layer with 17.8% organic carbon. High levels of substrates and high

respiration rates were associated with surface organic soil from sites at the forest-tundra transition zone.

The organic soil surface layers from all sites with shrub vegetation had high respiration as well as the organic layers from *Eriophorum* tussocks. Stocks of water-soluble organic carbon in soils did not correlate to total OC levels. These results point to how important it is that we recognize the soil substrate use shift, when attempts are made through modeling to describe cold-season respiration.

Soil active layers and upper permafrost layers are exposed to temperatures that are within a few degrees of –2°C for periods each year that vary from several weeks to months. Our results indicate that when soil permafrost and active layers are exposed to extended periods of cold-season temperatures around –2°C their potential for respiration of CO_2 is strongly influenced by the amount of water-soluble organic carbon present. In turn, amounts of water-soluble carbon present in soils are influenced by factors such as the presence of permafrost or cryotubated carbon (carbon levels enhanced by frost action). The presence of woody and shrub vegetation apparently increases levels of water-soluble substrates in the organic layers, and surface lichen-moss vegetation increases substrate levels in underlying mineral soils.

Results from this project will provide insight into controls on gas fluxes from soils of the arctic system for the cold-season, a period where up to 60% of emissions can occur but about which little is known. We provide real soils data as a basis for models describing winter flux of carbon to the atmosphere for the arctic system, and ultimately the arctic model will be an essential part of an improved global climate model for prediction of the impacts of climate change.

• *Chien-Lu Ping and Gary Michaelson*

Morphogenesis of cryosols in the alpine zone of Tienshan, West China

The objectives of this study are to characterize the cryogenic soils in the Tien Shan region and to test the newly adapted Gelisol order in Soil Taxonomy in the alpine regions of Western China.

A joint research project was initiated between SALRM, the Cold and Arid Regions Environment and Engineering Research Institute (CAREERI), and the Chinese Academy of Sciences to study the soil climate of alpine and plateau environments. The soil landscape relationship was investigated in the Upper Urumoqi River Basin of the Tienshan Mountain Range, Xingjing, China. Soil study sites were then selected on representative landforms. Soil pits were open and soil morphological properties were studied then soil samples were taken from soil horizons and shipped to the USDA National Soil Survey Center laboratory for characterization analysis.

Cryosols (permafrost soils) were found occurring in glaciated valleys and north-facing toeslopes at elevations above 3000m. Most Cryosols developed in moraine are Aquiturbels. The microrelief is dominated by earth hummocks, thus the surface organic layers are either discontinuous or broken due to frost action. The Bg horizons are either gleyed or mottled and frost-churned organic matter is common in the lower Bg horizons. Stratified horizons and buried organic or A horizons are also common on gentle sloping or undulating moraines indicating the effects of gelifluction.

The active layer thickness ranges from 140-200 cm. The Organic Cryosols (Hemistels) occur in depressions and north-facing toeslopes with an active layer thickness ranging from 90-110 cm. Soils formed on south-facing slopes have a mollic epipedon 20-25 cm thick and strong brown cambic horizons and are classified as Haplocryolls. A total of four automated soil climate monitoring stations were set up and two of them were equipped with deep borehole monitoring sensors to monitor the alpine permafrost stability.

The study provided baseline data for alpine soils and also provided an opportunity for field-testing Soil Taxonomy, the official US soil classification system that is designed to encompass soils of the world. The study also provided site-specific information for soil climate monitoring stations in western China, as part of the worldwide active layer monitoring project designed to provide baseline data for climate change models.

• *C.L. Ping, L. Zhao and R.F. Paetzold*

The effects of bull exposure on reindeer cow estrous activity

The objective of this study was to investigate the effects of reindeer bull exposure on the onset of the reindeer cow breeding season, and to investigate whether cows with calving experience responded differently than cows with no previous reproductive experience.

The bull was removed from cows more than two months prior to the start of this experiment and housed at a separate facility approximately 2 km distant. Blood samples were collected from cows 3 times weekly beginning on Aug. 11, 2000 (day 1) and continuing until Sept. 29, 2000 (day 50) and plasma was stored frozen for later assay of progesterone (P4). On day 6, cows were divided into two groups such that group one (early bull exposure, EBE), consisted of four cows that had calved the previous spring and four cows that had no reproductive experience. Group two (late bull exposure, LBE), consisted of three cows that had calved the previous spring and three cows that had no reproductive experience. The EBE group experienced bull introduction on day 13, 23 days earlier than the average onset of ovarian activity during 1999. The LBE group experienced bull introduction on day 46, 10 days later than the average onset of ovarian activity during 1999.

Previous reproductive status had no effect on the onset of ovarian activity within the EBE reindeer or within the LBE reindeer. Time of bull introduction had a significant effect on the onset of ovarian activity when the EBE group was compared to the LBE group. The EBE reindeer initiated ovarian activity 12 day after bull introduction, two weeks earlier than normal. The LBE reindeer initiated ovarian activity 5 days before bull introduction. Results indicate that bull management affects the onset of the breeding season in reindeer cows, regardless of previous reproductive experience

Reproductive management is an important factor in profitability of livestock production. Reindeer producers have the potential to improve the profitability of their business by improving management of reproduction in the reindeer enterprise. Results from this research will provide important information that will allow reindeer producers to manipulate animal management routines, benefiting reproductive success in their herds.

• *Milan Shipka*

Long-term tillage practices and soil properties in central Alaska

The objective of this study was to determine the effects of long-term tillage and small grain crop residue management practices on various soil chemical, physical, and biological properties in a subarctic environment.

This study was part of a long-term tillage and crop residue management experiment which is in its 18th year in central Alaska. The study area was cropped to barley each year except in occasional years when chemical fallow was used to control weeds. Tillage treatments consisted of: disk-twice (disked each autumn and spring), disked-once (disked each spring), chisel-plow (tilled with a chisel plow each fall), and no-till (no tillage done). Crop residue management treatments consisted of leaving all residues on the plots following harvest, removing loose residues but leaving standing stubble, or removing all above ground residues.

For purposes of this study, we sampled only the no-till, disk-once, and disk-twice tillage treatments and treatments with all residues left on the plots or all residues removed. Soil samples were collected in spring prior to all tillage operations and in fall following harvest. Soils were analyzed for total carbon (C) and nitrogen (N) (indicators of soil organic matter), microbial biomass C and N, mineralizable C and N (indicators of potential soil organic matter turnover), pH to determine if acidification has occurred), and wet aggregate stability (indicator of soil structural stability and thus resistance to erosion).

Results were highly variable, but in general, total C and N and mineralizable C were lowest in the disk-twice treatment and were similar in the disk-once and no-till treatments. Microbial biomass C was highest in the no-till and lowest in the disk-twice treatment; microbial biomass N was little affected by tillage treatment. Soil pH was not affected by tillage treatments. Soil wet aggregate stability was highest in no-till and lowest in the disk-twice treatment. Crop residue management had little effect on any of the soil properties measured.

This research is important because it helps us to understand how crop and soil management practices affect important soil properties in a subarctic environment.

• *Stephen D. Sparrow, Charles W. Knight, and Carol E. Lewis*

No-till forage establishment

The overall objectives of this project are to assess the effectiveness of no-till forage establishment for renovation of degraded pasture or hay-lands. The specific objectives are to: 1) evaluate the efficacy of no-till planting as compared to planting, following conventional tillage under various fertilizer nitrogen rates for establishing timothy or smooth bromegrass in Alaska; 2) evaluate promising annual crops for forage production and as nurse crops during grass establishment in no-till and conventional planting systems; and 3) determine the effectiveness of no-till seeding of forage grasses and red clover at various seeding rates.

Experimental plots were established on farmers' fields at two locations in Interior Alaska and four locations in Southcentral Alaska. For objective 1, Manchar smooth bromegrass (Interior Alaska and Palmer locations) or Engmo timothy (other southcentral Alaska locations) were no-till seeded or seeded into tilled soil. Nitrogen fertilizer was applied with the seed at rates of 0, 15, 30, or 60 lbs/acre. For objective 2, oats, annual ryegrass, and fodder rape were planted as companion crops with smooth bromegrass or timothy. Crops were seeded into tilled soil or untilled sod. For objective 3, smooth bromegrass or timothy and red clover were seeded into untilled sod at 0.5X, 1X, or 2X the normal seeding rates. Above ground plant material was harvested each year, separated into weeds and crops, and dry matter yields were determined.

No-till seeding resulted in poor germination and low dry matter production at the Palmer and Interior Alaska sites. The no-till seeded crops did not generally recover enough to equal that of the conventionally seeded crops at those locations in years subsequent to the seeding years. At the other Southcentral Alaska locations, no-till seeding generally resulted in good yields, often exceeding those seeded into tilled soil. Inclusion of companion crops resulted in higher total yields, but reduced bromegrass or timothy yields as compared to seeding grass alone.

Yields for all nurse crops except oats were generally lower in no-till than when planted into tilled soil. Grass seeded with companion crops usually recovered enough by the second year following establishment to equal yields of grass seeded alone. Red clover germination was very poor and yields were essentially zero-under all seeding rates at Delta Junction and grass yields increased slightly as seeding rate increased. Red clover established well at other sites, with little effect of seeding rate.

This research will provide farmers in Alaska with better recommendations for reestablishing forage crops in degraded pastures or hay fields.

• *Stephen Sparrow, Beth Hall, and Raymond Gavlac*

Forage crop variety trials in Interior Alaska

The objective of this study is to screen forage crop species and cultivars for adaptation, yield, and forage quality potential under various climatic and soil conditions in Interior Alaska.

Forage legume and grass species and cultivars were planted at several locations in Interior Alaska. Plants were harvested at early flowering and herbage yields determined. Samples were analyzed for various forage quality attributes.

Among the grasses, perennial ryegrass produced the highest yields (sometimes as high as 3 tons/acre) during the seeding year. However, it did not survive after one growing season, and thus must be treated as an annual crop under Interior Alaska conditions. Annual ryegrass headed very early in the season, prior to much vegetative growth, resulting in low yields and poor quality forage. Among the perennial grasses, smooth bromegrass generally produced highest yields in years subsequent to the establishment year. Forage legumes generally yielded considerably less than grasses, although alfalfa and red clover yields sometimes exceeded 1 ton/acre.

This research will provide farmers with recommendations for forage crop varieties adapted to their area.

• *Stephen Sparrow*

Crops for game-bird cover

A relatively new use of farmland in Alaska is to release and then allow hunting of game-birds. Owners of such operations have asked the Agricultural and Forestry Experiment Station for recommendations on crops to plant which will provide good cover for birds but will not greatly inhibit movement of hunters and dogs and will stand up under snow.

The objective of this project is to evaluate several plant species that can be grown in Alaska and will meet the criteria listed above for good game-bird cover.

Several crop species were planted in 2000 at Fairbanks and in the Eielson Farm Area and evaluated for their effectiveness as cover for game-birds. None of the species tested were found to be suitable. Other species were planted at Delta Junction and Fairbanks in 2001 and are currently being evaluated.

This research will provide operators of shooting preserves with recommendations for cover crops.

• *Stephen Sparrow*

Production and harvest of quality forage at northern latitudes

Production of quality forage for hay and silage in the subarctic is difficult but is a high priority for Alaska dairy farmers. We are evaluating varieties for winter survival, harvest timing, and grass-legume mixes for long-term persistence and quality.

Nugget bluegrass, Arctared red fescue, and Garrison creeping foxtail were dropped from the 1993 grass species trials based on continued low yields in 1999 and 2000. Dry matter production in the remaining bromegrass, timothy, and reed canarygrass species in 2000 was significantly lower than in 1999, ranging from 3.3 to 4.3 ton/A for Polar bromegrass and Palaton reed canarygrass, respectively. Average grass yields (all species) in 2000 was 3.8 ton/A compared to 5.6 ton/A in 1999 and the reduction is attributable to drier conditions, particularly in May and June of 2000.

The 1999 Palmer seeding rate/N application study with Altaswede red clover interseeded with Vantage reed canarygrass showed mixed results. Individual treatment dry matter production ranged from 2.9 to 5.4 ton/A. Altaswede check plots produced no measurable production and showed minimal survival in plots interseeded with reed canarygrass. Neither residual N nor seeding rate of either reed canarygrass or red clover significantly affected yields in the second year.

In contrast to essentially no survival of Altaswede red clover at Palmer, in trials at Point McKenzie in which red clover was interseeded with timothy grass, red clover produced over 4.9 ton/A when averaged over two years. Lack of snow cover from winter winds at Palmer is largely responsible for the red clover winter kill. Forage analysis of quality parameters for these and other grass and grass/legume production systems are being performed.

Success of dairy production in Southcentral Alaska will depend to a great extent on the on-farm production of high quality forage. Winter survival and yield of new varieties and combinations coupled with outreach transfer of production information has assisted the resurgence of in-state milk production.

• *Stephen Sparrow and Ray Gavlak*

Forest Sciences

Stream temperature response to timber harvest activities in Interior Alaska

This project is dealing with several questions associated with the direct and indirect effects of timber harvest activities on stream temperature regime. The focus is on answering, or at least exploring, questions pertinent to Interior Alaska streams: Can ice-bridges increase ice thickness such that fish or fish habitat might be negatively affected? Can we predict how ice thickness will respond to alterations in construction techniques and weather? How does summer water temperature change as a function of downstream distance, regardless of local buffering by riparian vegetation? Finally, can stream temperature be affected by broad-scale changes in watershed vegetative cover, independent of riparian buffers?

I will be exploring these questions by a combination of literature reviews, simulation experiments, and field measurements. Knowing undisturbed river ice thickness in a channel segment from historical records or from ongoing measurements, various models of ice growth as a function of freezing-degree-days will be tested. I will use a layered model to account for ice thickness changes associated with either buildup of ice bridge surfaces or with the removal or compaction of snow. To understand the changes in summer stream temperatures with distance downstream I will be making stream temperature measurements on selected streams and also using a range of simple to complex computer models to explore the dynamics of water temperature and sensitivity to riparian shade.

An annotated bibliography of ice thickness and ice-bridge construction indicates that ice thickness can be enhanced by ice bridge construction, due to snow removal and/or compaction. In fact, this enhancement and acceleration of ice growth is an objective of ice-bridge construction. While there is a limit to ice thickness attainable, due to air temperature regimes, that would restrain potential problems to cross-sections with less than 2 meters of water, issues of floating ice-bridge buoyancy and displacement need to be considered further. In general, the best salmon habitat is in areas of upwelling and prolonged ice-free openings in the river. These are not attractive cross-sections in which to build an ice-bridge from a strength and safety perspective.

Analysis to date indicates that the effects of steam-side timber harvest on stream temperature is limited in interior Alaska by low sun angles, cold water temperatures, and mixing effects downstream from areas affected by timber harvest. This result is qualified by scale factors. At the pool-riffle scale, and in channels wide enough not to be shaded by non-tree vegetation, local temperature increases can be observed. These effects, however, are difficult to detect downstream from the harvest area or in high order channels, due to mixing and normal energy exchange.

Parts of this work have contributed to a recently published report by the Alaska Dept. of Natural Resources to the Alaska Board of Forestry, entitled *Region III Forest Resources & Practices: Riparian Management Annotated Bibliography*. This report and discussions surrounding it have led to proposed changes in the Alaska State Forest Practices guidelines for Region III. I anticipate additional useful results as the project advances.

• *John Fox*

Duff moisture dynamics in black spruce feathermoss stands

In the Alaska Interior ground fuels, usually feathermosses, are the predominant fire carrier. The depth of ground fuel consumption in this fire adapted ecosystem determines fire severity and hence post-fire succession. It is the moisture content of the ground fuels that largely determines ignition probability and depth of burn.

The Canadian Forest Fire Danger Rating System's (CFFDRS) Fire Weather Index (FWI) attempts to model the moisture content profile of the forest floor with three fuel moisture indexes. The system was empirically derived in forests near the 48th parallel, which typically do not exhibit the deep ground fuel component common in boreal forest types. Despite this fact, the system is currently used throughout Alaska for evaluating fire danger and as a guide in a variety of fire management activities, including prescribed fire planning. The overall objective of this research was to characterize the forest floor fuel structure, to measure their moisture regimes, and then to compare the latter to those modeled by the FWI fuel types.

To enhance understanding of how the feathermoss ground fuels of the boreal forest ecosystem might be incorporated into the FWI, an intensive sampling study was conducted over the course of five months in the Alaska Interior. The feathermoss mat in the study area (Ft. Wainwright, AK) was composed of *Hylocomium splendens* and *Pleurozium schreberi*. Four distinct fuel layers were found in the organic mat. The layers were defined as Live Moss, Dead Moss, Upper Duff and Lower Duff. Bulk densities and drying rates were used as a guide for identifying,

sorting and combining the four fuel layers into the three fuel moisture classes incorporated in the FWI.

The FWI fuel moisture codes showed strong correlation with moisture contents of the different fuel layers over the course of the fire season. This indicates that general drying and wetting trends in the ground fuels are being tracked with the FWI. However, the variance in moisture content between sampling sites for a given FWI fuel moisture value suggests that the FWI still needs refinement for consistent fire behavior prediction and achievement of prescribed fire objectives.

Wetting and drying rates in the four fuel types were significantly different, lending additional support to the fuel type stratification. The wetting and drying rates inherent in the FWI were not consistent with those observed in the forest floor. Early in the fire season the fuel moisture content predicted by the FWI was considerably overestimated in the upper and lower duff. At the end of the fire season the reverse was true.

The consequences of relying on a fuel moisture prediction system that has not been locally validated can have far reaching effects. The tendency of the CFFDRS FWI to overestimate early season fuel moisture can lead to underestimates of fire behavior and fire severity. This affects all facets of fire management from pre-attack suppression planning to long-term resource objectives defined in prescribed fire plans. The results of this study have been communicated in various forms to the Alaska Fire Service, the U.S. Forest Service, and the State Dept. of Natural Resources. A Master of Science degree has been completed.

• *John Fox*

Ectomycorrhizae on disturbed lands in Southcentral and Interior Alaska: a comparison of regional similarities and differences

Ectomycorrhizae (EM) are symbioses of fungi on roots of certain plants where the fungi help the plants obtain nutrients and moisture from the soil and the plants provide the fungi with a source of energy (carbon). Successful restoration needs not only plants but their EM fungi. We know that different EMF occur with different substrates (e.g. mineral vs. organic), but we do not know how similar the EMF are across a latitudinal gradient. Are the early successional EMF relationships in the Brooks Range similar to those of the Kenai Peninsula?

The primary objective of this project is to compare ectomycorrhizal communities in early successional sites across a latitudinal gradient in Alaska, to determine whether there are similarities in species of ectomycorrhizal fungi and plant species and to assess feasibility of a common inoculum or strategy for revegetation. A secondary objective on selected intensive sites is to determine whether early successional fungal morphotypes are still present in midsuccession.

Primary successional sites (recently deglaciated, floodplains, and mining) and mineral soils of a secondary successional site (prescribed burn) are being evaluated by two methods: collecting roots from individual plants, where the roots can be traced to selected plant species; or soil/litter cores in intermediate successional stages where the tangle of roots may preclude tracing roots to the host plant.

During 2000, root collections were made from FrostFire (see separate summary), Exit Glacier, and Muldrow Glacier chronosequences. Exit Glacier roots in the mature cottonwood forest (*Populus balsamifera* ssp. *trichocarpa*) were collected using cylindrical root-litter corers at points spaced 250 m apart. National Park Service personnel had discovered a buried forest that had been buried by debris during the last glacial advance. The trees were C-dated to about 1000 years before present. However, the most exciting part was that some of the original soil appeared to be relatively intact, and the roots had EM sheaths.

• *Dot Helm*

Role of mycorrhizae in ecological recovery following a prescribed burn on permafrost in the boreal forest

FrostFire was a prescribed burn in the Caribou-Poker Creek watershed in July 1999. This watershed is dominated by black spruce (*Picea mariana*) and mixed hardwood forests. Fire alters vegetation and microbial communities either directly or indirectly through changes in soil and environmental characteristics. Understanding the post-fire recovery will depend on documenting pre-fire plant–mycorrhizal relationships, and then following mycorrhizal succession over time. The objective was to characterize ectomycorrhizae by substrate in black spruce and mixed hardwood forests before and after a prescribed burn.

We used a cylindrical corer to collect roots from hardwood (paper birch, *Betula papyrifera*, and aspen, *Populus tremuloide*) and black spruce (*Picea mariana*) communities inside and outside (control) the proposed burn site before and after the fire. The samples were divided by obvious horizons in the substrate, although this differed among the sites. The roots were washed free of soil and organic material in the laboratory, then the mycorrhizae are being described and the mycorrhizal communities quantified.

The year 2000 was the first full growing season after FrostFire was ignited, and samples were collected in both June and August in or near permanent plots. Although the burn was patchy, portions of the black spruce forest plot near the stream were burned to mineral soil, and most trees were uprooted. In the

unburned areas, some samples are showing clear stratification of EM morphotypes that were visible in the field, supporting the concept that EM fungi may be associated with different substrates. Over 20 morphotypes have been described so far, mostly from pre-burn samples. Several types are distinctly different from the Exit Glacier samples while at least some EM morphotypes, e.g. *Cenococcum geophilum*, are present in both areas.

Understanding the types of ectomycorrhizal fungi that colonize after fire and the types of substrates they may use may help identify fungi suitable for revegetation or bioremediation applications.

• *Dot Helm*

Black spruce and climate

The objectives of this study were to find out the relationship of temperature and precipitation to the growth of black spruce, trends in the climate favorableness for the growth of black spruce, and the age structure of black spruce in the Caribou-Poker Creeks Research Watershed.

We collected 120 tree disks cut at breast height (137 cm) from 3 stands in the watershed. We counted tree-rings and measured ring-width in all disks. For 31 trees a disk section was also cut at ground level, allowing a measurement of the number of years required for growth up to breast height. We compared the growth of 76 trees that had measurable rings from 1940 through 1999 to monthly temperature and precipitation at Fairbanks during the same period.

Only seven trees had measurable rings prior to 1924, the year a wildfire occurred in the watershed. The earliest rings in the seven oldest trees were from 1806 to 1825. Of the 31 trees with both basal and breast height disks, 21 grew to breast height in 15 years or less, a much faster rate of growth than black spruce trees achieve later in life. The great majority of the post-1924 fire black spruce achieved less than 0.5 mm average radial growth during their life, a slow rate of growth compared to trees on sites with commercial forest potential. Radial growth was at a maximum 20 years following the fire and then declined steadily. Radial growth of these black spruce is strongly negatively correlated with April and May temperature (trees grew best in cold years, worst in warm years), and positively correlated with February temperature in the year prior to ring growth.

Black spruce stands make up over half of the Alaska boreal forest and are very important in the fire cycle because they burn frequently and spread fire readily. Although some old black spruce occur in the watershed, most trees established promptly after the 1924 fire and a few trees continued to establish for the next 40 years. After a 20 to 30-year period of very rapid height and diameter growth, black spruce growth slows markedly. More frequent fires would sustain more of the landscape in more rapidly growing young stages of forest development. The warm climate in the last three decades of the 20th century has been less favorable overall for black spruce growth than the earlier 20th century.

• *Glenn Patrick Juday and Kenji Yoshikawa*

200 years of summer temperature from white spruce tree rings

The earliest climate records in Interior Alaska begin in 1904. This study was designed to reconstruct climate in the 1800s based on the relationship between tree-rings and climate at Fairbanks since 1906, when instrument-based records are continuous. The Interior region of Alaska experienced a rapid climate warming in the 1970s, and another goal of this study was to look at the rate of temperature change over a nearly 200-year period.

We compared the ring-width, carbon 13 isotope content, and the density of latewood of white spruce tree-rings collected at 3 sites across Interior Alaska to long-term climate records at Fairbanks. We used principal components analysis to identify statistically significant relationships between the tree-ring properties and monthly temperature and precipitation. Based on these relationships we then used tree-ring properties alone to reconstruct climate in the 1800s when climate records are not available.

Ring-width was influenced by 2 years of weather (year of ring formation and 1 prior year), so it was not as useful as latewood density and carbon 13 content for reconstruction. We were able to reconstruct mean summer (May through August) temperature. Summer temperatures followed a pattern of 1 to 3 decade-long periods of characteristic temperatures with restricted variability, which we call temperature regimes.

Change between regimes is quite abrupt, and usually takes place in 1 or 2 years. We developed a standard numbering system for Interior Alaska summer temperature regimes and identify 4 regimes in the period from the earliest 19th to the early 20th century and 2 regimes in the 20th century. These regimes were characterized by cool, warm, hot, warm, cool, and hot summers respectively. Temperature regimes of the 19th century exhibit generally high levels of moisture stress (13C signal) and low radial growth consistent with a dry continental climate influence.

The highest sustained summer temperatures in the climate record occur in the most recent climate regime since the 1970s, but we reconstruct a nearly equally warm summer temperature period in the 1820s and the 1860s and 70s. The strong warmth in the 1800s in our results is the opposite of cooler conditions reconstructed from treeline trees across the western North American Arctic. Further research will be necessary to explain this contradiction. From the perspective of 200 years, the first regime of the 20th century was a uniquely favorable period of low mois-

ture stress, moderate summer temperatures, relatively high precipitation, and very high radial growth for white spruce, consistent with a stronger maritime influence.

• *Glenn Patrick Juday, Valerie Barber, and Bruce Finney*

Seedling tree growth at Reserve West plot

This study is a long-term monitoring project in the Bonanza Creek Experimental Forest and Long-Term Ecological Research site that measures survival and height growth of seedlings and saplings in an area burned in the 1983 Rosie Creek Fire.

All white spruce seedlings in a 100m by 100m hectare (2.47 acres) have been mapped and annual survival and height growth measured since 1988.

As of the end of the 2000 growing season, 2,402 white spruce seedlings are in the database, including 2,120 currently alive and 282 that have died since they were first encountered. Apparently, at the low to moderate density of stems in the monitored portion of the Reserve West stand, mortality of seedlings over the 12 years of monitoring has been low (11.7%). The mean height growth of all white spruce seedlings in the year 2000 was 12.5 cm, a 146.7% increase over 1999 and the highest measured in the series. Nearly all seedlings belong to the 1983, 1987, or 1990 seed crops. Only 17.4% of seedlings alive in 2000 are from the 1983 seed crop. Mean height growth in 2000 of the 368 live seedlings from the 1983 seed crop was 24.8 cm, a 133.5% increase over 1999, for a mean total height of 161.7 cm.

The 1983 seed crop seedlings are the best positioned for eventual dominance of the site, and are in transition between the ground-layer of vegetation and an emerging forest canopy. The acceleration in height growth in 2000 is correlated with significantly cooler summer temperatures in 1999 and 2000 than in the previous 25 years, and the occurrence of relatively abundant and well-timed rain in the summers of 1999 and 2000. The Reserve West hectare plot is typical of highly productive upland forest sites, and the trends reported here should have wide applicability to sites managed for the production of wood products.

• *Glenn Patrick Juday*

Forest productivity

Productivity of Northern Forest lands is commonly estimated using height-over age-curves called site index curves; such curves are species specific. Curves are not available for all species; existing 30-year-old curves are inadequate because they are based on a single, average guide (anamorphic) curve. Our data and published curves from elsewhere document that productivity curves for Alaska species are polymorphic—that is, they have different shapes for different levels of productivity.

The first balsam poplar/black cottonwood curves and equations have been published; new Alaska paper birch/Kenai birch curves have been reported as part of a thesis. No curves or equations exist for tamarack and black spruce in Alaska.

Four healthy, vigorously growing trees are selected from pure, single-age stands; trees must be at least 50 years old and contain no advanced decay or serious environmental damage. Trees are felled, measured for total height, and disks are removed at 4-foot intervals. Disks are measured for diameter, rings are counted, and individual ring widths are measured. Height-over-age curves are plotted for each tree and regression analysis is used to develop site index curves.

In 2000, stem analyses and curve fitting were completed for 248 aspen; the report is scheduled to be completed in mid-2001. Initial field sampling was completed for 46 black spruce sites (186 trees). The review of data sets suggests that additional sites are required.

When completed, equations and graphs will permit objective assessment of site productivity for each species so that sites can be ranked for management and investment purposes. Comparison between species is not possible until adequate number of permanent and temporary sample plots is established to determine per acre fiber volume.

• *Edmond C. Packee, Sr.*

Reforestation stocking standards

The objective of this study is to determine for Alaska's Northern Forest species the effect of planting espacement on stem size and characteristics, yield per acre, stand structure, and wood quality. A second objective is to recommend espacement guidelines for both Alaska's Northern Forest and Coastal Forest species.

Espacement is the distance between trees. Espacement impacts forest tree characteristics which in turn affect stand structure, wood quality, wood volume per acre, and ecological process (especially succession and soil processes).

Levels-of-Growing Stock (LOGS) plantations with espacements of 4x4, 6x6, 8x8, 10x10, 12x12 feet were established at two locations (Bonanza Creek near Fairbanks and at Tok). Survival and height have been measured annually. Once the majority of trees reach one-inch in diameter at breast height or 15 years of age, diameter will be measured and plots will then be measured at three or five year intervals. An ongoing literature review addresses the impact of espacement on tree characteristics. To ensure that aboveground competition is only that of the species being studied, hardwoods and conifers are routinely removed. Review of the literature and of operational practices elsewhere provided the initial espacement

guidelines for both Northern Forest and Coastal Forest species.

Plots at both Bonanza Creek and Tok were remeasured and cleaned of competing vegetation. The 10-year results for Bonanza Creek were published. At Bonanza Creek, height growth of white spruce at 15 years of age continues to be least at the narrowest and widest espacements. Diameter growth at Bonanza Creek will be measured in spring 2001 before growth begins—most trees are measurable, with many trees over one inch in diameter. Understory vegetation distinctly differs between the widest and narrowest espacements; at narrowest espacement crown closure has occurred and self-pruning has begun. Observations in spruce indicate that gall aphids (*Adeleges* and/or *Pineus*) severely attack spruce in open-grown conditions; a senior thesis has been proposed to determine the insect and the impact.

Initial espacement guidelines are a discussion point in terms of the Alaska Forest Practice Regulations and Guidelines. At the narrowest espacement, the grass, *Calamagrostis canadensis*, a commonly strong competitor, is weak and being crowded out whereas in the wider espacements it is present, forms a sod, and is a vigorous competitor for summer moisture. This suggests that dense stocking of spruce may biologically control the grass.

• *Edmond C. Packee, Sr.*

Permanent sample plots (PSPs)

The objective of this study is to establish a network of PSPs throughout the Northern Forest of Alaska for the development of growth and yield models, continuous forest inventory, continuous wildlife habitat inventory, and monitoring forest health, change, and biodiversity.

PSPs provide a long-term, continuous inventory of forest stand conditions and are the basis for yield conditions. PSPs provide the basic yield data that are accessed through site index curves.

A network of one-tenth acre plots are being established in representative forested stands throughout the Northern Forest. Within each stand, three square plots are established and described in terms of geology, topography, general soil characteristics, and plant community. Individual tree characteristics are measured and presence and cover-class of each understory species are determined. Five regeneration plots are located systematically within the PSP and regeneration by species is tallied and measured. A second set of 196 plots, selected yield plots (SYPs) that monitor treated stands (spaced, thinned, partial harvested) are similar to PSPs except for treatment and are measured at regular intervals.

During the summer field season 100 PSPs were established in southcentral Alaska bringing the total number of PSPs to 331. First five-year remeasurements were completed on 66 mixed hardwood plots (22 stands). Data entry for all existing PSPs and SYPs continues and is expected to be completed by mid-2001. Earlier evidence that mixed stands, or mature stands that originated as mixed stands, do not regularly fill-in with spruce at a rate sufficient for stands to become fully stocked was confirmed by calculating stand density indices for the plots.

Our data suggest that many sites are capable of producing greater amounts of fiber than current inventory information suggests—an increase in forest management intensity will lead to increased annual allowable harvests. Opportunities for thinning natural stands appear to be much more limited.

• *Edmond C. Packee, Sr.*

Early height growth of Northern Forest trees

This study develops models of the early height growth patterns of Northern Forest tree species under operational conditions, with early emphasis on free-to-grow white spruce plantations, hardwood dominated white spruce plantations, natural white spruce stands, and then other species. Early height growth data, for the first 10 to 20 years of growth, is essential for comparing growth of crop trees under different conditions, for development of forest resource management models, and for comparison with growth and models of other regions.

This study uses methodology developed and tested on Levels-of-Growing-Stock white spruce plantations. Internodal stem growth, the distance between annual whorls, is measured to nearest centimeter. Nineteen operational plantations were selected based on age and free-to-grow status, west of Fairbanks in the Tanana Valley. The plots contained 25 trees. Because of the likelihood of "current" growth being dependent on previous years' growth, precautions must be taken to avoid autocorrelation problems. Regression analyses are being used to develop the initial model.

A literature review for white spruce was completed; data have been obtained from other regions. Statistical analyses were completed. A draft M.S. thesis addressing free-to-grow white spruce height growth will be finalized during 2001.

The "free-to-grow" height growth models developed in this study can be used to evaluate height growth of other regenerating stands (plantation and natural) and thus evaluate the success of the regeneration effort. The model will, for white spruce in Alaska, predict age range at which free-to-grow status is reached, age for trees to reach breast height, and the early growth pattern or trajectory for yield forecasts.

• *Edmond C. Packee, Sr. and Jamie Hollingsworth*

Individual tree volume equations and tables

Accurate tree volume equations and tables are essential as forest-products markets and opportunities become more competitive and utilization standards improve. This study addresses concerns with current equations including: differences among tables for a given species; negative volumes for small trees; lack of standard procedures among tables; which tables should be standard (seller vs. buyer); use of equations developed for one species for another species (e.g. white spruce for black spruce).

The objectives are to develop new individual tree cubic-volume tables and equations and taper equations for Northern Forest species using standard procedures, and to test the suitability of statewide equations versus regional equations. Initial emphasis is on white spruce, to be followed by black spruce, and then by the other species.

Only cubic volume equations and tables will be developed; these can be readily converted to weight. Measures such as cords and board feet do not address solid fiber content and are influenced by operator skill and equipment. A standardized procedure is used for all species. We measure total tree height and then diameters at four-foot intervals beginning with a six-inch stump. Wherever possible, commercially harvested or trees cut for land clearing are used—the major exception being small, noncommercial trees less than five inches in diameter. Cubic volume of each section of a sample tree is calculated and then the section volumes are added together. Regression analysis of all sample tree volumes for a species is used to make user-friendly equations or tables based on tree height and diameter breast high (4.5 feet). Equations permit obtaining volumes for the total tree and for various top diameters inside and outside bark.

Analysis of Tanana Valley white spruce data indicate that tree volume equations for the Tok and Fairbanks areas are similar; equations for Delta Junction area trees are different. The difference is likely due to the much smaller sample of trees from the Delta Junction area; additional sampling is currently underway and will be completed in 2001 before finalizing white spruce volume equations for the Tanana Valley. During 2000, additional funds were obtained to sample black spruce in 2001-2002 with emphasis on the Tanana Valley.

New equations and tables will replace existing ones statewide. Once equations are tested and accepted for the Tanana Valley, equations will be developed for other regions and statewide. Improved equations and tables will improve timber sale cruise efforts, forest inventory, flexibility in marketing trees, forest management growth and yield forecasts, and ecosystem models requiring tree (stem) volumes.

• *Edmond C. Packee, Sr. and Tom Malone*

Disturbance history in the Tanana Valley

Humans have influenced ecosystems and biodiversity through time—both unknowingly and deliberately. Intervention in natural processes, especially fire control and use, impacts long-term forest health and ultimately the local economy and the subsistence lifestyle. Preliminary information suggests that human impacts were and are much greater than commonly perceived.

The objective of this project is to document historical information concerning human-caused disturbance to Northern Forest ecosystems in Alaska and implications for forest resource planning and ecosystem management. A combination of literature review, archival search, personal interviews, and site searches is used to determine locations, types, and extent of human-caused disturbance.

In 2000 a paper was published describing some of the early activities. Efforts were initiated to determine location of pre-statehood sawmills in the Tanana Valley—the remnants of one mill were on a barge on the shore of a major interior lake. Work was begun on a paper describing early harvest methods and silvicultural systems suitable for Alaska's Northern Forest.

• *Edmond C. Packee, Sr. and James Roessler*

Close forest fiber utilization: ethanol production

Extensive areas of Alaska's Northern Forest consist of unmerchantable fiber for traditional forest products; additionally, a considerable portion of every merchantable tree contains unmerchantable material (bark, tops, branches). Unmerchantable forest biomass could be used as alternatives to fossil fuel and to meet human needs such as clean-burning biofuels.

Initially objectives were quite straightforward: to determine fiber need and availability for a 300-350 tonne per day plant, to identify fiber supply sources, and to identify additional fiber supply information requirements. During 2000 a fourth objective was added, to determine high-value chemicals and pharmaceuticals that can be extracted/distilled from Alaska Northern Forest species.

Ethanol production is typically associated with standard agricultural crops such as corn and barley. Use of tree biomass greatly reduces fossil hydrocarbon requirements since disturbance occurs only two or three times during a rotation and natural soil processes maintain or restore soil fertility. The Paszner process, which can utilize any vegetation biomass, is feasible and cost effective, especially since it can handle both conifer and hardwood fiber; ethanol per gallon production cost is less than one-half that of other processes and below 1999-2000 wholesale gasoline prices.

Alaska Forest Refinery, Inc. inquired about fiber supply in the upper Tanana Basin and adjoining areas. A review and analysis of all existing published forest fiber inventories for the upper Tanana Valley (east of Delta Junction) and adjacent areas and estimates of fiber quantity (cubic feet and tonnes) available from private lands and annual allowable cut capabilities were reported. Additionally, a literature search of potential chemical and pharmaceutical products from Northern Forest species with possible expansion to minor species will be done beginning in 2001.

Fiber quantities and annual allowable cut estimates were made from published inventory reports for major private entities holding adequate fiber supplies. Extensive areas of dwarf black spruce forest stands exist throughout the Northern Forest, however, no growth and yield data exists. A New Crops grant was secured to investigate the growth and yield of black spruce.

High value of chemical and pharmaceutical extracts and distillation products was confirmed—current high value products range from $500 per gram (one birch product) to $2 gram (one spruce product). It is uncertain at this time whether non-tree species should be treated as part of this project or become a new entity. The Paszner process continues to be superior to other ethanol production processes currently known.

Based on progress to date, Alaska Forest Refinery, Inc. is continuing pursuit of venture capital for a facility near Tok. Once on-line, the plant would employ approximately 125 persons year-round plus woods workers and truckers. Creating a market for otherwise unmerchantable-sized material should improve small forest product firms and operators profitability. Improved utilization standards will increase fiber value. Forest chemical and pharmaceutical products have potential to broaden the industrial base of Alaska's interior and to develop new industries and additional employment opportunities. Forest fiber use for ethanol replaces fossil fuel and associated production of greenhouse gases.

• *Edmond C. Packee, Sr.*

Phytochemicals from Alaskan Northern Forest species

This project, initiated in late 2000, is a direct outcome of the "Close Forest Fiber Utilization: Ethanol Production" project previously presented. Foliage, bark, wood, and sap of woody plants are a relatively untapped renewable source of chemicals that include foodstuffs, pharmaceuticals, health-care products, cosmetics, and industrial chemicals.

Paper birch is not native to non-coastal Alaska. Kenai birch is endemic and Alaska paper birch is also found in northern Canada west of Hudson Bay. The investigation of the chemistry of these species has been minimal; a major question exists with regards to how the chemical contents relate to paper birch in eastern North America.

Alaskan birches are tapped to produce syrup; paper birch has pharmaceutical potentials—one compound is being tested as a cure for herpes. Aspen is a source of aspirin. Spruce contains vitamins and tannin; an extract from the bark is an antioxidant. Opportunities for the largely uncommitted Northern Forest resource of Alaska are exceptional.

Initial objectives of this project include: in conjunction with other growth and yield program activities, to determine productivity of the forest to provide appropriate biomass (individual tree volumes and stand volumes of small wood); to identify potential chemicals, quantities, values, and extraction methods for each woody species and; to compare chemical contents of Alaskan woody species with the same or similar species elsewhere.

The methodology is to extend volume data collection to small diameter and short trees (under 4 inches and 25 feet tall) and revise equations as necessary. We then determine stand volume for dwarf forest stands currently not included in most inventories because of noncommercial size of trees. Ultimately data collection will be extended to include bark volume or weight of bolewood, branch wood and bark, and foliage. A literature search will be conducted to obtain phytochemical information with primary, but not exclusive, emphasis on tree species. Based on the results we will develop protocols and cooperative efforts to compare chemical composition.

This project is in its infancy. Funding was obtained to collect tree volume data and limited stand volume data for dwarf stands of black spruce for 2001-2002. Similar data will be collected from dwarf stands of other species as time permits.

Based on preliminary information the value potential for chemical products is enormous. The potential for a sustainable, non-petroleum based chemical and pharmaceutical industry is high because of the low commitment of the forest resource to more traditional uses (lumber, pulp, composite wood products).

• *Edmond C. Packee, Sr.*

Understory influences on soil processes

We examined the influence of *Ledum palustre* (Labrador Tea, a common understory plant species in Interior Alaska boreal forests) on nitrogen availability and soil microbial activity. We compared the influence of *Ledum* on these processes in both organic and mineral horizons from underneath *Ledum* patches with those from nearby areas lacking *Ledum* in laboratory incubations.

Mineral soils associated with *Ledum* had significantly lower net nitrogen mineralization and higher

CO_2 production compared to the *Ledum*-free controls, suggesting a higher nitrogen immobilization rate. Comparable effects were not found in the organic horizon. High concentrations of phenolic compounds in foliar water leachates suggested that they might be important.

We incubated *Ledum* and *Ledum*-free soils with litter leachates that also contained these phenolics. Leachates substantially increased net nitrogen immobilization rates in both cases, but only in the short term. That difference resulted in increased total net N immobilization. Incubations with ^{15}N confirmed that these differences were primarily the result of increased gross immobilization (i.e., stimulation of microbial activity) rather than decreased gross mineralization (i.e, allelopathic depression of specific kinds of microbial activity). These laboratory studies indicate that leachates from throughfall under dense *Ledum* canopies could limit N availability to other species, including the aspen and birch trees in the overstory.

• *Eva Castells and Dave Valentine*

Soil respiration and responses to disturbance

We examined soil respiration in a variety of situations in order to identify the responses of respiration (microbial and plant) to fire in black spruce and hardwood ecosystems (mostly funded by NSF through the Frostfire project). A second objective was to evaluate the relative contribution of roots and microbes to soil carbon dioxide efflux along a temperature gradient in black spruce forests (jointly funded with NSF through the BNZ LTER project).

Results from the Frostfire experiment indicate that soil respiration declines markedly following fire, and does not recover within the first two years (measurements are continuing). Early results from the microbial/root separation study indicate that trees in colder soils contribute proportionately less to the carbon flux than do trees in warmer soils. This suggests that either tree growth or respiration is more constrained by temperature than are microbial growth and respiration. We will include an ongoing nutrient availability study in a future synthesis of this work to determine the relative potential of warm-cold forests to respond to increasing soil temperatures.

• *Jason Vogel and Dave Valentine*

Use of radar to map waterfowl habitat

Many of the river systems in Interior Alaska have lakes with water levels that fluctuate with river water levels. These drawdown lakes are important habitat for dabbling ducks and geese since they provide abundant food in terms of annual seed crops and invertebrate populations. They also provide open mud flats for visibility of mammalian predators and escape routes to open water, which is especially important during the flightless molting period.

A current inventory of drawdown lakes is important since alluvial deposition or beaver dam construction can block lake connections to source rivers each year. For many waterfowl refuge areas in Alaska, satellite imagery is the only cost-effective method available for a spatially-explicit inventory that can be incorporated into a Geographic Information System (GIS). However, use of popular optical satellite imagery is difficult because of frequent cloud cover and associated cloud shadow at high latitudes. Satellite radar sensors use microwave energy that penetrates through clouds and is independent of solar radiation and therefore not sensitive to shadows. In addition, radar backscatter is very sensitive to the presence of water and at high latitudes radar images are available every few days.

We used radar from a normal and low water period to develop a method for mapping drawdown lakes within a GIS in the Innoko National Wildlife Refuge. The method had an accuracy of 80%. Because radar backscatter is especially sensitive to moisture, and radar can penetrate clouds and smoke, this method is ideal for monitoring and mapping drawdown lakes at high latitudes.

• *Julie Fogde and Dave Verbyla*

A potential wildfire-feedback mechanism in the Alaskan boreal forest: do fire scars increase lightning activity?

Previous modeling studies have suggested a potential feedback mechanism between wildfire in boreal forests and fire frequency via a change in thunderstorm activity. Lightning strike data provided by the Alaska Fire Service is used to investigate a potential feedback mechanism between wildfire burn scars and local convective activity in Alaskan boreal forests.

Lightning-started wildfires are responsible for the majority of area burned annually in North American boreal forests. Satellite derived radiant temperatures of burn scars indicate that the burned regions have temperatures much higher then the surrounding vegetation for more than 10 years after the fire. We are investigating a potential feedback mechanism—that heating differences between the burned and unburned areas can promote thunderstorm development and therefore more lightning.

• *Dorte Dissing and Dave Verbyla*

Wetland loss within Copper River Basin

By using satellite imagery from the mid 1980s and mid 1990s, we documented a significant drying of open water bodies within the Copper River Basin.

This loss of wetlands seems to have occurred despite similar precipitation amounts during the study years. The drying was especially evident on south-facing outwash slopes and may be due to a warming trend causing a reduction of discontinuous permafrost in the area. There was no evidence of a decrease in water body areas at higher elevations where continuous permafrost may still dominate.

See www.lter.uaf.edu/~dverbyla/copper_river_valley/wetlands.html for satellite images showing the reduction in water bodies from 1985 to 1995.

• *Dave Verbyla*

Testing radar to detect spring leaf flush

Radar remote sensing is potentially useful at high latitudes because radar can penetrate clouds and smoke, and is independent of sunlight. Can radar satellite remote sensing be used to reliably detect spring green-up? In theory, radar backscatter is sensitive to surface properties such as canopy structure and moisture content. During green-up, there is an increase in canopy structure and moisture content. Do these changes significantly affect radar backscatter?

I used spring leaf flush data from the Fairbanks area to select radar satellite image from periods before and after spring green-up to answer these questions. By using spruce stands as controls, I found that radar backscatter did not significantly change during the leaf flush period. Some broadleaf stands increased in backscatter, while others decreased, and some remained the same. Based on data from two different radar satellites and three years, I concluded that radar remote sensing is not useful for detecting spring leaf flush in interior Alaska. Confounding factors such as variable freeze/thaw, soil moisture, and precipitation patterns may be problems.

• *Dave Verbyla*

Bias in landscape change estimates

We found a significant bias in estimating changes by subtracting a time series of satellite images inside a GIS. We investigated the impact of misregistration on classified images at 25-m and 1-km pixel size using random normal errors. The bias in landscape change estimates is especially significant in heterogeneous landscapes such as those typical of Interior Alaska. We then developed a statistical method for estimating bias in change detection due to positional error.

• *Dave Verbyla and Steven H. Boles*

Assessing white spruce resistance to beetle attack on the Kenai Peninsula.

Over the last ten years, more than three million acres of Alaska forests have been infested with spruce beetles. It has been called the largest insect infestation in recorded history. In some areas, such as around Homer, mortality of spruce trees ranges from 90 to 100%. In other areas, mortality is much lower, and the reasons for these differences in mortality are the subject of much speculation. Though a variety of factors are likely involved, researchers believe that genetically-based differences in the ability of individual trees to resist attack play a critical role.

To date, the majority of research on the spruce beetle infestation has focused on the use of insecticides, selective thinning regimes, and insect pheromones. No one has attempted to document or exploit the natural resistance that occurs, to varying degrees, in the white spruce trees themselves. Our work makes use of two sets of white spruce seed collected by Dr. John Alden on the Kenai. The result was two samples of seed from 27 different stands of Kenai Peninsula white spruce: one collected before the stand was infested, the other collected from a rare surviving individual after the infestation had run its course.

In our planned experiment, the 1980s collection will function as the "control" group. The level of resistance to beetle attack inherent in this group should be no different than the overall pre-infestation population. Conversely, the seeds collected in 1998 will function as the "presumed resistant" group. By simple virtue of their survival to 1998, we hypothesize that this group has some genetically-based ability to resist beetle attack.

In 2000, we installed the five research plantations on the Kenai Peninsula, collected GPS data on 1998 seed collection locations, and generated maps of collection areas and plantation lay-outs.

• *Trish Wurtz, Matt Macander and John Alden*

Spatial Alaskan Forest Ecosystem Dynamics Model

The Spatial Alaskan Forest Ecosystem Dynamics (SAFED) Model was developed and validated for the major vegetation types found in interior Alaska. The model was programmed in a spatial framework as an ARC/INFO AML within the GRID package. The minimum geographic cell size used for the current implementation of the model was 1-m^2. The current version of the model has been validated at a 1-m^2 cell size (individual tree) basis in a number of forest types found in Interior Alaska. Model output of tree growth, litter fall, and forest floor decomposition routines were compared with data from LTER field research sites.

This model now gives us the opportunity to estimate specific dynamics of interest occurring within a boreal forest stand with a spatial resolution of those dynamics. The next step in this modeling work will be to the augment the model to allow for a larger cell size (1 ha or larger) and model forest function within a watershed perspective.

• *John Yarie*

Resources Management

Feasibility study of irrigation in Alaska.

The objective of this study was to determine the feasible operation of irrigation systems for feed barley in Alaska. Cash Flow analysis was used to determine the profitability of three irrigation systems for a 160 acre field. A 15 year payoff period was used.

In general, the initial purchase price impacts the decision to purchase an irrigation system, and ultimately its positive cash flow, over the 15 year period. Also, the area of land irrigated by a system (efficiency) also determines its feasibility. For instance, a center pivot system is the most expensive and least efficient in covering the acreage in a 160 acre field (only 133 out of 160), versus 154 out of 160 for the other systems (wheelline and handline). Thus, in order of profitability over a 15 year period, the most profitable is the handline ($38,081), the next most profitable is the wheelline ($26,652) and the least profitable is the center pivot (-$11,085).

One of the major considerations in deciding the profitability of the systems was that feed barley is a very low value crop, so that irrigation is a very marginal operation for all of the systems. Also, irrigation in Alaska is a very low volume activity. That is, the systems are used much less than in other areas of the country. Thus, labor and other variable costs do not become a limiting factor as they do in areas of high water usage.

Application of the results of this research may help farmers to determine which irrigation system might be appropriate for their operations.

• *Hans Geier*

Canola crusher feasibility study

The feasibility of an oilseed industry (Canola) for the agricultural community in Alaska was assessed. Current conditions do not warrant farmers growing Canola, but certain policy and economic variables could be emphasized to guide future actions by those interested. Supply problems by farmers were documented and reported, including the difficulty in growing a crop without an herbicide, or proper drying and handling facilities. Future Canola industry efforts were proposed, including increased efforts by the University in cooperation with growers and private industry. While Canola has been attempted as a crop for some time in Alaska, there may be a future in growing the crop if markets and other technical problems in production are solved.

• *Hans Geier*

Socioeconomic and ecological controls over land-use patterns of reindeer herders in northwest Alaska: economic impact analysis component

The overall project goal is to increase our understanding of the feedbacks between climate, environment, and human land-use in the Arctic. The goals for the economic component of the project are to estimate the contributions of the reindeer industry to local and regional communities and to identify economic consequences of reindeer-caribou interaction.

The reindeer industry represents a local independent owner operator industry in a region where few alternative locally based industries exist. Furthermore, the reindeer industry represents a basic industry, that is an industry that exports a large portion of its output and is therefore a basis for regional economic growth.

A Seward Peninsula regional economic model has been developed to evaluate the socioeconomic impact of reindeer-caribou interaction on the Seward Peninsula. The evaluation focuses on estimating the contribution of the Alaska reindeer industry to the regional economy. The methodology chosen for investigation is input-output analysis (IO) and the IMPLAN input-output system. Input output models are applied economic tools used to analyze the interdependence of economic factors in a regional economy. Input-output analysis has been the cornerstone or regional economic analysis for everything from feasibility studies to assessment of marginal policy changes.

Preliminary model estimation has been completed. Model verification is the next step to be followed by estimating various scenarios. The scenarios are intended to provide a range of possible outcomes for the reindeer industry. They will be used to further examine the costs of recent losses to the industry from caribou interaction and to provide insight into possible future performance of the reindeer industry. Results will be forthcoming.

• *Joshua Greenberg, Stephanie Moreland*

Federal – state marketing improvement program: marketing Alaska – an action plan for potato and vegetable producers

Approximately 90% of the food for the 650,000 people in Alaska is imported. Receipts from Alaska's agricultural industry have been increasing in recent years and have substantially increased since the mid-1970s. While the potato segment of the industry is beginning to expand, the vegetable segment is

stagnant. Farmers are producing high quality products and they are in demand by consumers. Markets are not the problem. Marketing is the problem.

A cornerstone of the project was to quantify the demand for vegetables and potatoes in Alaska by value-added processors and food retail outlets. Farmers were surveyed to determine their concerns about market barriers. Information was compiled on state programs that assist farmers in marketing.

The project was completed in 2001. The amount of vegetables produced in the state is equal to about 10% of the fresh product demand with the exception of potatoes. Alaska producers supply about half of the retail market fresh product demand for table potatoes. The demand figures were based in part on surveys of wholesalers, retailers, and processors in Alaska. When information was not available, national per capital consumption information was used. Marketing was identified as a major barrier to farm profitability, as well as a lack of processing capability instate. A comparison of the Alaska Grown program, a marketing program within the Alaska Division of Agriculture, to other aggressive state/province marketing programs was made to offer suggestions for improvement of the Alaska Grown program.

There is high regard for the Alaska Grown program by both buyers and growers. Both groups pointed out limitations of the program. A significant problem is lack of funding making widespread advertising virtually impossible. The Alaska Grown program was recommended as the most effective vehicle for Alaska producers to improve their market position. The Division of Agriculture is responding with increased focus and funding for the program.

• *Carol E. Lewis, Hans Geier*

Muskox: looking toward the future

Despite increasing demand for knitted products from qiviut and an emerging market for meat products, the muskox industry in Alaska is not growing. The Alaska Science and Technology Foundation has provided funding for investigations of new feed rations and preparation of a plan for revitalizing the industry.

The Agricultural and Forestry Experiment Station in cooperation with the Institute of Arctic Biology, the University of Alaska Fairbanks, and individuals from the private sector, developed a footprint for industry growth. A working task force was formed and met to formulate the plan. A follow-up meeting at the Alaska Agricultural Symposium highlighted qiviut producers and developed the base for a diversified livestock association.

Participants in the muskox workshop developed a three-point plan addressing the status of the industry, a producers action plan, and an industry advocates action plan. Highlights of the discussions were the lack of available animals, the need for commitment to the industry and information to strengthen that commitment, the high demand for qiviut and the backlog of fiber processing, and the need for a support group and information network for producers and new entrants into the industry.

The Diversified Livestock Producers Association was formed as a result of the muskox workshop and a diversified livestock workshop sponsored by Cooperative Extension Service and organized by Milan Shipka, Assistant Professor of Animal Science and Extension Livestock Specialist. The association will provide the support needed to producers. Diversified animal numbers in the state of Alaska have doubled in the past two years in part as a result of increasing interest and participation by the Agricultural and Forestry Experiment Station and the Cooperative Extension Service.

• *Carol E. Lewis*

Economic analysis of subsistence bowhead whaling

This project was intended to provide an important baseline assessment for future comparisons of Bowhead whaling off the north coast of Alaska, and to depict the unique features of this cash/noncash economy.

There were three segments to the approach to this project. The first was to derive the food value of the bowhead whale on a caloric and protein content basis and determine the replacement costs using commercially available products. The second was to depict whaling as an industry and determine the benefit to the community from money spent by those involved in whaling activities. Finally, we were to determine the economic value of whaling to the residents of the North Slope Borough.

The project was not completed. We were required to obtain written permission from the Alaska Eskimo Whaling Association and the North Slope Borough to complete the third segment of our approach. To do so, we met with community leaders to develop the strategy for presentation of the project. We were also involved in organizing a session on subsistence whaling at the International Institute of Fisheries Economics and Trade Conference held in Oregon in July, 2000. This session included discussions of the project and various methods of approach that might be acceptable in the communities in the North Slope Borough.

After devising a plan for the approach, the study was delayed because an additional socio-anthropological study was required. Funding for that study was delayed and we were subsequently denied permission to proceed with the economic analysis of subsistence bowhead whaling.

• *Joshua Greenberg, Hans Geier, Carol E. Lewis, Mark Herrmann, Kelly Giraud*

Using e-mail and the Internet in public involvement

The objective of this study was to develop several Internet tools (listservs, surveys, etc.) and apply them in actual planning cases, to explore both their advantages and their limitations for enhancing citizen participation. A second objective was to determine how different agencies are currently using the Internet to involve the public. A third objective was to evaluate the pros and cons of each of the primary tools available on the Internet (such as e-mail, listservs, Web pages, etc.) that could be used in public involvement.

A manuscript summarizing how different agencies are currently using the Internet and on the pros and cons of the primary Internet tools has been submitted to *The Public Administration Review*. Most public agencies now have Internet sites, but most of these provide passive information and offer little, if any, opportunity for feedback.

While basic information is valuable, a passive Web site misses a great opportunity for two-way communication. To realize the Internet's full potential to involve the public in ongoing discussions of the issues that affect their lives, agencies should also incorporate interactive tools such as e-mail lists, listservs, bulletin boards, Web forms and Web surveys.

• *Susan Todd*

The use of maps in planning and environmental mediation: a survey of planners, mediators, and planning team members.

Maps are scale models of space; they reduce an overwhelming amount of data to a more manageable level. They help us visualize spatial relationships by utilizing one of humankind's most powerful information-processing abilities: vision. Maps, as well as other visuals such as graphs, are processed by different parts of the human brain and thus may tap sources of creativity that are not reached by words alone.

But is this remarkable power of maps being fully tapped in planning and mediation? Most of us have attended planning and mediation meetings where a specific region was being discussed, but no one thought to bring a map of the area. Flipcharts are always there for recording every word, but maps are often an afterthought—something that might have been nice, but not essential. And yet, as cartographer Erwin Raisz put it, "A map has an advantage over text in that it can be seen at a glance, while words must come in sequence. No verbal description of a region can rival the impact and retention possibilities of a map." This statement implies that—if a specific area of the globe is under consideration—it would be better to remember the map and forget the flipchart.

What *is* the relative importance of text versus maps in planning and mediation cases involving spatial data? After months of searching databases, we have not found an analysis of this question. The use of maps in planning and environmental mediation, in general, appears to be an overlooked area of research. This survey is a first step toward filling that gap.

The hypothesis of this project is that—if spatial data is involved in a plan or a dispute—settlement efforts that use maps are more likely to reach agreement than efforts that do not use maps. Specifically, the project will examine how maps are being used in planning and environmental mediation efforts. Are planning team members encouraged to draw directly on maps? If so, does this improve the likelihood of agreement? Are team members more reluctant to draw on computer-generated maps than on hand-drawn overlays? Are maps left on a wall or are they on the negotiating table? How important are maps compared to text in planning efforts today? Are aerial photos more useful than maps? Why are maps often omitted in environmental mediation efforts? Graduate student Laura Walker and I are developing a survey to send to planners, mediators, and planning team members to begin to answer these questions.

• *Susan Todd*

Perceptual geography of Alaska

Imagery from advertising, postcards, and other items marketed to tourists is being collected to support a study of nonresidents' popular perceptions of Alaska.

Alaska is one of the most recognized states in the union, and yet one of the most inaccurately perceived. Since before statehood, news stories, popular books, popular films, advertisements, and lately, "Northern Exposure," have filled American minds with images of Alaska as a wild, exotic land full of rustic Sourdoughs, polar bears, and igloos. Contemporary evidences of these popular perceptions are available in some very ordinary media: postcards, restaurant place mats, and other items aimed at visitors to the state, or at their friends and family back home. The images conveyed by these items appear intended to conform to the popular perceptions that visitors bring with them from the lower 48, and as such may offer clues to contemporary popular perceptions of "The Last Frontier."

A better understanding of current and evolving perceptions of Alaska could be used to help determine what images most draw visitors to Alaska, and to predict how the images conveyed may impact the tourism industry.

• *Cary de Wit*

Agricultural Research Service

Predicting phenology of Alaskan grasshoppers

Rates of growth and development by grasshoppers depends on temperature. Current phenological models developed in other locales severely underestimate rates of development in Alaska. Grasshoppers commonly raise their internal body temperatures by basking in the sun. Alaska's relatively cool temperatures and long days allow grasshoppers ample opportunity to elevate body temperatures and thus increase their rate of development. Our objective is to develop temperature-driven phenology models appropriate for Alaska conditions.

Natural populations will be regularly censused to test and validate predictions made from controlled-environment temperature experiments. Estimates of internal body temperatures of grasshoppers will be incorporated into predictions of growth rate.

Grasshopper populations in the Delta Junction region were sampled 2-3 times weekly during the summer of 2000. The proportion of grasshoppers within each instar (molt) were determined. Hourly air and soil temperatures, wind speed, and solar radiation were automatically recorded. Internal body temperatures of grasshoppers have been measured under a range of sunlight levels, wind speeds, and air temperatures. During the winter, rates of growth were measured under a range of constant temperatures in controlled-environment chambers.

Accurate models of grasshopper growth and development will allow extension personnel to make better estimates of the time available to treat grasshoppers, and improve predictions of population trends.

•Dennis Fielding

Grasshopper/habitat relationships in Alaska

Reducing grasshopper populations by manipulating their habitat is a proactive, environmentally sound method. Environmental factors can affect grasshoppers through the presence or absence of their favored food plants, by altering the temperatures they are exposed to (shady vs. sunny microclimates), or by encouraging natural predators (e.g. spiders or birds). The objective of this study is to determine what types of vegetation are favorable, or not favorable, to common species of grasshoppers in the Delta Junction region.

Grasshoppers and plants will be sampled under a broad range of conditions. Statistical correlations between grasshopper densities and plant community characteristics will be made to identify favorable habitat for grasshoppers. This information will suggest research into the mechanisms underlying the observed correlations.

During the summer of 2000, grasshopper density and species composition were sampled, along with plant species, at 92 locations in the Delta Junction area, representing a range of vegetation types such as hay fields, roadside rights-of-way, CRP fields, pastures, and bluegrass seedings. Also, a dozen long-term study sites were established to monitor population trends over time in a variety of habitats. Statistical analyses are underway.

Information about habitat preferences of common pest species of grasshoppers will suggest methods of habitat management that will potentially reduce the severity of grasshopper outbreaks, without having to resort to reactive, crisis-oriented methods of population suppression based on pesticides.

•Dennis Fielding

Monitoring grasshopper invasion of cultivated crops

Grasshopper populations generally do not persist in cultivated crops because tillage destroys most of the eggs, but they will invade crops annually from surrounding areas. Standard methods of estimating grasshopper abundance by counting the number of individuals in rings placed on the ground are not very reliable in most crops. Also, visual counts are highly dependent on weather conditions at the time of sampling. Similar problems also occur when sampling with sweep nets. Traps that can be left out in the field to capture grasshoppers may circumvent some of these problems. The objective of this project is to evaluate the usefulness of windowpane/pan traps for monitoring grasshopper populations.

Windowpane-style traps were constructed consisting of a vertical pane of glass (about 39 inches wide) with trays of water (sections of plastic rain guttering) at the base of the glass pane. Grasshoppers are captured as they hop about, hit the glass and fall into the water. A small amount of dishwashing detergent was added to the water to aid in breaking the surface tension, which allows the grasshoppers to sink and drown rapidly. By placing the traps in various locations around the field, we hope to be able to determine when grasshoppers begin invading crops, which species of grasshoppers are involved, and from which direction they are coming.

In the summer of 2000, a series of these traps were placed in a barley crop, CRP fields, and the interface between the two habitats. Grasshopper numbers and species were recorded along with the location of the trap. The barley was planted as a cover

crop for a new seeding of bromegrass hay, and so was not so dense as a normal planting, allowing standard methods of monitoring grasshoppers to be compared with the trap catches. Proportions of species captured by the traps were similar to that obtained by sweep net samples in both the barley and the CRP fields. The number of grasshoppers captured was not directly proportional to visual counts from the rings: ring counts indicated that the CRP fields had nearly 4 times as many grasshoppers as in the barley, but traps only captured about 2 times as many grasshoppers in CRP as in barley. Trap catch apparently was affected by weather, but not to the degree of visual counts and sweep sampling. On several occasions during the wet summer of 2000, rain caused our sweep samples to yield very few grasshoppers, whereas the traps always provided a good number of grasshoppers. We also suspect that the grasshoppers were attracted to the traps in some manner. When the wind was consistently from one direction during the interval between emptying the traps, the sides of the traps facing downwind consistently captured more grasshoppers, indicating that they were moving upwind towards the traps. Tests are underway this summer (2001) to evaluate the attraction of the detergent, freshly killed grasshoppers, or a combination of the two.

A reliable method of monitoring grasshopper movements is needed to study the invasion of crops by grasshoppers. Preliminary results indicate that the traps may not be useful for estimating absolute numbers of grasshoppers, but may be useful for estimating the species of grasshoppers present, the time of movement, and the direction from which they are coming. The traps would be especially useful in Alaska where late-summer rains frequently prevent sampling by standard methods.

•Dennis Fielding

An individual-based model of grasshopper populations

Increases in computing power have enabled the development of computer models that simulate individuals of a population rather than the average of the population. Such models can provide insights into population processes that arise from the interactions between individuals. Our objective is to develop a flexible model that will simulate various ecological or pest management scenarios.

We are writing a computer program that explicitly models the feeding, growth, and reproduction and death of a population of individuals. Growth and reproduction is dependent on temperature and food quality. The model will be tested against mathematical models developed under a simplified set of conditions. The prototype computer program has been written and several ecological scenarios have been simulated, such as competition between two species of grasshopper differing in their dispersal ability. Preliminary results are being presented to other grasshopper researchers for their evaluation and suggestions.

Primarily intended as a research tool, this model will provide a flexible tool for researchers to explore different ecological scenarios, test assumptions made in their experiments, and generate hypotheses for future research efforts.

•Dennis Fielding

Response of small-grains, oilseed, and forage crops to pest damage

The objective of this project is to measure several parameters of plant growth in relation to biotic (insects and weeds) and abiotic (moisture) stresses. The study includes early stages of plant growth and development in addition to yield components of mature plants.

A series of experiments are underway to examine grasshopper feeding damage, weed competition, and moisture stress using a combination of growth chamber, greenhouse, and field studies. Varying numbers of grasshoppers are caged with plants and the amount of leaf tissue consumed is measured. Water stress is induced by extending the time between waterings. Competition from weeds is studied by manipulating the number of weeds in the cage. The plants are harvested at intervals and leaves, stems, grain, and roots are weighed and the nitrogen and carbon content of those plant parts determined. In field studies, the amount of light intercepted and absorbed by the plant canopy will be measured in relation to defoliation by insects.

Three greenhouse experiments have been completed during the winter and spring of 2000-2001: various levels of grasshopper feeding on later stages of barley growth; grasshopper feeding damage during early stages of growth on barley, oats, wheat, and canola; and a study of the interaction between moisture stress and grasshopper feeding in barley and oats. Data are still being analyzed. A field study has been initiated this summer (2001) to study the interactions between grasshopper feeding and weed competition in barley and oats.

We anticipate three areas of impact. First, this information will be vitally important for integrated pest management applications by enabling us to better estimate yield reductions due to grasshopper feeding, and thus decide whether or not treatment is justified economically. Secondly, evaluation of crop responses to different stresses should allow us to determine the relative importance of different factors limiting crop production, and so help set priorities for research and management efforts. Lastly, this information can be used to incorporate pest damage models into existing crop growth models, increasing their utility.

•Sultan Begna and Dennis Fielding

Faculty Publications January 2000—December 2000

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Verbyla, D. L. and M. Story. 2000. Introduction to remote sensing. A Workshop for National Park Service Rangers. National Conservation Training Center, Shepardstown, W.V. 249p.

Thesis

Lisa Maria Popovics. 2000. The effect of soil and stream water quality on primary and secondary productivity of Rock Creek, Denali National Park and Preserve. M.Sc. thesis. University of Alaska Fairbanks.

FY 01 research funding

Grants and Special Funds; July 1, 2000– June 30, 2001

National Science Foundation

Chien–Lu Ping ..... Winter C–flux in arctic ecosystems
John Yarie ..... LTER: Successional processes in taiga forests of Interior Alaska
John Yarie, Dave Valentine ..... The role of wildfire in Alaska
Dave Verbyla, Elena Sparrow ..... Global plant waves
Greg Finstad ..... Reindeer herding
Elena Sparrow ..... Global change education
Marilyn Walker ..... ITEX

United States Department of Agriculture

Jenifer McBeath ..... Cooperative agriculture pest survey
Chien–Lu Ping ..... Wet soils monitoring studies in Alaska; *(SCS funding also)*
Tricia Wurtz ..... Spruce and alder interactions

United States Department of Agriculture; ARS

Dennis Fielding ..... ARS research support
Stephen Sparrow ..... Control of AK grasshoppers

United States Department of Agriculture; CSREES

G. Allen Mitchell ..... Dairy research
Stephen Sparrow ..... SARE, no–till forage establishment to improve soil and water conservation

University of Alaska Natural Resources Fund

Don Carling ..... Late blight disease of potato
Patricia Holloway ..... A plant propagation system for horticulture, forestry and photoremediation in Alaska
Glenn Juday..... Development and calibration of SKOG
Meriam Karlsson ..... Light quality for off-season raspberry production
Meriam Karlsson, Jenifer McBeath .. Evaluating ginsenosides in ginseng produced in AK
Carol E. Lewis, Robert Trent ..... UA–MIT partnership
Jenifer McBeath, Meriam Karlsson .. Cultivation of ginseng in AK
Jenifer McBeath, Meriam Karlsson .. Cultivation of ginseng, chavanbeimu, and huanggi in Alaska
Edmond Packee ..... Continuous forest inventory
Charles Knight ..... Forage management
Meriam Karlsson ..... Resource ambassador program
Meriam Karlsson ..... Leadership continuum program for K-12 students
Tricia Wurtz ..... Assessing white spruce resistance to beetle attack
Cary de Wit ..... Development of a circumpolar regional database
Carol E. Lewis ..... Development of a UA and federal initiative
John Fox ..... Management Plan for UA Experimental Forest

AK Department of Natural Resources

Patricia Holloway ..... Mulches for tree planting in AK landscapes

UA International Arctic Research Center (IARC)

Elena Sparrow ..... GLOBE: Global change education for K-12 students

Usibelli Coal Mine, Inc.

Dot Helm ..... Revegetation studies on Two Bull Ridge

AK Science and Technology Foundation

Don Carling ..... Potato chipping

University of Alaska Foundation

Patricia Holloway ..... Georgeson Botanical Garden

Larry Burke ..... Experiment Farm

U.S. Fish and Wildlife

David Verbyla ..... Radar remote sensing of alluvial habitat

David Verbyla ..... Synthetic aperture radar

USDA Forest Service

John Yarie ..... Forestry research

Cornell University

Meriam Karlsson ..... Raspberry production

U.S.G.S., AK Biological Center

Dot Helm ..... Ecological monitoring

University of Montana

David Verbyla ..... EOS applications for AK natural resources management

U.S. Department of Education

Carol Lewis ..... Star Schools

Department of Commerce and Economic Development

Jenifer McBeath ..... Export certification process

Fred Gloeckner Foundation, Inc.

Meriam Karlsson ..... Production requirements for dwarf black-eyed Susan

University of Arizona (EPA)

Elena Sparrow ..... Environmental outreach

U.S. Department of the Interior

Carol Lewis, Kelly Giraud ..... Bowhead whaling

National Geographic Society

Chien–Lu Ping ..... Soil and vegetation in China

Formula Funds

Hatch General

Chien–Lu Ping	Hydric soil properties of permafrost–affected soils
Stephen Sparrow	Tillage and crop residue management effects on properties of a subarctic soil
G. Allen Mitchell	Agricultural and Forestry Experiment Station
Meriam Karlsson	Environmental plant physiology of greenhouse produced crops
Carol E. Lewis	Marketing Alaska's agricultural and processed seafood products
Charles Knight	Alternative crops for the subarctic
Don Carling	Evaluation of production practices, cultivars, and some diseases of potato and vegetables
Patricia Holloway	Horticulture crop production for AK
Joshua Greenberg	Regional economic modeling for rural AK
Milan Shipka, Greg Finstad	Raised reindeer
Susan Todd	Resource planning
Milan Shipka	Reproductive performance in domestic ruminants

Hatch Multistate

G. Allen Mitchell	Regional research planning and coordination, western region
Jenifer McBeath	Biological suppression of soil–borne plant pathogens
Milan Shipka	Reproductive performance in domestic ruminants

McIntire–Stennis

John D. Fox, Jr.	Simulating the effects of forest harvest on soil freezing and thawing
Edmond Packee	Tree species growth and yield and site productivity of the Alaska northern forest
Dot Helm	Ectomycorrhizae in disturbed lands
David Verbyla	Satellite change detection techniques for mapping spruce bark beetle infestations in AK
Glenn Juday	Relationship of tree growth and climate variability in Alaska
John Yarie	Long-term forest ecosystem monitoring and GIS modeling of taiga forest dynamics

Financial Statement

Expenditures — July 2000 through June 2001

The following is a statement of expenditures of federal and state funds for the fiscal year beginning July 1, 2000 and ending June 30, 2001 (FY 01). NOTE: This is not an accounting document.

Federal		(percent of total)
Hatch General Formula Funds	$764,039	11.61
Hatch Multistate Formula Funds	$117,860	1.79
McIntire–Stennis Formula Funds	$314,660	4.78
Other Grants and Contracts	$2,119,386	32.19
State Appropriation/Program Receipts	$3,267,758	49.63
Total	$6,583,703	100.0 percent

School of Agriculture and Land Resources Management
University of Alaska Fairbanks
PO Box 757200
Fairbanks, AK 99775-7200

Nonprofit Organization U.S. POSTAGE PAID Permit No. 2 Fairbanks, Alaska

Palmer Research and Extension Center in Southcentral Alaska, looking toward Pioneer Peak