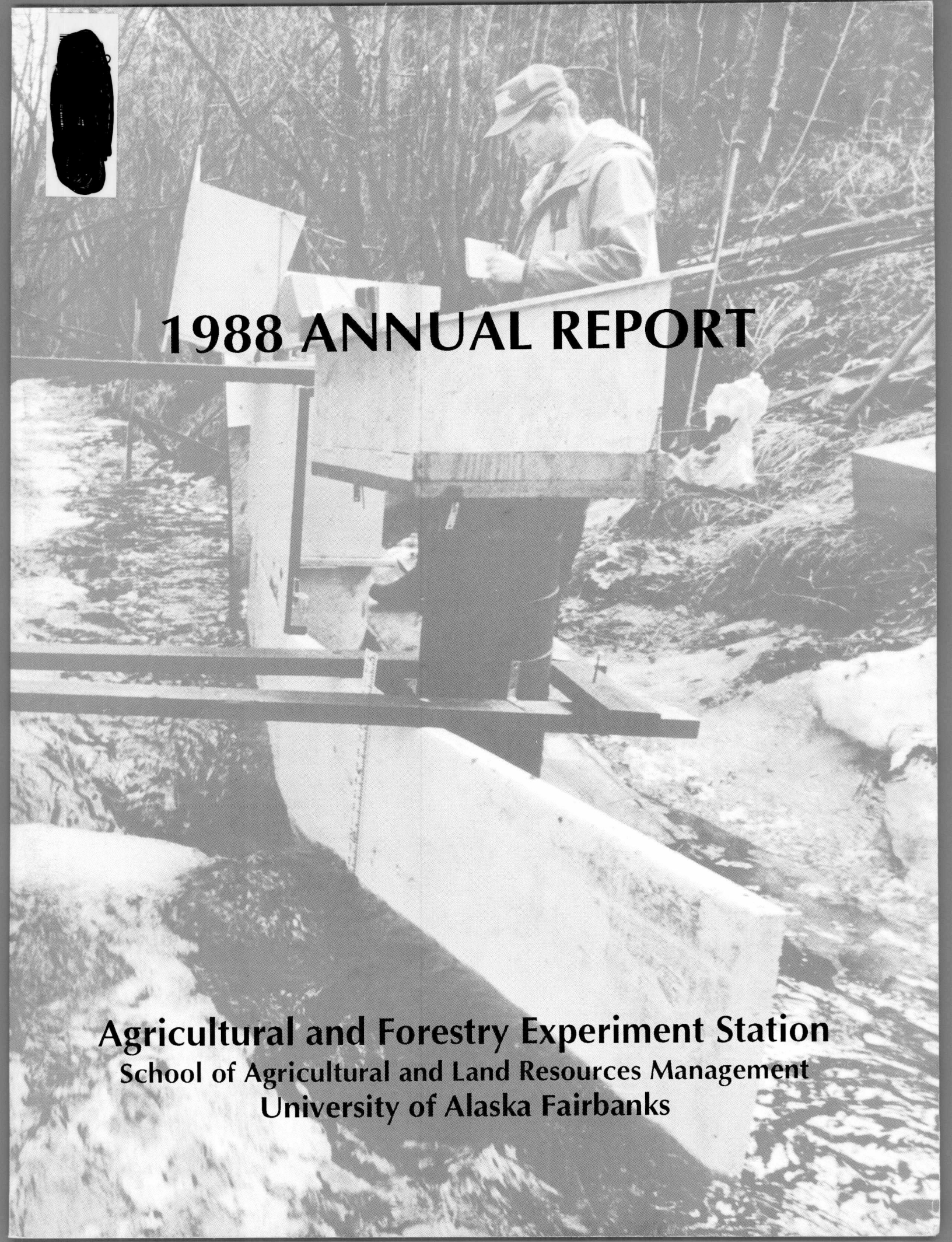

1988 ANNUAL REPORT

Agricultural and Forestry Experiment Station

School of Agricultural and Land Resources Management
University of Alaska Fairbanks

Cover: Dr. John D. Fox, forest hydrologist with the AFES, monitors spring runoff from the Spinach Creek instructional and demonstration watershed, near Fairbanks. Dr. Fox is investigating ways of predicting spring runoff patterns in relation to topography, climate, and land use.

AFES Photo by Samuel Winch

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ANNUAL REPORT

For the year ending December 31, 1988

Fairbanks, Alaska 99775-0080

Misc. Pub. 89-1

June 1989

Letter of Transmittal

The Honorable Steve Cowper
Governor of Alaska
Juneau, Alaska 99811

Dear Sir:

I submit herewith the annual report of the Agricultural and Forestry Experiment Station, School of Agriculture and Land Resources Management, University of Alaska Fairbanks, for the period ending December 31, 1988. This is done in accordance with an act of the 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,

James V. Drew

James V. Drew
Director

Fairbanks, Alaska
June 30, 1989

Contents

Statement of Purpose

This report summarizes research progress at the Alaska Agricultural and Forestry Experiment Station (AFES). Our research projects are designed to provide results useful for the development and conservation of land resources in Alaska.

Specifically, the AFES research objectives are to provide new information to:

1). provide a base of research information for the management of renewable resources of high latitudes; and

2). provide technology for enhancing the economic well-being and quality of life at high latitudes.

Foresters, farmers, and land managers use AFES research results. All Alaskans directly benefit from the wise use of land resources.

In identifying local Alaskan research needs, experiment station scientists regularly meet with land managers, foresters, and farmers from throughout the state to discuss specific needs and problems. Our researchers also work directly with producers through farm forums, agricultural field days, greenhouse workshops, vegetable conferences, reindeer herder workshops, and forestry workshops. Through these direct public contacts they discover additional research needs. In addition, experiment station scientists work with Cooperative Extension Service personnel who have day-to-day contact with land managers foresters, and farmers. Agency managers and staff share their research needs with members of the AFES faculty and staff.

Several experiment station scientists also serve on advisory panels for land and resource management agencies.

Because of these contacts, most of our research projects described in the plant and animals sciences section of this report were in response to producer requests. Research projects in the forest sciences and resources management sections were developed at the request of industry and state or federal agencies for information to address specific needs.

Research completed at AFES is published in scientific journals as well as experiment station bulletins, circulars, conference proceedings, books, and the station's own journal, *Agroborealis*. Experiment station scientists disseminate their findings through conferences, professional journals, workshops, and other public information programs. Subjects range from greenhouse operations to potato production, from reindeer herding to forest productivity, and from mine soil reclamation to the management of outdoor recreation.

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 direct linkage between research and teaching in forestry, agriculture and natural resources. Scientists who conduct research at the experiment station also teach, sharing their expertise with both undergraduate and graduate students.

Research Assistant Bob Van Veldhuizen demonstrates plant propagation techniques in soilless medium to local students visiting the UAF greenhouse on a school field trip.

Plant and Animal Sciences

W-166, Hulless and Covered All-Barley Starter Pig Diets Containing Black and Gray Cod Fish Meals

The utilization of barley in starter pig (20 to 45 lb. body weight) diets is usually limited to 20 percent of the diet due to the higher fiber content and resultant lower available energy. This recommendation is found in the literature and still followed by feed formulators and swine producers despite recent research indicating that starter pig performance is more limited by dietary protein quality than energy density. In addition, some research has been reported that all-barley starter diets produce equal performance to corn, sorghum and wheat diets. However, recent research of the Alaska AFES reported superior growth of starter pigs fed corn diets vs. barley diets but no difference for feed efficiency.

Recently hulless barley cultivars have been developed that meet standards for commercial production. 'Thual' barley from Alaska is a hulless cultivar available for feed formulation in the state. Research from other universities has indicated that hulless barley may be equal to other grains and superior to hulled cultivars for growing-finishing swine. However, these results are not consistent across all hulless cultivars tested. Only one report (from Alberta) has compared hulless barleys to covered barley for starter pigs and one hulless was superior. The second cultivar was inferior in feed performance.

All-barley starter diets containing 10 percent high- or low-salt Alaskan herring meal provided satisfactory rate and efficiency of gains for starter pigs. Recently, fish meals have been produced from processing wastes of black cod (sablefish), *Anoplopoma fimbria*, and gray or pacific cod, *Gadus macrocephalus* but nutritional and feeding values are unknown.

This study was designed to compare 'Datal' (covered) to Thual barley as the sole grain source with 10 percent black or gray cod meal as part of the protein supplement. This completely randomized design with a 2 x 2 factorial arrangement was conducted in triplicate with 36

weaner pigs from 28 days of age at weaning (18 lb.) to 56 days of age (44.7 lb.). All diets were formulated with 20 percent dried whey and to contain four percent fat (equalized across all diets with herring oil) and 125% NRC trace mineral and vitamin levels. The fish meals were produced from processing wastes in a steam cooker and rotary steam dryer. On a dry matter basis, the black and screened gray cod meals contained 52.5 and 69.5 percent protein and 22.5 and 7.7 percent fat, respectively.

Growth and feed performance were not significantly different for the four diets. Mean average daily gains and feed efficiency of the four diets were 0.95 lb./day gain and 1.73 lb. feed/lb gain, respectively. There was no advantage for hulless barley over covered barley in these starter pig diets and no difference was evident between diets containing black or gray cod fish meals. *F.M. Husby*

Hulless Barley and Tanner Crab Shell in Beef Cattle Finishing Rations

A 117-day beef cattle feeding trial was conducted to replicate a similar 1987 study and to compare coarse tanner crab shell to chopped bromegrass hay as a roughage source in hulless 'Thual' barley diets. Thual barley was developed in Alaska by Roscoe Taylor (ARS, Palmer, AK) as an introductory cultivar of the hulless type. These types contain significantly lower fiber content due to the loss of the hull during threshing and it has been assumed that they may contain greater concentrations of available energy when included in nonruminant diets. However until recently, hulless cultivars have not been produced as a feed grain, but the development of cultivars with suitable yield and disease resistance has resulted in commercial production of three cultivars in North America ('Scout' and 'Tupper' in Saskatchewan and Thual in Alaska). Canadian research has indicated that Scout is superior to covered (hulled) barley and Tupper is equal to wheat for growing-finishing pigs. However, research conducted at the Alaska Agricultural and Forestry Experiment Station failed to demonstrate any difference in performance of growing-finishing pigs or 4 to 8 week old starter pigs when Thual was compared to a covered cultivar. Research conducted with sled dogs has demonstrated significantly greater dry matter digestibilities for diets containing Thual than covered barley. Canadians have reported poor performance of broiler chickens fed hulless barley but that egg production was equal when laying hens were fed hulless barley- or wheat-based diets. With the exception of an Alaskan report by Kreig and Husby that growth performance of lambs was similar when fed hulless or covered barley, no information is available concerning the feeding value of hulless barley for ruminants.

Roughage is an expensive ingredient in Alaska. The coarse material of crab shell (separated physically at screening greater than 40 mesh) may be utilized as a dietary fiber source in cattle rations.

The diets were Thual barley: bromegrass hay or crab shell (85:15) and balanced for macro- and micro-minerals. Steers were injected with vitamins A,D, and E. Four Hereford steers (908 lb.) and two Hereford heifers (845 lb.) were randomly allotted with two steers and one heifer to each of two diet treatments. Each animal was individually penned and provided free-choice feed and water. Final body weights for the steers and heifers were 1180 and 1067 lb., respectively. The rate of gain was significantly better for steers fed bromegrass vs. crab shell (2.86 vs. 1.76 lb./day) with efficiency of gains of 7.2 and 7.9 lb. feed/lb. gain for steers fed bromegrass and crab shell diets, respectively. These results were similar to the 1987 feed trial. The heifer fed the Thual/crab

shell diet had better daily gain and feed conversion than the Thual/bromegrass fed heifer (2.2 vs. 1.76 lb. gain/day and 7.5 vs. 8.4 lb. feed/lb. gain, respectively). Rumen pH was significantly lower for the three head fed the crab shell diets and may indicate a limited buffering capacity and therefore, an insufficient roughage substitute. Thual barley appears to be a suitable grain for finishing beef cattle. At the present a study is being conducted to compare Thual barley to corn in beef cattle finishing rations. *F. M. Husby*

Digestibility of Tanner Crab Meal and Chitin by Cattle

Previous research at the Alaska Agricultural and Forestry Experiment Station - Fairbanks with tanner crab meal indicated that chitin, a polysaccharide in crab shell, was a fibrous component of shellfish meals and that following a six-week diet adaptation period, rumen microorganisms may adapt to a diet containing chitin. Results from both *in vivo* and *in vitro* two-stage digestion techniques indicated that up to 21 percent of the chitin content may be degraded in 48 hours. Results from total digestibility trials with beef cattle also indicate that some of the chitin (determined as acid detergent fiber) was utilized when crab meal replaced 15 percent of bromegrass in maintenance diets. The ruminant microorganisms responsible for chitin degradation in the rumen ecosystem are unknown.

In the last year, a collaborative study with Dr. M. T. Yokoyama, rumen microbiologist, Dept. of Animal Science, Michigan State University, has been conducted to determine what ruminant microorganisms are degrading crab shell chitin. Preliminary observations indicate the occurrence of an anaerobic fungus in enrichment cultures, containing 10 percent ground crab shell as the sole carbon source. In cultures, the fungus is present in numbers as high as 10^6 per ml. Although bacteria are also present, the predominant organism for degrading the crab shell is the fungus. Research is proposed to identify and characterize the fungus. This research may provide a better understanding of how to improve the process of chitin degradation and utilization. In addition, the information gained would increase our knowledge of chitin degradation in anaerobic environments. *F.M. Husby and M.T. Yokoyama*

W-166, All-Barley and Alaskan Salmon Meal Starter Pig Diets.

A joint project was conducted with Dr. W. I. Hugh, swine specialist, University of Hawaii, Manoa, to determine the effect of replacing soybean oil meal in all-barley starter pig diets with 0, 5, 10 or 13.5 percent of the diet as Alaskan salmon meal (60 percent crude protein, 4.0 percent lysine). The 13.5 percent dietary level represented a total replacement of soybean oil meal in these diets. Dr. Hugh has been a cooperator in the W-166, Western Regional Hatch Project for Swine Nutrition, and, in 1987 reported that Alaskan fish meals were being imported into Honolulu to formulate livestock feeds. Mr. Mike Meehan, Icicle Seafoods, Inc. of Seward, Alaska provided 600 lbs. of salmon meal that was sent to the University of Hawaii for this joint study involving the University of Alaska-AFES.

Ninety-six pigs (Yorkshire x Hampshire x Duroc) weaned at 28 days of age (14.6 lb.) were equalized for sex, litter, and live weight and randomly allotted to one of four diet treatments replicated with four

pens of six pigs each. Pigs were housed in elevated flat decks and fed the experimental diets with free-choice water until 63 days of age (43.4 lb.). The all barley (54.6 to 64.7 percent barley) diets were formulated to contain 18 percent crude protein, one percent lysine and four percent fat, equalized with corn oil. Dietary protein was provided with 20 percent dried whey in each diet and then balanced with the above levels of salmon meal and soybean oil meal.

The average daily gains for the barley-soybean meal control, 5, 10 and 13.5 percent salmon meal diets were 0.86, 0.84, 0.85 and 0.73 lb./day, respectively. The rate of gain for pigs fed the diet where salmon meal completely replaced soybean meal was significantly less than the other three diets. Although not fully understood why gains were depressed in this diet treatment, the pigs consumed significantly less feed (1.53 lb./day compared to the average of 1.73 lb./day intake on the other three diets). There was no difference in feed efficiency with all four dietary treatments averaging 2.07 lb. feed/lb. gain.

Diets were chemically analyzed for proximate components and amino acid content by W-166 project cooperator, Dr. R. L. Harrold of North Dakota State University.

The results of this study indicate that suitable weaner pig growth performance can be obtained with all barley diets containing up to 10 percent Alaskan salmon meal. *F.M. Husby, W.I. Hugh, and R.L. Harrold*

Fishmeal as a Source of Rumen Escape Protein for Dairy Cows

Previous research at the Palmer Research Station suggested that the addition of salmon meal to dairy cow diets resulted in increased milk production compared to soybean meal (SBM) diets. However, milk fat percent was depressed with diets containing salmon meal. The current study was designated to determine the total milk production and milk consumption of high-producing dairy cows fed diets containing salmon meal and urea. Milk production and diets will also be evaluated in terms of rumen protein degradability. The experiment was started in August 1988 and is expected to continue through June 1989. Thirty Holstein cows will be used over a 16 week lactation trial. Two experimental diets containing six percent salmon meal or 5.5 percent salmon meal plus .45 percent urea will be compared to a control diet containing SBM as the primary protein source. Bromegrass silage and alfalfa will serve as forage sources. Milk production and feed intake will be measured daily. Weekly milk samples will be analyzed for fat, protein, lactose, total solids, and fatty acid composition. Ruminal fluid and blood samples will be collected and analyzed to examine ruminal fermentation of each diet and uptake of nutrients into the mammary gland. Data is currently being collected. The data will be summarized and reported following the completion of the lactation experimental period. *P.M. Windschitl*

Feedstuffs for Beef Production in Alaska

Two major areas are being studied in this project:

1). alternative approaches for calculation of beef cattle diets; and
2). evaluation of Alaskan feedstuffs for use in beef production in Alaska.

Use of net energy values to balance beef cattle diets for specific

intakes and average daily gains is difficult because feeds are utilized differently for maintenance and gain. In this study, coefficients were derived for use in the quadratic formula which precisely calculated percentages of two feeds needed to meet required NEg and NEm. Once this algorithm was established, the intake prediction equation used by the NRC was evaluated. This equation was incorporated into the balancing equation and reduced. This was done for several classes of beef cattle, yielding simplified equations for use with a hand-held calculator for predicting intake. Evaluations are continuing to develop an equation for use in calculating least-cost feeding programs.

Alaska produces a variety of non-traditional crops that have significant potential as livestock feeds, if these crops can be used correctly in a balanced diet. To study this problem, a trial was initiated in December 1988 with finishing beef cattle. Twenty-four steers and heifers were divided into four groups and placed on finishing rations using Alaskan-grown barley, ground barley, corn or ground corn. Groups fed Alaskan feeds were compared to the corn fed group. These animals will be weighed every two weeks. Feed intake records will be maintained daily. When the animals are slaughtered, carcass data will be gathered. From these studies, a better understanding of Alaskan crops as beef cattle feeds should be gained, so that ration recommendations can be made to producers using local feeds.

Feedstuffs grown in Alaska are typically deficient in selenium. A study with 32 crossbred Alaskan beef cows was conducted to compare methods of selenium supplementation. The cattle were studied in four groups: no selenium supplementation; selenium supplemented by ingestion of soybean meal; selenium supplemented with monthly intramuscular injections; and selenium supplemented by an injection every eight week period. Cows were weighed, and blood samples were taken monthly. Dietary intake was closely monitored. The feeding and injections began in mid-December and continued until April. At calving, observations were made on the status of both the cow and her calf. Analyses of blood and cow and calf performance are being used to evaluate the success of the various supplementation treatments. Preliminary results indicate supplementation with small amounts of feedstuffs containing adequate selenium and injections, monthly or every two months will supply adequate selenium. A single injection of selenium was not sufficient. *L. B. Bruce*

Forage Quality

A new research program has been initiated to address problems related to the production of high quality forages in Alaska. Ruminant livestock are an important component of Alaskan agriculture. At present, the costs of importing protein and energy concentrates to Alaska are very high. Improvements in the technology for producing high quality forages will reduce the input costs for ruminant animal production in the state.

Several aspects of forage quality and production will be addressed in this program. The following research areas will be emphasized:

1). forage legumes;
2). alternative management schemes for cereals and grasses;
3). agronomic practices for *Brassica* crops;
4). post-harvest quality improvement;
5). forage sampling techniques for quality analysis; and

6). computerized forage management evaluation.

The computerized forage management evaluation is an important component of the whole program. Forage management affects forage quality, and quality affects the need for energy and protein supplementation of livestock rations. The evaluation system will integrate crop production, livestock feeding, and economic factors. The objective is to evaluate forage management alternatives in terms of total feeding costs. The system is currently under development. It will provide:

1). the means to identify areas of forage research that will have a positive impact on producers;
2). a real world test of the significance of research results; and
3). a new basis for the development of forage management recommendations. *M. T. Panciera*

Strawberry Runner Plant Production and Flower Bud Initiation

Six cultivars of California strawberries were grown to determine the potential for runner plant production and flower bud initiation under subarctic conditions. All cultivars were heeled in peat in a greenhouse on 13 May, and moved to a cold frame three days later. Cultivars were field planted on fumigated Tanana silt loam soil on 23 May, fertilized, and irrigated as needed. Flowering began on 10 June; plants were disbudded weekly after 17 June. Runner production commenced on 20 June. Plants were well rooted by the first harvest date on 30 August. Each cultivar produced a minimum of 10 runner plants per plant. A sample of crowns was dissected beginning 16 August to determine the timing of flower bud initiation of the runner plants. By 12 September, all cultivars had initiated flower buds. Research to determine the fruiting potential of these runner plants in California is pending. *P. Holloway, G. Matheke and P. Wagner*

Flower, Vegetable and Fruit Demonstration Cultivar Trials

Cultivar trials were conducted with 450 annual flowers and 200 vegetable crops from experimental and commercially available sources. These plants were grown in a public demonstration garden where newly released cultivars were compared with those that had performed well during the past eight years. Evaluation of herbaceous perennials, begun in 1981, continued with extensive renovation and relocation of planting beds and the addition of 20 new cultivars for long-term evaluation. A computer program was devised to assist in compilation of accession information, data analysis, and cultivar evaluation.

Cultivar trials with fruit crops were initiated at six sites in interior Alaska and seven sites in southcentral Alaska. Hardy cultivars of 'Amelanchier,' 'Ribes,' 'Rubus' and 'Vaccinium' were planted in May and June to evaluate plant adaptation to a diversity of agricultural sites throughout the state's railbelt area. Information on plant hardiness, reproductive phenology, fruiting, and fruit quality will be gathered during the next five years. *P. Wagner, P. Holloway and G. Matheke*

Utilization of Wood Chips and Stone Mulches for Ornamental Plantings in Fairbanks

Five woody ornamental trees and shrubs (*Rosa rugosa, Cotoneaster acutifolia, Malus baccata, Picea glauca,* and *Pinus contorta* var. 'latifolia') were grown on Tanana silt loam soil since 1985 under five different mulch treatments: a one-or-two inch depth of Brown's Hill basaltic quarry stone (D-1, 7/8" minus), a two-or-four inch depth of quaking aspen wood chips (81.9 percent by weight less than 3/4" minimum diameter), and a control (no mulch). Plant growth information including dry weight, height, spread, and leaf area was measured, and environmental parameters including soil moisture, soil and air temperature, and weed growth were monitored on each mulch treatment.

Maximum soil temperatures were decreased by as much as 7.8°C over control plots, and soil moisture was increased on the wood chip plots. Stone mulch plots differed from the control plots by no more than 1.5°C maximum soil temperature throughout the growing season. Soil minimum temperatures were lower on the wood chip plots early in the season, but slightly higher in September. Soil pH and available N, P and K did not differ among mulch treatments. Weed growth was suppressed by all mulch treatments but was best controlled on the chip mulch plots followed by two inch stone plots.

Plant growth for all species except *Rosa rugosa* was greatest on the stone mulch plots. Roses growing on the stone mulch plots and the control were subject to significant dieback from winter injury and did not show any difference in total growth after four years when compared to plants grown on the chip plots. All other species except *Malus baccata* grew as well on the chip plots as they did on the control. Plants grown on the chip mulch plots exhibited varying degrees of nitrogen deficiency which may be related to reduced nutrient uptake in cooler soils or to a significant amount of rooting in the mulch-soil interface above the zone of greatest nutrient availability. *P. Holloway*

Effects of Different Polyethylene Mulches and Row Covers on Yield of Day-neutral Strawberries

Strawberries have been produced commercially and by home gardeners in the Interior since the late 1970s using clear polyethylene mulch and row covers to promote early fruiting of day-neutral strawberries. The major drawback of this technique is that it requires the use of herbicides or inefficient hand weeding. Black or opaque mulches have been used with limited success as a means of weed control. The objective of this three-year study is to determine the effect of various mulches on strawberry yield, soil temperatures, and air temperatures above the mulch. After one growing season, yields using clear polyethylene mulch with or without row covers (189.4 lb. and 171.3 lb. per 100 ft. row, respectively) were significantly greater than all other mulch treatments. During the second year, yields using clear mulch were significantly greater than all treatments except for black plastic with row covers (clear without row cover: 270 lb./100 ft. row; clear with row cover 258 lb./100 ft.; and black with row cover 235 lb./100 ft. row). The summer of 1988 was warmer than average, and this may account for the improved performance of the black plastic mulch.

Yields in 1988 for other mulch treatments ranged from 176 lb. to 191 lb. per 100 ft. for black polyethylene; black over white two-sided, embossed polyethylene; black latex spray mulch; permeable mulch; or

white over black two-sided, embossed polyethylene mulch. All of these treatments included clear polyethylene row covers. Unmulched strawberries (control) and those grown on a black polyethylene mulch, each without row covers, yielded 182 lb. and 177 lb. per 100 ft., respectively. When data for both 1987 and 1988 were combined, yields of strawberries grown through clear plastic mulch with or without row covers were significantly greater than all other mulch treatments. *G. Matheke, P. Wagner, and P. Holloway*

Use of Thermal Tubes and Row Covers for Frost Protection of Field-grown Tomatoes

Two types of polyethylene mulch, clear plastic and thermal tube, were tested in combination with slitted plastic, spunbonded polypropylene (Agryl) or no row covers in order to determine the effectiveness of these products on extending the frost-free growing season and increasing fruit yield of field-grown 'Subarctic 25' tomatoes. The thermal tube is a new mulch product with seven-inch diameter, water-filled, clear plastic tubes paralleling each side of an eight-inch clear plastic planting strip. Row covers were used from 17 May to 13 June and again in September until the test was terminated on 23 September.

The effect of the mulches and row covers on spring frost protection could not be determined since no frost occurred after the 17 May planting date. Tomatoes grown under row covers began production about nine days earlier than those grown without covers and had significantly higher yields (19 lb./plant and 12.2 lb./ plant, respectively). Slitted row covers performed slightly better than Agryl (20.2 lb./ plant and 18.0 lb./plant, respectively). There was no difference in yield between covered plots with thermal tubes or clear plastic as a mulch. Plants grown without row covers were killed by frost on 14 September, while the covered plants produced a limited quantity of fruit until 23 September. This study demonstrated the benefits of using row covers to provide early-season protection for warm-season crops in interior Alaska. *G. Matheke, P. Wagner, and P. Holloway*

Potato Yield Trials

Irrigated and nonirrigated trials were conducted with twenty-four named cultivars or numbered selections of potatoes in 1988. The 1988 growing season was warmer and earlier than usual, which resulted in fast emergence and yields that were much higher than normal. A numbered selection (6-78-139-80) from the collection of C.H. Dearborn had the best yield with 17.2 and 21.3 tons/acre of US #1 tubers in nonirrigated and irrigated trials, respectively. Total yield of 6-78-139-80 was 19.5 and 23.5 tons/acre in the nonirrigated and irrigated trials.

The 6-78-139-80 will be seriously considered for its commercial potential in the future. Other top yielding varieties included 'Green Mountain,' 'Sangre,' 'Superior,' 'Shepody,' 'Rosa,' and 'IditaRed.' The percent of US #1 tubers and the specific gravity among all varieties in 1988 was generally higher than average. Detailed accounts of potato yields and environmental conditions for the 1988 season are available at the Agricultural and Forestry Experiment Station. *D.E.Carling*

Pathogenicity of *Rhizoctonia solani* and Similar Fungi on Potatoes

Pathogenicity of fungal isolates representing all known anastomosis groups of *Rhizoctonia solani*, some other *Rhizoctonia* species (*R. oryzae, R. zeae*) and binucleate *rhizoctonia*-like fungi was determined on sprouting potatoes ('Bakeking' & 'Russet Burbank' varieties) at 50°F. Inoculum was placed in a layer above potato seed pieces, making it necessary for sprouts to pass through the inoculum prior to emergence. *R. oryzae, R. zeae*, and binucleate rhizoctonia-like fungi were essentially nonpathogenic on sprouting potatoes. Isolates of *R. solani* AG-3 were moderately to highly pathogenic while most other anastomosis groups of *R. solani* were essentially nonpathogenic. Isolates of AG-8 and AG-2-1 were somewhat pathogenic, but did not damage potato sprouts to any great extent. These data are consistent with the belief that AG-3 is the principal, and perhaps the only group within *R. solani* capable of causing significant damage to potato. This information permits us to focus on the specific fungus causing *rhizoctonia* disease of potato. *D.E. Carling*

Nitrogen Fertilization of Head Lettuce

Residual levels of nitrogen (N) were established in a low N soil by applying 0, 50, 150, or 250 lb./acre N as ammonium nitrate on field plots in the summer of 1987. Plots remained fallow for the 1987 growing season. In the spring of 1988 plots were split and 0, 25, 50, or 100 lb./ N was applied. Head lettuce (var. 'Salinas') was then transplanted onto all plots. High residual levels of N, resulting from the 150 and 250 lb./ acre applications in 1987, resulted in yield depressions that were not offset by spring applications of N at any of the four rates tested . Spring application of N onto plots with low residual levels of N (0 and 50 lb./ acre 1987 rates) resulted in yield increases up to the 100 lb./acre spring rate of application. This is consistent with data from 1986 and 1987 that indicated maximum lettuce yields were attainable with application of approximately 100 lb./acre of N in the spring. Data from plots receiving high rates of N in 1987 indicate lettuce yields may be limited on soils when high residual levels of N are present. This study is to be repeated in 1989. *D.E. Carling and C.L. Ping*

Soilborne Populations of *Rhizoctonia solani* AG-3

This study, begun in 1984, is designed to determine the effects of different crops on populations of *Rhizoctonia solani* AG-3. Previous data indicates potatoes are required to be grown if soilborne populations of *R. solani* AG-3 are to persist. In 1988, as in previous years, non-potato plots, fallow, carrot, bluegrass and barley, supported little or no *R. solani* AG-3. Potato plots, from contaminated or non-contaminated seed, supported populations somewhat lower than in years prior to 1988. We suspect that population declines observed in potato plots are related to increases in populations of microorganisms antagonistic to *R. solani*. Preliminary tests indicate populations of *Trichoderma spp.* are much higher in plots where populations of *R. solani* are higher. This study is to continue, but has identified suitable rotation crops for potato in fields where *rhizoctonia* disease is a problem. Additionally, new plots have been initiated with which we hope to monitor the relationship between fluctuations in *Trichoderma spp.* and *R. solani* populations. *D.E. Carling*

Chemical Weed Control in Potatoes

Five herbicides: Enide, Eptam, Lorox, Sencor and Treflan were tested in potato plots in Palmer and Fairbanks in 1988. The objectives were to compare weed control potential and to evaluate carry-over problems. There were some significant differences due to weed control treatments although differences due to location were apparent, and must be considered. Eptam provided the best control at Palmer while Sencor and Lorox provided the best controls at Fairbanks. Enide and Treflan exhibited poor control at both locations. We believe that Eptam, Sencor or Lorox could be used to advantage by potato growers, assuming applications are properly timed and careful attention is paid to varietal restrictions appearing on the label.

Soil samples are to be taken from the 1988 plots in the spring of 1989 and will be evaluated for signs of carry-over problems. Also the experiment described above will be repeated with minor modifications in order to better evaluate the weed control capacity of Eptam, Sencor and Lorox; and to evaluate the effect of time-of-application on the behavior of Lorox and Sencor. *D.E. Carling and J.S. Conn*

Resistance and Susceptibility of Plant Introductions From the IR-1 Potato Germ Plasm Repository to *Rhizoctonia solani* AG-3

Seed tubers of 49 plant introductions (PI) representing 36 species of *Solanum* were planted in the field and inoculated with barley kernels colonized by pathogenic isolates of *Rhizoctonia solani* AG-3. Control treatments were inoculated with sterile barley kernels. Ten replicates of the inoculated and noninoculated treatments were arranged in a randomized complete block design, and data were collected on emergence, plant weight, root weight, and damage induced by *R. solani*. Generally poor emergence not related to treatment made it impossible to evaluate 11 PI. Emergence and plant weight of 14 PI was not affected by treatment in spite of stolon damage on most plants. Delayed emergence associated with treatment was observed in 12 PI with the average delay in emergence being 7.3 days. Emergence was reduced in 17 PI. Delay and reduction in emergence appeared to be the most common form of *R. solani* induced damage. An increase in emergence was observed in several PI, an unexpected observation that will require additional study to confirm.

We plan to continue these studies with the hope of identifying sources of resistance to *R. solani* in the genus *Solanum* that may be incorporated into commercial varieties of *S. tuberosum*. A detailed account of this study is available. *D.E. Carling*

Cereal Breeding and Production

Eighteen barley crosses were successfully completed in March 1988 at the winter season nursery in Arizona. Hybridized seed was returned to Palmer in June and was increased in the growth room. Additional crosses were produced as desired during the increase process. This material furthers the planned development of segregating populations possessing multiple disease resistance and general adaptability to the Alaskan environment. Conventional six-row hulled, hooded, hulless, and two-row materials are represented in this hybridization program.

More than 5,000 advanced generation plant selections from 18 crosses were row planted in the field for visual evaluation for agronomic desirability. Most of these crosses represent disease-resistant parents combined with well adapted lines. An additional 30 early generation

crosses were also evaluated visually. An estimated 10,000 selected plants will be available for evaluation from these populations. About 4,000 selections from disease-resistant composite crosses were subjected to initial selection for general adaptability to this environment.

Replicated barley, oat, and wheat trials were limited to a few advanced generation selections grown in comparison with standard cultivars. One selection each of barley and oats appears to warrant serious consideration for naming and release as improved cultivars. Single plant yield and agronomic evaluations were limited to 384 barley lines. About 45 of these were relatively recent introductions from Scandinavia. The remainder were largely disease-resistant selections from composite crosses. The breeding objective of these evaluations is the selection for the breeding program of disease-resistant materials possessing reasonable adaptation to Alaska. However, lines which may be used directly as new cultivars will be fully evaluated.

Limited quantities of breeder seed of most released cultivars remains available. Field space limitations and a shortage of technical assistance prevented additional increases in 1988. *R. L. Taylor*

Plant Germ Plasm Introduction, Increase, Evaluation, Documentation, Maintenance and Distribution

Grain variety trials are conducted on an annual basis so that new varieties developed in Alaska and other northern agricultural regions can be evaluated to determine their adaptability to Alaska's growing conditions. These trials are the basis for making variety recommendations to farmers in the Alaskan interior. During 1988, 23 barley, 14 oat, and 16 wheat varieties and experimental lines were evaluated in replicated standard trials at Fairbanks and Delta Junction. The testing was conducted on land that had been summer-fallowed the previous year. Both test sites had favorable climatic conditions for growing small grains. However, a severe grasshopper infestation caused some damage to crops at Delta Junction. Grain yields for this site were not noticeably reduced. Most of the damage was to leaves and occurred late in the growing season during the filling and maturation period.

The varieties and experimental lines for each grain type were separated into two maturity classes: very-early-to-early and medium-to-late. At Fairbanks, the highest yields in each of these crops for the very-early-to-early maturity class were: 'Jackson' barley, 86 bu./acre; 'Pol' oats, 134 bu./acre; and 'Chena' wheat, 63 bu./acre. The highest yields for each of the crops for the medium-to-late maturity class were: 'Lewis' barley, 99 bu./acre; 'Calibre' oats, 165 bu./acre; and 'Tapio' wheat, 83 bu./acre.

At Delta Junction, the highest yields in each of the crops for the very-early-to-early maturity class were: 'Hankkija's Eero' barley, 92 bu./acre; 'Toral' oats, 107 bu./acre; and 'M5213-150' (ACA2571) wheat, 69 bu./acre. The highest yields in each of the crops for the medium-to-late maturity class were: Lewis barley, 89 bu./acre; 'Cascade' oats, 117 bu./acre; and Tapio wheat, 69 bu./acre. *F.Wooding*

Genesis and Classification of Volcanic Ash Soils in Alaska

The classification and land-use interpretation of volcanic ash soils are important in Alaska because of their extensive distribution. Research projects were initiated in 1985 to study the morphological, chemical, physical, and mineralogical properties of volcanic ash soils in southcentral Alaska. These studies are in cooperation with the USDA Soil Conservation Service, the U.S. Forest Service, and Tohoku University of Japan. As a result of the cooperative efforts, a new suborder of Cryand was adopted by the International Committee on Andisols (ICOMAND) to accommodate all volcanic ash soils in the cryic temperature regime. A proposal to modify the great groups and subgroups of Cryand has been accepted by ICOMAND, and submitted to USDA SCS for field testing. As a result, most of the volcanic ash-derived soils in the Cook Inlet Region and southeast Alaska previously classified as Spodosols will be reclassified as Andisols. Studies on the micromorphology and toposequence of some of these soils are underway. The research in soil genesis and classification in Alaska is contributing to the National Soil Data Base and to the classification of cold soils in soil taxonomy. *C. L. Ping*

Soil Climate Study in Alaska

In soil taxonomy, pergelic soil temperature regime is defined as mean annual soil temperature at or below 0°C. As a result, most soils in the Interior and the Arctic Slope are classified in the pergelic subgroups of Cryaquepts, Cryochrepts and Cryorthods. However, in the Tanana Basin and the Copper River Basin areas, some pergelic soils have thawed after the duff layer and the forest vegetation were removed through either land clearing or fire. The mean annual temperature of these soils will remain above 0°C, warm rapidly in the spring, and the soil temperature regime becomes cryic. Similar pergelic-cryic temperature cycles were also found in natural succession after forest fires, although the stages and pattern are more complex. A study, in cooperation with the USDA Soil Conservation Service, is underway to identify these soils and to propose a new taxonomic unit to map those cyclic-pergelic soils in interior Alaska and to facilitate land-use management. *C.L. Ping*

The Effects of Rock Phosphate Fertilizer on Timothy and Bromegrass Grown on Volcanic Ash-Derived Soils

Volcanic ash-derived soils are found in the Susitna Valley, Pt. MacKenzie, and the lower Kenai Peninsula area of southcentral Alaska. These soils are often strongly acidic and have the capacity to sorb large quantities of phosphorous (P). As a result of the high P sorption capacity, these volcanic ash derived soils often test low in available phosphorus. Forages show a growth response to higher rates of P fertilizer on these soils than on other soils of the state. However, there is little benefit from residual fertilizer even with larger amounts of P applied, due to the high P sorption by these soils.

A field study was initiated in the spring of 1988 to investigate the use of P fertilizer as it relates to the performance of timothy and bromegrass on the volcanic ash-derived soils. The first objective of the study was to compare the effects of various rates of rock phosphate (RP) fertilizer material in relation to the recommended rate of the commonly used triplesuperphosphate (TSP) P source.

The second objective of the study was to investigate the residual

effectiveness—two-to-three years—of RP by studying its effect on the P fertilizer requirements of the two grasses. Three soils were selected for this study: Kashwitna silt loam (Typic Cryorthods) at Pt. MacKenzie, Nancy silt loam (Vitric Haplocryands) near Montana Creek, and Kachemak silt loam (Typic Fulvucryands) near Homer. Rock phosphate was applied at the rates of 0, 100, 200, and 300 lb. of P_2O_5/acre. Soil samples were analyzed for pH, Mehlich 3 extractable P, K, Ca, and Mg. Forage tissue samples were analyzed for N, P, K, Ca, and Mg.

The results of the first year of study can be summarized as:

1). Soil P and Ca levels indicate that the less soluble RP fertilizer is dissolving in all soils. The dissolution appears to be greatest at the Homer site where pH is lowest.

2). Stand establishment, as indicated by first-year production, was about equal for timothy and bromegrass at the Pt. MacKenzie site, 21 percent better for timothy compared to bromegrass at the Montana Creek site, and 30 percent better for bromegrass compared to timothy at the Homer site.

3). Increases in production of both grasses were observed at all sites with the application of RP at the rate of 100 lbs P_2O_5/ acre.

4). Indications are that the more slowly-available (less soluble) nature of RP may have a beneficial effect on availability of P to the establishing grasses. Yield responses were observed with RP treatment even when applied in addition to the recommended rate of TSP.

Subsequent years of this study will help determine the significance of this beneficial RP effect for forage production. *C.L. Ping and G. J. Michaelson*

Organic Carbon Recovery in Subarctic Soils in Alaska

Soil organic matter is commonly estimated by organic carbon (OC) content determined by the Walkey-Black wet oxidation method or by total carbon (TC) content by the dry combustion method such as with the Leco induction furnace. This study was conducted to determine the carbon contents of different groups of soils in Alaska, and to compare the results of the two methods. Both the Walkley-Black and the Leco induction furnace methods were performed on 130 soil samples taken from Yukon Flats, Seward Peninsula, Tanana Basin, Cook Inlet, and Baranof Island. The highest OC levels were found in the Humic Cryorthods (Hydrocryands) and Typic Cryohumods (Fulvucryands) developed under a mixed stand of Sitka spruce and hemlock in a perudic moisture regime. Found were 11 to 18 percent in A, E, Bh or Bhs horizons and 1 to 6 percent in BC and C horizons.

In the humid environment of Cook Inlet, the Typic Cryandepts (Melanocryands) developed under a mainly blue-joint grass vegetation. Typic Cryorthods (Haplocryands) developed under white spruce. In Cryandepts, OC averaged 9, 5, and 2 percent in the A, B, and C horizons, respectively. In Cryorthods, OC averaged 6, 3, and 1 percent in the E, B, and C horizons, respectively. In the subhumid environment of interior Alaska, the Cryochrepts developed under white spruce had the lowest OC levels of 3 percent in A or E horizons, 0.6 percent in B horizons, and 0.3 percent in C horizons.

The average recovery rate of OC vs. TC for all samples was 91 percent. However, the rates for A, E, and B horizons were much higher—95-100 percent—than BC or C horizons which were less than 60

percent. This low recovery rate in subsoils may be due to the presence of carbonate or higher degree of polymerization of organic matter. Another study is underway to address this problem. *C.L. Ping and G. J. Michaelson*

Potassium Status of Alaska Soils

The soil mineral fraction influences exchange, release and fixation of potassium (K) cations in a soil. The soils of Alaska that either have agricultural potential or are currently in cultivation, generally have a similar silt loam texture but vary considerably in their mineralogy. Soils from the Susitna Valley and Kenai Peninsula are highly allophanic with few layered minerals, whereas soils in the Tanana Basin and Matanuska Valley are rich in micaceous and other layered minerals with little allophane. Currently there is little known of the supply or reaction of K in these soils. A study of the K status in Alaskan agricultural soils was initiated in 1987. The objective of this study is to better characterize soil K supply. This information can ultimately lead to better understanding of plant-available K and its assessment for these soils.

Soil K quantity-intensity (Q/I) relationships and potential buffering capacity (PBC) have been used to characterize soil K supply and K fixation, respectively. Cryandepts and Cryorthods in southcentral Alaska (Kachemak, Kashwitna, Nancy, and Soldotna series) are high in allophane content. They have lower PBC or fix considerably less K than the Cryochrepts with mixed mineralogy. All the preliminary data reveal that there are differences in PBC, hence K fixation, among genetic horizons of the same soil series. Generally, the subsoils have higher PBC values or higher K fixation. Such differences are thought to be related to degree of weathering. More work will be necessary to relate the Q/I data to an available K soil test, plant growth-fertilizer response, and specific soil mineralogy. *C.L. Ping and G. J. Michaelson*

Uses of Mycorrhizal Inoculum for Plant Establishment on Abandoned Mined Lands

On-site mycorrhizal inoculum is being investigated to improve plant establishment on abandoned mined lands. The mycorrhizal relationship is a symbiosis between fungi and plant roots which aids the plant in absorption of phosphorus and other nutrients. Mycorrhizae are important for establishing most plant species. Adjacent soils may be a readily available source for inoculation. A preliminary survey of existing mycorrhizal infection indicated that a relatively undisturbed forest vegetation had a larger percentage of root lengths infected than roots from disturbed communities of various ages. Grass roots from a recently revegetated site had negligible signs of infection. Roots from grasses on four-year-old revegetated sites had low levels while those eight-year-old sites had more mycorrhizal infection. Naturally colonizing species on the disturbed site had low levels of mycorrhizal infection. Indications of both endo- and ectomycorrhizal infection were found on balsam poplar (*Populus balsami fera*).

Several experiments were implemented in the field using poplar cuttings and alder seedlings to examine the use of on-site inoculum to improve plant establishment, the source of inoculum to improve plant establishment, the source of inoculum with respect to age of community, interaction of poplar with alder, and enhancement of slope

stability. Survival in three of the four experiments was more than 90 percent for the first growing season. The other experiment suffered high mortality with survival between 55 and 64 percent for alder and poplar. Mortality resulted from moose damage and hot, dry weather just after the time of planting. The project is funded by the U.S. Bureau of Mines Abandoned Mined Lands program. *D. J. Helm*

Wishbone Hill Vegetation Studies

The premining vegetation inventory was conducted on the Wishbone Hill project for the Alaskan-owned company Idemitsu Alaska, Incorporated. The inventory assessed the current extent of vegetation types, species composition, diversity, successional relationships, and moose browse. The most important vegetation types were: closed paper birch–aspen, open paper birch–white spruce, young birch, lowland meadows, and upland meadows. Five additional types were identified and mapped, but all were of minor extent. The dominant tree species were paper birch (*Betula papyrifera*) and aspen (*Populus tremuloides*). Bluegrass (*Calamagrostis canadensis*) was the most important grass while important forbs included fireweed (*Epilobium angustifolium*) and bunchberry (*Cornus canadensis*). Oak-fern (*Gymnocarpium dryopteris*) was an important fern. Understory vegetation was very similar among the forest types and consisted of bluejoint, bunchberry, and oak-fern. Many birch trees have been heavily browsed to the point of retaining a shrub growth form. The area has been disturbed in the past by mining, wood cutting, and recreation. The vegetation types are fairly common in the area, and most of the species occur widely throughout the state. *D. J. Helm*

Summarization of Data on Grazing Lands of the Matanuska-Susitna Borough

The Matanuska-Susitna Borough and Upper Susitna Soil and Water Conservation District requested a synthesis of data on grazing lands of the borough to develop a grazing program. The most extensive data collection in the area was the Cooperative Susitna River Basin Study where numerous sites were sampled for annual production, plant cover, timber resources, and wildlife habitat. Only the production data were used here. Additional supporting data were found in the Hatcher Pass soil survey preliminary data (SCS) primarily on state lands. Estimates of useable forage/acre in each vegetation type and acres of each type were used to estimate the number of animals that could be supported on borough land.

The highest production areas for grazing were bluejoint and saltwater grasslands followed by alder and salt water low shrub. The greatest grazing resource, however, appears to exist in mixed forest (usually birch-white spruce) vegetation types because of their productive understory and extensive acreages. Grazing could be combined with a forest industry on some of these sites. Intensive grazing management could be enhanced by better knowledge of plant species nutrient content throughout the grazing season and their short- and long-term response to grazing. Most grazing in the near future would probably be low intensity. *D. J. Helm*

Crop Uptake of Residual Fertilizer Nitrogen

A recently completed field study indicated that about 40 percent of the N applied as urea at a rate of 100kg/ha to interior Alaskan soil is taken up by barley during the year of application and that approximately 40 percent of the applied N remains in the soil at the end of the growing season. We do not know how much of this residual N can be used by crops in years succeeding application of the N in subarctic soils. In this study, we are measuring the uptake of ^{15}N labeled residual fertilizer by barley plants in years following application. The field aspects of this study are now complete. However, due to problems in getting the ^{15}N analyses done, we do not at present have any results on the uptake of the residual N. This study will add to the understanding of N-cycling in subarctic agricultural soils. *S. D. Sparrow and C. W. Knight*

Arctophila Fulva Revegetation Feasibility Project

Describing the life history and determining the habitat requirements for *Arctophila fulva*, arctic pendant grass, are the focal points of this research. The U.S. Fish and Wildlife Service and BP Exploration, formerly Standard Alaska Production Company, want to know the feasibility of establishing new *Arctophila fulva* stands in impoundments resulting from construction activities in the Sagavanirktok River delta. This was a logical extension following the discovery that this aquatic grass was associated with prime habitats for waterfowl and other migratory birds that nest on the coastal plain province of Alaska's arctic slope. Major efforts during 1987 and 1988 have been to identify the chemical properties of waters and muds inhabited by *Arctophila fulva* to determine whether there are factors which either encourage or obstruct the grass from surviving in some ponds, as the plant does not occur in all ponds of that region.

Over 100 sites have been included in this study, which extends from Oliktok to Endicott (across the Prudhoe Bay and Kuparuk oil fields), southward along the Trans-Alaska Pipeline to Pump Station Number 4. There is one site in the boreal zone, east of Denali National Park. The laboratory data from this study have shown that *Arctophila fulva* has an extremely wide range of tolerances to environmental conditions. It has been found in alkaline and acid muds, fresh and saline water, and even in an abandoned reserve pit at an exploratory well site. Our findings provide insight into the background levels of nutrients and metals that occur both naturally and as perturbations from human activities in arctic Alaska.

During the 1987 growing season water was collected weekly from eight ponds and one impoundment during a nine-week period to characterize selected chemical and physical properties of water in these ponds. Turbidity, pH, and electrical conductivities were measured in the field. Dissolved elements determined in the laboratory included: nitrate-N, Al, As, Ba, B, Cd, Cu, Ca, Cr (hexavalent), Fe, Pb, Mg, Mn, Hg,Ni, K, Na, Se, V, and Zn. Also total Kjeldahl-N, PO_4, Cr, and Cr (hexavalent) were measured. In addition, 51 other locations were sampled once and analyzed for the same set of elements to determine whether there were distinct patterns in water chemistry for *Arctophila fulva* and non-*Arctophila fulva* ponds. Electrical conductivity (salinity), turbidity (water clarity), and twelve elements (Al, As, B, Ca, total and dissolved Cr, Fe, K, Mg, Na, Ni, P, and Se) differed among the nine ponds repetitively sampled. None of these differences seemed to explain either

occurrences of, or effects from, *Arctophila fulva*. In a 51-pond survey conducted in 1987, electrical conductivity, Na, B, Mn, Ni, and Zn were higher in non-*Arctophila fulva* ponds than in ponds with the grass. Some of these elements had been elevated by seawater contaminations. Since water chemical properties in these ponds reflect chemical conditions of underlying muds and sediments, water chemical differences not associated with seawater were likely from natural variations in soil properties. Perturbations from human activities were noted for selected sites. Freshwater electrical conductivity in this region averaged 470 to 940 µmho/cm (95% confidence interval). *Arctophila fulva* was found growing in brackish water with E.C.of 2,700 µmho/cm, which is about 1/3 the salinity of near-shore Beaufort Sea water. This indicated the grass has a wide tolerance to variations in habitat. Even though we discovered differences in water chemistry between *Arctophila fulva* and non-*Arctophila fulva* habitats, we remain unconvinced that the species was prevented from inhabiting those open sites due to water chemical properties. Eutrophication of ponds by water enriched from sewage treatment plants increased the phytoplankton levels and restricted the water depths that *Arctophila fulva* tolerated. This was the only water chemical feature that we could confidently identify as controlling the distribution of this species. In those same locations, *Arctophila fulva* and other vascular plants grew more densely and vigorously along the pond margins than in any of the unaffected locations. These plants growing on enriched sites remained green late in the growing season. The eutrophic pond and lush surrounding vegetation attracted large numbers of shorebirds and waterfowl late in the growing season, when the unfertilized vegetation was aging. *Arctophila fulva* transplanted to new locations reproduced more rapidly when fertilized with phosphorus fertilizer, substantiating the natural limitation of that nutrient in this ecosystem. We do not recommend pond eutrophication to enhance habitat for *Arctophila fulva*, but we do recommend using judicious amounts (15 to 30 lb. P/acre) of phosphate fertilizers to encourage the expansion of transplants in new sites. *J. D. McKendrick*

Leaf Unfolding Rate in *Begonia x hiemalis*

Begonia x hiemalis is produced as a flowering potted plant. Long photoperiods (16 hours of light per day) encourage vegetative growth while short days (10 hours of light per day) favor flower initiation and development. To produce a high quality *Hiemalis begonia*, a balance must be established between vegetative and reproductive growth. Three weeks of long days are recommended to attain adequate plant size for flower initiation. Proper flower initiation will take place under two to three weeks of short days, and the plants are then finished under three weeks of long days. Better documentation of the initial vegetative phase will allow improved crop scheduling and timing. The environment can be adjusted to give similar plant development prior to the short day treatment and flowering can be scheduled easier for desired marketing dates.

Leaf unfolding rates were determined for the two *Hiemalis begonia* cultivars 'Hilda' and 'Ballet'. Multistem cuttings were grown at 13°, 16°, 19°, 22°, 25° and 28°C. The number of unfolded leaves was recorded daily. There were no significant differences in the rate of leaf unfolding between the two studied cultivars. A second-order polynomial regression equation was developed to describe the leaf unfolding

response. Fastest rate of leaf unfolding occurred at 21°C as indicated by the developed function. The predicted rate of leaf unfolding at 21°C was 0.1065 leaves/day (9.4 days required to unfold one leaf). The rate of leaf unfolding at 13°C was 0.0733, and at 28°C, 0.0811 leaves/day. *M. Karlsson, and H. McIntyre*

Low Temperature Effects on Chrysanthemum Flower Initiation and Development

A study was initiated during 1988 to determine the effects of low temperature (10°C) on the transition from vegetative to reproductive meristem in *Chrysanthemum morifolium Ramat.* Delayed and abnormal flower development in chrysanthemum at high temperatures have been observed and reported several times. Temperatures below the optimum temperature for flower initiation also result in delayed and atypical flower development. Maintaining optimum greenhouse temperatures may not be possible during periods of outside low temperatures. Under these circumstances, an understanding of the low temperature effects during flower initiation will facilitate early decision making. The magnitude of damage during flower parts formation may warrant early crop termination or adjustments in the environmental conditions during successive plant development.

The flower initiation process at low temperature is compared in this study to flower initiation at recommended temperatures (15-20°C). Light, fluorescent and scanning electron microscopy are used to study and document the transition from vegetative to reproductive meristem. The impact of early low-temperature duration on abnormalities in the continued flower development and the possibility to reverse early negative temperature effects on flower development by subsequent optimum environmental conditions are also examined. *M. Karlsson and H. McIntyre*

Flower Initiation in Primrose as Affected by Temperature and Irradiance

Low temperature requirements for development (13-16°C) make *Primula vulgaris* (primrose) a suitable flowering potted plant for greenhouse production in high latitude areas. Flower initiation has traditionally been scheduled and controlled by six weeks at 7-10°C. Recently it has been suggested, primrose flower initiation will occur without the cold treatment and temperatures below 10°C only delay development. The effects and interactions of temperature, photoperiod and light intensity on the efficiency of primrose flower initiation will be determined in this study.

Flower initiation will be studied under constant day and night temperatures of 8°, 12°, 16°, and 20°C. The selected total daily light intensities are 2, 10 and 18 mol $day^{-1}m^{-2}$ and the chosen day lengths are 8, 11, and 14 hours to include the critical photoperiods for most long- and short-day plants. To avoid confounding the effects of day length and total light intensity per day, the instantaneous light intensities are adjusted based on day length. The event of flower initiation will be determined by dissecting plants under a microscope. Continued development of the remaining plants after flower initiation, will take place at a common environment of 16°C, 11-hour day length and 10 mol $day^{-1}m^{-2}$. Any abnormalities in flower development due to non-optimum conditions during the initiation process are expected to become appar-

ent under these recommended environmental conditions for flower development in primula production. *M. Karlsson and J. Dart*

Snow Mold Disease Research

Snow mold disease is a major problem in Alaskan agricultural development. It not only affects wheat and rye winter survival, it can also cause rapid decline in forage and turf grasses. Since 1980, the disease has been systematically studied. Research topics have addressed:

1). identification of snow mold disease-causing fungi;
2). interactions of snow mold fungi with host plants; and
3). synergistic and antagonistic interactions among snow molds.

The objectives of this research is to thoroughly understand pathogens and their impacts on host plants in order to develop an effective and economical method of controlling this complex disease.

Sclerotini aborealis is one of the low-temperature tolerant soil-borne plant pathogenic fungi causing serious snow mold disease on winter cereals and grasses in northern latitude regions. Contrary to other findings, myceliogenic germination of *sclerotia* was found to be the primary source of infection in interior Alaska.

A simple, space-saving snow mold chamber and a new method for inoculating snow mold fungi were developed. Using the chamber and the new method, plants were inoculated with snow mold. Within seven days all plants in the test were penetrated by the snow mold. Mortality among the inoculated plants was 100 percent. *J. McBeath*

Anther Culture and Snow Mold Resistance of Winter Wheat

Growing winter crops in Alaska provides great advantages for farm management, water and soil conservation, and pest management. Due to environmental conditions, winter cereals grown in Alaska need to be cold-hardy, early-maturing, and snow mold disease-resistant. Several hard red winter-wheat cultivars have proven capable of sustaining winter harshness, but of all the germ plasms tested that were reputed to be resistant to snow molds *Fusarium nivale* or (sLTB) and *Typhula spp.*, none has been found resistant to the snow molds *Sclerotini borealis* and sclerotial low-temperature basidimycete which are found in Alaska

Breeding plants to meet the needs of the Alaskan farmer using traditional methods, such as pedigree and backcross, is very time consuming, labor intensive, and costly. It usually requires many generations to obtain pure lines from a heterozygous source. Androgenic haploid plants, obtained through such *in vitro* techniques as anther culture or anther-panicle culture have proven to be useful in plant breeding. Cell culture techniques provide a means for recognition and recovery of genotypes that are difficult to manipulate in field populations.

Since starting in 1986 in cooperation with USDA-ARS, a technique has been developed to obtain androgenic haploid plants from anthers of cold-hardy, early-maturing, hard red winter-wheat. Concerted efforts are currently underway to develop methods to screen these winter wheat cultivars for snow mold resistance. The long-range goal is to provide a means by which snow mold tolerance in winter wheat cultivars can be expanded. *J. McBeath*

Cottonwood Bud Proliferation, A New Disease (Possibly Caused by Mycoplasm) Found in Alaska

In 1982 an abnormality was observed on cottonwood trees (*Populus balsamifera L.*) growing under alpine conditions near the treeline in Denali National Park. Recently the same disease was found on cottonwood trees in the Donnelly Dome area.

The disease can be recognized by the proliferation of terminal buds—up to 50—fused together in a flattened fashion. Histological studies of diseased tissues revealed an excessive proliferation of secondary phloem. Leaves formed were small, malformed, and turned yellow prematurely. Significant decreases of stem diameter, tree height, canopy size, and root sucker production were found on the diseased trees.

Attempts to determine the cause were unsuccessful in 1982 because of the obsolete equipment used. Starting in 1987, using a newly purchased transmission electron microscope, another study was undertaken to determine the cause of the disease.

Mycoplasm-like organisms were observed in the sieve elements of the diseased tissue. The organisms were not observed in tissue from healthy trees. *J. McBeath*

Biological Suppression of Snow Mold and Other Soilborne Plant Pathogens

In 1985 isolation of natural antagonists of snow mold fungi in the Alaskan environment was initiated in an attempt to find alternative means to control snow mold disease. In 1986 an unusual fungus was isolated in soils near Fairbanks. This isolate displayed marked tolerance to low temperatures. At 7°C, colonies reached nine cm in nine days. At 4°C, the colonies grew much slower, but still grew faster than the snow mold fungi, and the isolate colonies were well established and appeared normal. This isolate appears to be a mycoparasite preying on snow mold. In addition to snow mold fungi—*Sclerotina borealis*, LBT, *Fusarim nevale Typhula incarnata, T. idahoensis, T. ishikariensis*—the isolate was also found to be effective in controlling *Armillaria mellea, Rhizocotonia solani* and *Pythium spp. J. McBeath*

N_2-Fixation and Green Manure Potential of Annual Legumes in Alaska

This study was designed to measure forage production and N_2-fixation by several annual forage legumes in Alaska and to determine the availability of residual N from legume crops to non-legume crops planted in the year succeeding the legume. This three-year study, which was begun in 1988, is being conducted at the AFES research farm in Fairbanks and at the Delta research site near Delta Junction. Total plant N and ^{15}N data are not yet available so we do not have any estimates of N_2-fixation at this time. Plant yield data showed that some of the legumes tested have a very high potential productivity. For example, inoculated yellow sweetclover, red clover, Austrian peas, faba beans, and white lupines all produced more than three tons per acre of dry matter at Fairbanks and more than two tons per acre at Delta when the soil at Delta was limed. Liming of the acid soil at Delta caused a substantial yield increase for most of the legumes tested. At Delta, inoculation with root-nodule bacteria (*Rhizobium*) resulted in yield increases by as much as five-fold for some legumes; at Fairbanks there was little or no effect from inoculation. Barley will be planted on the plots in 1989 to determine how much of the N in the legumes plowed under in the fall becomes available to the non-legume crop in the year following the legume crop. *S.D. Sparrow, V. L. Cochran, and E. B. Sparrow.*

Forest products are a major export industry in most northern circumpolar nations. Interior Alaska, despite its millions of forest acres lags behind the rest of the circumpolar north in forest industry development.

Forest Sciences

Forest Floor Ecosystem

A new program, initiated in 1988, is designed to evaluate the importance of the forest floor as the key ecosystem compartment controlling nutrient supply for tree growth in taiga forest of interior Alaska. Because of cold soils, and consequent shallow plant rooting depths, this detrital layer plays a changing role in element supply with advancing succession. Acting primarily as a source of nutrients in early stages of community development, element flow through this compartment becomes progressively restricted with advancing succession. This change in element supply is thought to be primarily caused by a reduction in decomposer activity due to a shift in chemical characteristics of the organic matter in concert with a cooling of the layer as its thickness increases. Chemicals implicated in controlling decomposition include lignin, cellulose, and plant secondary chemicals such as tannins and terpenes.

The principal questions being considered, in a successional context, in the research deal with:

1). the role that changing forest floor organic matter chemistry plays in control of decomposition and element supply for plant use from this detrital layer and

2). the role of vegetation-caused changes in light, moisture, and nutrient availability in control of plant biomass, productivity, and organic distribution.

These two focal points are closely related through the influence of successional changes in plant species composition and plant chemistry on detrital decomposition and, in turn, element supply.

Documenting the changes in forest floor organic and inorganic chemistry, and the relationships between decomposition, element release, and their control by the chemical properties will greatly

increase our understanding of element supply processes in taiga forest. Documenting the changes in foliage chemistry, tree growth and carbon allocation, and their control by nutrient availability and other environmental factors (i.e. moisture, radiation) will also greatly increase our understanding of forest development in taiga forests. Moreover, this work is a logical extension of our research dealing with nutrient cycling and nitrogen dynamics in interior Alaskan forests. The research activities address important, basic aspects of the control of nutrient supply for tree growth and the control of tree growth by nutrient supply. Moreover, both from short- and long-term viewpoints, sound forest management must include understanding phenomena that control soil fertility. The proposed research will substantially increase our knowledge in this regard. *K. Van Cleve and J. Yarie*

Salt-Affected Forest Soils

In connection with the study of the development of salt-affected soils on the Tanana River floodplain of interior Alaska, we examined several hypotheses dealing with soil development. One approach, independent of other field experimental work in hypothesis testing, was to determine the stable ^{13}C and ^{18}O isotopic composition of $CaCO_3$ along the floodplain primary successional sequence (250 years) and to examine possible mechanisms controlling the formation of $CaCO_3$.

A total of 120 soil samples were collected and analyzed for stable isotopes from duplicate plots of three successional stages:

1). open shrub (Stage III, four years),
2). young balsam, poplar-alder (Stage V, 30 years), and
3). mature white spruce (Stage VIII, 170-250 years).

The early stages of plant succession showed little variation in the mean ($\partial^{13}C$(PDB*) = -4.3 to -4.0‰O), while the Stage VIII sites showed the greatest carbon depletion ($\partial^{13}C$=-7.9 to -6.2‰O). This isotopic depletion in ^{13}C relative to marine carbonate rocks suggest a pedogenic origin for the soil $CaCO_3$. The mean $\partial^{18}O$(PDB) values ranged from –16.3 to –14.6‰O. These low $\partial^{18}O$ values were due to the very depleted meteoric precipitation ($\partial^{18}O$(‰O) = -50.3 (PDB) = -21.0(SMOW**)) for this cold, continental site. Mechanisms of formation were assessed by comparing experimental measurements to theoretically derived limits on isotopic composition. There was little evidence to support a freezing mechanism for $CaCO_3$ precipitation. Soil drying via transpiration and evaporation was the dominate mechanism controlling $CaCO_3$ precipitation. The relative importance of the transpiration and evaporation mechanisms varied over the short-term primary successional sequence. Over the longer-term pedogenic perspective, $CaCO_3$ precipitation in the Tanana River floodplain soils was 60-68‰ due to transpiration in equilibrium with C_3 plant CO_2 and 32-40‰ due to evaporation in equilibrium with atmospheric CO_2. (*PeeDeebelemnite, **Standard Mean Ocean Water) *G. Marion and K.Van Cleve*

Long-Term Ecological Research Program (LTER)

During the first year of the taiga LTER (Long-Term Ecological Research) program, we emphasized work in three general areas:

1). purchase of equipment for support of field, laboratory and office work;
2). location of field study sites and establishment of experimental plots; and

3). description of experimental areas and sampling of vegetation and soils.

The Vice Chancellor for Research provided complete funding for purchase of a new riverboat, motor, and trailer. This will greatly facilitate transportation to floodplain field sites. Additional purchases included data pods to remotely sense and log atmospheric and soil temperature, radiation, humidity, soil moisture, precipitation, and wind speed and direction. Computer support was the other major purchase. This equipment will be employed in data processing, archiving and transfer among local project personnel and other LTER sites, and promoting our process modeling capability. Experimental site selection and environmental monitoring instrumentation were completed on the floodplain. Instrumentation is in place in the appropriated upland locations. Vegetation and soil sampling were completed at each of the instrumented study locations in the uplands, and will be completed on the floodplain during the coming field season. Moose/hare exclosures were installed at four floodplain locations to allow evaluation of the impact of grazing on early successional processes. Results of this study will have important implications in evaluation of controls of long-term forest site productivity. *K. Van Cleve, L. Viereck*

Forest Hydrology/ Watershed Management Research

Research in the area of forest hydrology/watershed management has focused on the interrelationship between vegetation and the hydrologic cycle— —the link between the terrestrial and aquatic dimensions of the ecosystem. A model of the watershed hydrologic balance (budget) is used as the framework for organizing knowledge, forming hypotheses to be field tested, and gaining insights on probable impacts of vegetation changes. The model serves to focus research on those projects that will most enhance our capability for realistic and reliable predictions of hydrologic impacts. Also, by working within this framework, a variety of specific research directions are kept relevant to the management context.

Although many of today's water resource problems are water quality problems, a conceptually sound understanding of the pathways and magnitudes of water flow to ground and surface waters is a prerequisite to developing predictive and prescriptive powers regarding water quality. Consequently, our research has focused on reviewing and developing water balance techniques (water quantity vs. water quality models) applicable to northern climatic circumstances. Once an adequate understanding of the pathways of water flow exists, we will be better able to describe its quality. The current project is designed to measure snowmelt runoff from the Spinach Creek watershed near Fairbanks and to develop models to estimate the impact of vegetation manipulation on spring runoff in the boreal forest.

Streamflow from the 10 sq. mile Spinach Creek watershed is monitored from breakup to freeze-up using two Leopold & Stevens F-type water level recorders on a three-foot Parshall flume. A pre-melt snow survey is performed and summer precipitation is recorded at five locations within the watershed. We have four years of data currently being digitized from strip charts which will be tabulated to provide

managers with a knowledge of the range and variability of snowmelt runoff. These data will also serve as a basis for judging simulation performance.

Modeling efforts have resulted in a coupling of water balance and freeze-thaw calculations in a model that will simulate interactions of forest cover, frost and thaw depths, and runoff. Simulations to date indicate that water-yield increases due to forest harvest can be substantial and are likely to be most pronounced in the second spring following harvest and during wet antecedent and post-harvest conditions. The response is found to be quite variable depending upon the specific soil and climatic conditions. In general, the response is a result of higher snowmelt rates coupled with higher ice contents in the surface soil during spring. The latter is the result of decreased transpiration and higher soil water contents during the first post-harvest summer which then freezes in the fall. These results are preliminary and conditional but do provide some insight into the systems we manage. The model promises to be a tool that may allow us to be more site-specific in our impact assessments and tell the manager more than the familiar "it all depends." *J.D. Fox*

Role of Computer Models in Predicting the Consequences of Management on Forest Productivity

During the last 20 years, numerous studies have determined that current and intensified levels of forest management can have significant effects on the long-term productivity of forest ecosystems. Because of the long-term nature and complexity of these problems, computer models represent one means of addressing future consequences of current management practices.

In order to define the type of model required to address the problem, a specific question was developed from both a scientist's perspective and a forest manager's perspective. It was suggested that a scientist would ask the question, "why?," and a manager would ask, "how much?" Two types of models were then defined: a theoretical model which was based on perceived causal relationships, and an empirical model which was based on observed relationships. The universe of applicability of the empirical model is smaller than that of the theoretical model, but the precision of the estimate from a theoretical model is generally unknown while the precision of the estimate from the empirical model is generally well defined.

Representative examples of both empirical and theoretical models were reviewed, and it is concluded that no models currently exist that can answer both the "why?" and the "how much?" questions. It is suggested that the best way to proceed would be to develop a theoretically sound empirical model. This model should contain three routines: growth, carbon allocation, and decomposition. Relatively simple formulations of both the growth and carbon allocation routines can be developed. Development of the decomposition routing would require additional work to yield the smallest possible subject site specific variables that would be combined with general process equations. A paper on this subject was presented at the International Energy Agency meeting on the Impact of Intensive Harvesting on Forest Site Productivity, March 1989, South Island, New Zealand. *J. A. Yarie*

Ecosystem Modeling as a Tool in the Analysis of Ecosystem Function

The predictions of future forest productivity as a result of intensive forest management using two substantially different ecosystem models (FORCYTE-10 and LINKAGES2) were compared. Comparing two models will offer greater insight into the consequences of intensive management on future productivity than would be possible by using either model alone. Four management scenarios were compared:

1). three 75-year rotations with no intermediate cuttings;
2). three 75-year rotations with a commercial thinning at year 50 in each rotation;
3). three 75-year rotations with a precommerical thinning at year 35 and a commerical thinning at year 50 in each rotation; and
4). three 75-year rotations with three commerical thinnings at years 35, 50 and 65 in each rotation.

In all scenarios FORCYTE-10 predicted higher harvested biomass than LINKAGES2. Both models showed no effect of management on future productivity for management scenarios 1 and 2 during the first three rotations. In the more intensive management schemes, scenarios 3 and 4, the two models differed in prediction of total harvestable biomass and production for each rotation. LINKAGES2 predicted a steady decline in harvested biomass and productivity across the three rotations for management scenarios 3 and 4. FORCYTE-10 did not predict a production decline for management scenario 3, and no production decline was indicated for management scenario 4 until the end of the third rotation. The decline then appeared to be catastrophic. It is suggested that neither model should be used as a forest management decision tool without the help of sufficient expertise in ecosystem ecology to correctly interpret the results. *J. Yarie*

Long-Term Ecological Research - an Analysis of the Relationship Between Resource Availability and Forest Productivity

Installation of the resource availability experiments began in 1988 and will continue through the summer of 1989. Starting in 1990, tree growth and foliar chemistry will be monitored for nitrogen fertilization, sawdust addition, sucrose addition, and summer moisture deficit effects. The sawdust and sucrose treatments were designed to examine the influence of the carbon source on microbial populations and subsequently the availability of nitrogen. The nitrogen fertilization and moisture deficit treatments will complement the carbon source treatments and add to our information on how resource availability (nutrients or moisture) affects tree growth and foliar chemistry which in turn affects the availability of carbon to microbial populations through litterfall and decomposition processes.

Work also continued on two mature white spruce clearcut sites. Three treatments—fertilizer nitrogen, phosphorus and N+P—were applied during the spring of 1988. In midsummer three trees per treatment were sampled for calculation of allometric relationships between height, above and below ground biomass, and determination of the concentration of N, P, K, Ca, and Mg. Tree height measurements and seedling survival estimates were completed in the fall. This data is currently being analyzed for publication. *J. Yarie*

Silvics

Selection of the tree species best suited to the site is the most important decision a forest manager can make. Not only is this important from a a timber production perspective, but it is often critical for habitat management, recreation, and streamside vegetation management. In selecting the species best suited to a particular site, the forest manager must consider not only the biological characteristics and the ecological requirements of the species but also, the management objective.

The search of the literature for fungal associates of tamarack continues. Nineteenth century documents were reviewed at the Forestry Library of the State University of New York, Syracuse, New York.

The Alaska Forest Tree Improvement Cooperative, a cooperative effort of the Alaska Reforestation Council, continued to develop. The first statewide meeting for foresters, land managers, and landowners/users was held in Anchorage/Eagle River in June 1988. An informal paper was presented. *E. Packee*

Predicting the Growth and Yield of Forest Stands in Interior Alaska

Growth and yield information is essential for effectively managing the tree species of interior and southcentral Alaska. Early efforts concerning tamarack are continuing. Finding trees of sufficient age (over 50 years) for site index curves is extremely difficult– one possible area was located during 1988. A paper discussing the number of years it takes tamarack to reach breast height has been prepared and will be submitted for publication in 1989.

Stem analysis work on paper birch is now complete. Data are being checked and "debugged." More than 200 trees will form the base for the final site index curves. Preliminary results confirm the inaccuracy of existing site index curves for Alaska. Completion of the curves is anticipated in spring 1989; curves and supporting documentation will be published as a Master of Science degree thesis. During 1988, 38 sites with balsam poplar were sampled; additional sites will be located and sampled in 1989. Annual rings from these trees will be measured beginning in 1989.

Three (two white spruce and one tamarack) Levels of Growing Stock (LOGS) plantations established in the spring of 1986 were again measured for survival and growth in the spring and fall of 1988. Review of the height growth data indicates that few of the white spruce seedlings have broken out of planting check; however, many of the tamarack are beginning to put on height growth. The spruce plantations were cleaned; aspen sprouts were beginning to takeover large portions of some plots.

Analysis of specific gravity and energy content of tree species was completed in 1988. Completion of final reports is anticipated during 1989. *E. Packee*

Forest Products

Based on 1969 data, the northern forest (spruce-birch-aspen-poplar) resource of Alaska is greater than the entire forest resource of Minnesota and slightly less than that of Wisconsin. Today, both Minnesota and Wisconsin have viable forest industries (sawmills, pulpmills, oriented strandboard plants, and fiberboard plants). The

forest, through the forest industry, provides employment for the citizens of these two states. In 1988, Minnesota's forest industry directly employed more than 50,000 people. The forest industries in these two states effectively compete in the world marketplace. In comparison, the northern forest region of Alaska has only a very small sawmill component and a log export industry, the latter essentially exports jobs to other countries. The potential for development of the Alaskan resource into a viable forest industry competing in world markets is strongly debated.

Commitment to good forest management and the forest industry are essential components of the Minnesota and Wisconsin success stories. The same commitment is evident in the province of Alberta. Success there is similar to that of Wisconsin and Minnesota. During the past three years, the provincial government has encouraged numerous companies to enter the province; the result is almost complete allocation of the available aspen forest resource. The white spruce resource is also heavily utilized. A major kraft pulpmill is planned for the Lac La Biche-Athabasca area with the production to be exported to Japan. Three chemithermomechanical pulpmills are being constructed: two at Whitecourt (one is in production) and one at Slave Lake. In addition, mills at Hinton and Grande Prairie are increasing their capacity.

Major impediments to the development of the Alaskan northern forest resource are many. Possibly the most serious is the lack of visible commitment which in part is demonstrated by the lack of an adequate reforestation effort and inadequate forest inventory information. Alberta and the Great Lake States prepared strategic development plans that adequately addressed forest management issues and provided realistic schedules for providing essential data. Misconceptions by Alaskans that white spruce is the only commercial species in the northern forest and that growth rates are inadequate and/or tree size is small add to the confusion regarding the value and potential development of the resource. In Alaska, the continual efforts to withdraw additional forest lands from timber harvest further exacerbates the problem of development by creating economically non-viable harvest units.

A major concern to Alaskans should be, "What are others doing with the same species?" The University of Alaska committed funds from the investment income from the university's trust lands during 1987 and again in 1988 to explore the question.

During 1988 the University of Alaska funded travel for five people to participate in the Mixed-Wood Symposium sponsored by the Canadian Forestry Service in Edmonton, Alberta. En route, as part of the symposium, visits were made to three high-tech sawmills, one veneer-plywood mill, two oriented strandboard plants, one medium-density fiberboard plant, a private forest nursery, and to the Alberta and British Columbia Forest Services. The Alberta Forest Service provided a complete overview of its timber management section with particular emphasis on tenure, development, and control. Material obtained on this trip has been provided to the Alaska Division of Forestry.

In early December, the University of Alaska and the Resource Development Council sponsored the second annual Boreal Forest Management Symposium. Emphasis at this symposium was to show Alaskans what other people were doing with a similar resource. These proceedings will be published during the first quarter of 1989.

In August 1988, two lumber/log terminals were visited in Japan. The Tokyo Lumber Terminal imports both green and kiln-dried lumber. The majority of softwood lumber is of Pacific Northwest origin.

Based on our informal observation of wrappers and logos, British Columbia was the major supplier. Lumber from one coastal Alaskan mill was noted. A western Japan terminal receives more than 90 percent of its logs from the Soviet Union (Siberia) with one load coming from the Lena River (port of Tiksi) via the Bering Straits. Species imported include Korean pine, Siberian pine (called cedar), and Dahurian larch. Japanese importers demand quality and close adherence to delivery schedules. This was emphasized over and over again. They are interested in doing business with Alaskans, and the best market is the north island, Hokkaido.

During summer 1988, the forestry operations of the Minnesota Department of Natural Resources at Baudette were visited. Tamarack is an important species for reforestation and apparently there is a demand for tamarack as piling and as a pulp species. The Alberta Forest Service Nursery at Smoky Lake was visited. Information obtained there was provided to the Alaska Division of Forestry. A small (2-3 million board-foot) sawmill near Athabasca, Alberta ships green, surfaced lumber via truck to Edmonton for shipment to Ireland and Great Britain via the Panama Canal.

This information demonstrates that it is possible to market northern conifer lumber and fiber overseas. *E. Packee*

International Union of Forest Research Organizations Working Party S1.05-12 Northern Forest Silviculture and Management

The main goal of the International Union of Forest Research Organizations (IUFRO) is "to promote international cooperation in scientific studies embracing the whole field of research, including forestry operations and forest products." The goals of the working party are essentially the same as the general goals of IUFRO except that emphasis is on the northern forest, also referred to as the boreal forest or taiga, of North America, Europe, and Asia.

The tenth symposium was held in northern Heilongjiang Province of the People's Republic of China during September 1988. Participants came from Canada, Finland, People's Republic of China, the Soviet Union, Sweden, and the United States. The eleventh annual symposium is scheduled for Newfoundland, Canada in mid-August 1989 and the twelfth is planned for Quebec-Ontario Canada in August 1990 in conjunction with the world-wide IUFRO Congress. Proceedings for the 1985 symposium are at the printer; those for 1986 and 1987 are currently being edited. *E. Packee*

Rosie Creek Fire Research: Regeneration and Forest Structure

Two studies, regeneration silviculture and forest structure, remain active in the fire effects study of the Rosie Creek Fire Research Project. In regeneration research, the three-year evaluation of white spruce seedling growth and survival was completed for three different site preparation trials. All three planted-seedling treatments experienced excellent survival (>90 percent). There was no significant difference in white spruce seedling survival or growth among the three site preparation treatments, but seedlings in all site treatments on a south slope site grew significantly more than seedlings on a ridgetop site. Many new seedlings appeared in 1988 in permanent natural regeneration study plots as a result of the excellent 1987 seed crop, the first excellent cone crop since 1983, the year of the fire. In the forest structure study, four one-hectare (2.47ac.) forest reference monitoring plots were completed, a burned and an unburned white spruce-aspen stand and a burned and an unburned birch stand. Log mapping and decay-class ranking, and tree height transects were completed for all stands, including a burned and an unburned white spruce old-growth stand. Over 400 basal tree disks were collected from two previously measured reference stands that were harvested in the winter of 1987-88. The burned and unburned birch stands support lower stocking levels at 582 and 277 trees (236 and 112per ac.) than the 799 and 634 trees in the burned and unburned aspen stands (323 and 257 per ac.). Stand basal area in the birch stands, 0.27 percent and 0.23 percent, was significantly lower than in the aspen stands (0.33 percent and 0.39 percent). The set of reference stands in the study area contains some of the largest and most productive of their type in Alaska. No snagfall had occurred by late 1988 in the burned birch stand even though all trees were killed in the fire and have been standing for five years. As of late 1988 the burned aspen stand had experienced only a minor amount of snagfall but had a dense understory of 4-meter tall aspen suckers that had been grazed to the snowline at least once by moose. Research installations in the fire area are permanently marked and available for monitoring and integration into the expanded range of studies underway in the Bonanza Creek Experimental Forest/Long-Term Ecological Research site. Data are being analyzed for journal publications. *G. P. Juday*

Monitoring in Serpentine Slide Research Natural Area

Natural diversity resources of the Serpentine Slide Research Natural Area (RNA) in central Alaska were studied and documented for long-term monitoring. The RNA contains an alpine exposure of serpentinite: a 22 ac. natural earthflow which has destroyed most vegetation in its path; bottomland white spruce and balsam poplar forests growing on coarse gravels and sands of a major clear water river floodplain; and warm, dry hill prairies on steep south-facing slopes. The area also contains several beaver dams, lodges, and ponds. The Beaver Creek riparian zone is heavily used as a local migration corridor for grizzly bear and wolf. Open gravel bars and the high-quality, clear water of Beaver Creek provide nesting and breeding habitat for shorebirds, especially the semipalmated plover. Concentric zones around serpentinite exposures in the RNA show increasing toxic effects on plants. A widespread alpine plant in Alaska, *Bupleurum triradiatum*, is the vascular species most tolerant of serpentinite, but no special serpen-

tine-adapted plant species have been discovered in the RNA. The earthflow has been periodically active since at least the early 1950's. Three plants collected in the RNA, *Carex eburnea*, *Artemisia alaskana*, and *Agropyron spicatum*, are growing beyond their previously reported distribution in Alaska. A permanent forest reference plot of 82 x 164 ft. was established in a 150-year-old floodplain white spruce forest that supports about 0.4 percent of plot surface in tree basal area (160 ft.^{2}/ac.), contains dominant trees from 12 to 18 in. d.b.h and are up to 98 ft. tall. An upper elevation south slope white spruce forest plot of 82 x 82 ft. supported 0.36 percent (144 ft.^{2}/ac.) basal area, dominant trees 8 to 14 in. d.b.h. and a maximum of 62 ft. tall. A contract report has been delivered to the Bureau of Land Management. Publication is planned as the third in the Forest Service Alaska Research Natural Area General Technical Report Series. *G. P. Juday*

Research Natural Area Proposals for the Tongass National Forest Plan Revision

New Research Natural Areas (RNA's) needed for the 10-year update of the Tongass National Forest land management plan were defined. RNA needs were based on:

1). the occurrence of 71 rare, uncommon, or range-limited vascular plant species;
2). the occurrence of 16 animal species that serve as indicators of management effects and 20 species that are dependent on special habitats, or that are uncommon in Alaska;
3). coverage of 59 forest community types; and
4). representation 62 aquatic life-forms, lake and stream morphologies, and fisheries types.

RNA candidate sites were chosen to maximize coverage of types within each proposal (local site diversity). They cover seven newly defined geographic regions of the Tongass National Forest, represent features most likely to decline in availability with time, and represent as many of the needed features in total as possible. Candidate areas recommended for inclusion in the forest plan update were termed priority RNA's and limited to 30. Other candidate RNA's that were found suitable numbered 17. Fifteen areas were nominated but not recommended. Of the 30 priority RNA's, 11 were in existing wilderness, five in roadless management areas, seven in areas approved for moderate intensity development, and six are in areas of high-intensity development under the old forest plan. One proposed RNA was in a special study area. A contract report has been delivered to the Forest Service and a workshop and Forest Service publication are planned. *G. P. Juday*

Natural Area Protection and Research Initiatives

A national assessment of the status and effectiveness of natural area programs was undertaken. Since 1965 the federal Land and Water Conservation Fund, LWCF, has spent $3 billion, matched by state and local governments, for the acquisition of over 2.3 million acres in 8,154 projects. In the 1980s federal government support for natural area acquisition through LWCF declined to about $200 million, compared to the authorized level of $900 million. The portion of LWCF allocated to the state matching grants program has declined from 50% to about 20%. The forum for creative thinking and action on natural matters has

shifted from the federal government to state governments.

Since 1982, 22 states have passed new funding initiatives for conservation programs in which natural areas and endangered species play a major role. Six states passed increases in real estate transfer taxes; eight states approved bond issues, and nine states made special direct appropriations. California voters alone approved $785 million in an initiative-petition bond issue. Sophisticated natural area information systems known as State Natural Heritage Programs have been a major factor in the new state initiatives; they provide detailed information on the status, characteristics, and location of the complete range of elements of natural diversity.

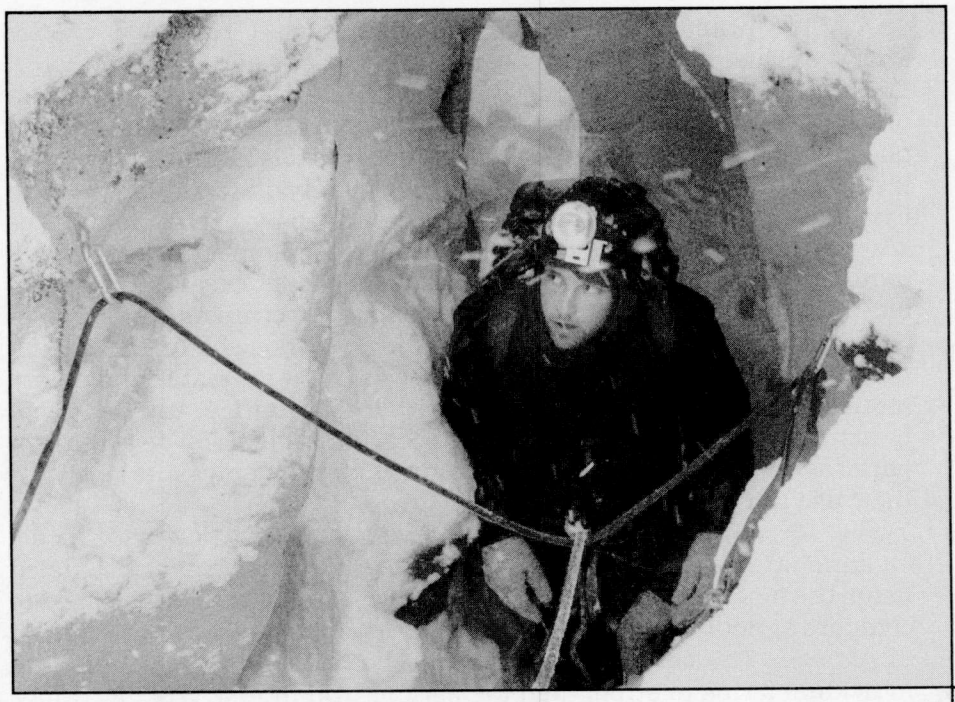
A network of 49 State Natural Heritage Programs is now in place across the United States. A proposal is pending in Alaska. Natural Heritage Programs document protection needs in a way never available before. Natural area protection efforts were not systematically focused on the protection of the most highly endangered elements of natural diversity until the advent of Natural Heritage Programs. The combination of new funding and highly refined information at the state level has resulted in measurable progress in slowing the elimination of important natural diversity resources. However natural area protection programs, if they are to succeed, must:

1). achieve operational continuity and expand in scale;
2). incorporate even more sophisticated scientific information from genetics, systematics, and ecology in selection activities;
3). incorporate new lessons from conservation biology and landscape ecology in preserve design; and
4). develop new sophisticated inventory, monitoring, and management techniques.

Journal articles are available, and other publications are in progress. *G. P. Juday*

Decomposition and Nutrient Cycling in Forest and Cleared Soils

When land is cleared for agriculture in Alaska, most of the forest floor and often a portion of the A horizon is removed. The removed material contains large amounts of valuable plant nutrients, but these nutrients are unavailable to plants until the organic matter decomposes. There is little information on how fast these nutrients would become available to plants if part or all of the forest floor were left on the the soil during land clearing. A study was begun near Delta Junction in 1988 to measure rates of mineralization of nitrogen and phosphorus from the decomposition of forest floor material in soils under virgin forest and in cleared fields. The study involves the use of mesh bags and sealed plastic bags containing different kinds of forest floor material and buried at different depths in a black spruce forest and in a cleared field. Weight loss and production of mineral nitrogen and phosphorus in these bags is being measured. No results from this study are available at the present time. Information from this study will be used to aid in making recommendations for optimum management practices for newly cleared soils in the subarctic. *S.D. Sparrow, E.B. Sparrow, and V.L. Cochran*



Resources management student Anthony Whitworth climbs out of a crevasse during a blizzard on Byron Glacier in the Chugach National Forest. Whitworth and Asst. Prof. Harry Bader did a survey of recreational use of the glacier.

Resources Management

Farming Systems Research

Farming Systems Research (FSR) is an on-going and developing program at the Agricultural and Forestry Experiment Station. The concept of FSR is to place the farmer at the core of the research effort. There are four steps used in research:

1). establish field research which is directly transferable to the farmer;
2). analyze historical and statistical trends in the agribusiness industry;
3). characterize typical farm management practices and farmers goals; and
4). develop models of a farm industry in a specific social, political and economic environment.

Field studies using the concept of low-input, sustainable agriculture are continuously established. Results from two years of continuing study using five nitrogen (N) rates and three seeding dates show that low (10 lb./acre) N rates applied at late seeding dates can result in positive returns over the cost of N. A three-year study indicates that banding the full nutrient requirement for barley with the seed at planting can increase yields above those obtained when fertilizer is broadcast. This is in contrast to results reported in more temperate climes. Additionally, an on-farm demonstration in 1987 showed good potential for rapeseed production in Alaska.

A five-year survey provided production costs and management techniques used in producing barley in interior Alaska to farmers for use as benchmarks in their own operations. Further characterization of farming practices, production costs, and management techniques throughout the state is continuing for lettuce and potato crops.

The primary focus of the FSR program in 1988 was on the analysis of historical and statistical trends in the agribusiness industry. The definition of four periods in agricultural development in Alaska provided background for investigation of specific products and regions playing a major role since statehood. Three models for this period were identified. The first, typical of the vegetable and potato industry, is one in which minimum state or federal investments have been made. In the second, investments are a mixture of public and private funds. The milk industry is an Alaskan example. The third model exemplified by the barley and red-meat industry is where state government investments were perceived to be high, even though many of those planned were not made. The most consistent production was in the vegetable and potato industry. Production fluctuated most in the barley and red-meat industry. The research provides historical information on development patterns to promoters and investors in the agribusiness industry for their use in investment decisions.

Research is beginning on the development of a statewide model for agricultural development in Alaska. The model is being constructed using the historical trends discussed above. This model will be used to compare agricultural development in other circumpolar regions to that in Alaska. The objective is to provide guidelines to developers and individual farms to strengthen the agricultural industry. *C. E. Lewis, C. W. Knight, R. W. Pearson, and B. J. Pierson*

Improved Planning and Permitting Procedures

Agencies responsible for Alaska's vast public lands are required to prepare plans for the land and to require permits of people who wish to use or develop the land or its resources. These plans and permits, if not coordinated, can become unnecessarily burdensome to project applicants. This research started with an analysis of the Colorado Joint Review Process in 1985. A book based upon research on the "cycle process" was completed in 1987.

In 1988 the governor's office requested an analysis of Alaska's Division of Governmental Coordination (DGC) – the permit coordination office– and it's process, the consistency review process.

The 1988 study produced five conclusions.

1). The DGC and its process are highly supported by all applicants, including large businesses, small businesses, individuals, and state, federal and local agencies. All groups felt that the DGC provides an effective clearing-house for coordinating permits. Groups felt the office should be retained.

2). All groups felt that the DGC office saves them time and money. The greatest benefits were registered by large businesses, small businesses, individuals, and local governments. Large agencies, such as the Department of Transportation and Public Facilities which has its own coordination staff, reported the least benefit in time and money savings.

3). All groups indicated there is some need to adjust the process to the scale and impact of a proposed project. An expedited process was suggested for emergency or benign projects. A longer process was suggested for large or controversial projects.

4). All groups felt the DGC staff was a key factor in the success

of the process. Staff professionalism was mentioned many times as preventing the DGC from becoming "just another bureaucracy."

5). Some clients were not aware of the DGC and its services. A proposal for advertising the office was made.

During 1988 graduate student Mara Kimmel conducted a study of the potential to use the cycle process in preparing village land plans. Working with the North Pacific Rim Corporation, she completed preliminary plans before grant funding ran out. The process, however, worked satisfactorily in helping residents of several villages define community goals. The findings of this study are now being prepared for publication in 1990. *T. Gallagher*

Public Participation in Planning

This research area concerns how the public, particularly the Native peoples of Alaska, might be more effectively involved in planning by state and federal agencies. A background study of major problems affecting Native participation was published in 1988. New research focused on agency plan readability. Data collected by graduate student Kent Patrick-Riley demonstrated that federal agency plans are written at a readability level far beyond that of the average citizen. He evaluated 23 plans prepared by the National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management, and the U.S. Forest Service. Plans were evaluated using several readability scales. On the Flesch Scale the plans ranged between the junior year of college and the first year of graduate school. Thus, the plans are equivalent in reading difficulty to scientific and professional journal articles. The average person, however, reads at the 8th or 9th grade level which is found in popular magazines such as *Time*. The major factor found boosting reading difficulty was the jargon-laden vocabulary used in the plans. Regulations requiring federal plans specify that the plans should be "written in plain language." It is evident that agencies have a long way to go to meet this directive. A journal article on readability was published in 1988. Graduate student Wendy Jacobson is currently researching the effect of graphics on the public's comprehension of agency plans. Graduate student Winton Weyapuk is also conducting research on how Native peoples are involved in agency plans. His study compares agency participation processes in Alaska to participation processes in Canada's Yukon Territory and Northwest Territory. His study, hopefully, will identify ways to help agencies and Native peoples work more closely together in developing and protecting Alaska's subsistence resources. *T. Gallagher*

History of Land Planning in Alaska and the Arctic

This research effort started with the collection of information for *Who's Planning Alaska: the Alaska Planning Directory* in 1985. Since then, the directory has been updated once. A third edition is due in 1990. Research for the directory evolved into two areas.

The first concerned the status of land ownership in Alaska and the implications of the diverse ownership pattern. The study concluded that the land ownership pattern threatened the development or protection of those resources that cross agency boundaries: minerals, timber,

water, and many large game species. The study found a variety of obstacles to coordination, including: the complexity of land ownership pattern– particularly inholdings, the large number of land owners and plans, the lack of coordination of plan boundaries, the lack of relationship between plan boundaries and natural boundaries, the wide diversity of landowner goals, the extremely small or large size of some units, and the lack of surveys and access. A journal article on the problems related to the division of Alaska was published in 1988.

A second area of research concerned the historic competition among agencies for land and the form of coordination that might work considering the ongoing competition. A review shows that competition among agencies dates back to the late 1800s and the first proposals to set aside the Tongass National Forest. The competition erupted again in the 1910-1920 period when the Department of Interior tried to reacquire the Tongass and Chugach National Forests from the Department of Agriculture, and again in the 1930s when the National Resources Planning Board, a federal New Deal agency, challenged the departments and the Territory of Alaska for control of the land. Following World War II, the drive for statehood threatened agencies and Native interests in the land. The Alaska Native Claims Settlement Act and the Alaska National Interests Lands Conservation Act were passed to resolve this competition. Throughout this century there have been a variety of federal or federal/state commissions mandated to coordinate agency planning in Alaska. The Alaska Land Use Council has this mandate today, but its attempt at co-management in the Bristol Bay region failed. With the present level of inter-agency competition, standard forms of coordination– such as a superplan or superagency or land czar– are unlikely to be accepted. The most acceptable form of coordination at this time appears to be a superprocess such as the Colorado Joint Review Process, that coordinates planning without changing any regulations or creating any new bureaucracy. A paper on this subject is in press. *T. Gallagher*

Natural Resources Economics

The economic welfare of Alaskans is dictated largely by patterns of production and use of the state's natural resources. While quality, location, and amounts of these resources are key determinants of their supply costs and, thus, commercial attractiveness, government institutions may represent equally important influences of their economic viability. Understanding the economic aspects of public sector policies, regulations, and programs that bear on natural resource disposal and use can lead to sets of institutions better able to produce outcomes desired by the public.

A nonlinear programming framework has been developed to characterize optimal time patterns of disposal for durable resources when alternative objectives for disposal programs are considered. To date, while the model does not account for many complications that are endemic to real world situations, it does provide useful insights into differences between efficient time profiles for disposal of durable versus nondurable resources and between programs intended to achieve different objectives. The next step will be to attempt to apply this framework to state land disposal programs in Alaska. Information is being collected that will allow both objectives and constraints to be more accurately represented. Results should permit both an evaluation of past disposal efforts and some guidance for future programs.

Traditional firm-level cost functions are based on asserted cost minimizing behavior. This special case may be inappropriate in some circumstances such as the analysis of labor managed firms, not-for-profit organizations, and government agencies. Treating non-cost minimizing motivations explicitly in objective functions is argued to be pedagogically superior to the alternative of adding an equivalent constraint to the traditional representation of firm behavior. The analysis is being extended to examine its implications for interpreting cost data reported in benefit/cost analyses of public natural resource projects/programs. To the extent that government agencies are not motivated to minimize costs, the welfare significance of standard efficiency tests of government constructed and operated projects and programs is called into question.

Users of public natural resources, lessees, concessionaires, etc., sometimes operate on incentives that lead to behavior that is inconsistent with agency management goals. Drawing on public economics literature, work is underway to examine the "incentive compatibility" characteristics of institutional arrangements affecting resource user behavior. The goal of this analysis is to suggest changes in institutions such that agency management targets and user welfare objectives are achieved simultaneously. *W.G. Workman*

Outdoor Recreation Project

Data collection and analysis on the recreational dog mushing study is complete. In addition to developing good baseline data on participation patterns in interior Alaska, the project focused on estimating the potential benefits of expanding the White Mountains NRA winter trail and cabin system. A profile of the various types of mushers and their preferences for specific management programs was developed. Contingent valuation methods were used to estimate net benefits associated with both the existing and expanded system. In addition to the use of traditional socio-demographic factors to explain variations in bids, two new methodological techniques were tried:

1). presenting respondents with different interval formats for their bid:, and

2). estimating the value of the expanded system as either an addition to the value of the current system or as a value not anchored by current system. Published results will be available in 1989.

Two subsistence use studies are underway. One focuses on the interrelationships between an enclave community and a wilderness national park. The data collection is complete and the analysis has begun. The other is a study of potential impacts under two subsistence regimes– one in which subsistence users are qualified based on living in a particular zone, the other where people are qualified under individual permits. Two scenarios of community dynamics will be used to assess impacts– a stable rural community and another with increasing population with changing community demography. The data collection will occur in June-August 1989.

One new future thrust is being developed– measurement of recreational river users under isolated conditions. Beaver Creek National Wild River will be the test river to develop the technology. The study will also involve a longitudinal survey of these users so that changes in user types as well as numbers of users can be detected. *A. Jubenville* and *W. Workman.*

Irradiation of Alaskan Food Commodities

The overall goal of this feasibility study, conducted for the state of Alaska and coordinated by the Institute of Northern Engineering, was to evaluate the potential social and economic benefits and risks associated with the application of food irradiation technology to Alaska's seafood and agricultural products. Irradiation is a physical process, as are canning, freezing, drying and pasteurizing. In this process, foods are exposed to an ionizing energy source that destroys bacteria, yeast, and molds as well as other microorganisms. These naturally occurring contaminates contribute to spoilage and are of increasing public health concern. Irradiation-treated food products retain the appearance, taste, and texture of the fresh product. Labeling of irradiated products is required so that consumers can choose between irradiated and non-irradiated products.

The research team concluded that socio-economic benefits may occur if food irradiation is commercially adopted in Alaska. Improvement in the quality, safety, and availability of food products in rural Alaska is a likely benefit of irradiating agricultural products.

Adoption of the technology by the state's agricultural industry is dependent upon its use by Alaska's seafood industry. Present and projected agricultural production levels are less than needed for commercial viability of an irradiation facility. Therefore, a multi-commodity facility which handles seafood and agricultural products will be necessary.

Despite economic potential and associated public health benefits, application of food irradiation technology to Alaskan seafood products is premature. The U.S. Food and Drug Administration, which determines what food products can be irradiated, at what levels and for what purposes, has not yet granted approval of this technology for seafood. The effects of irradiation on seafood products harvested, handled and distributed under Alaskan conditions is unknown. Similar questions must be applied to some agricultural products. A code of practice must be established before any irradiated product enters the marketplace. Test marketing must also be performed.

A research and demonstration facility has been recommended. A dual-mode electron-beam/X-ray machine is recommended as the source. Use of a machine source eliminates many environmental and safety concerns. Available federal funding should be sought. The facility should located adjacent to existing processing and research facilities with transportation links to other agricultural and seafood harvesting areas. This location will facilitate information and technology transfer to both industry and consumers. The location also allows use of existing scientific expertise and facilities. Surveys reveal that most consumers and industry personnel presently have inadequate information to evaluate the process and/or product quality. They expressed a desire for more information. *R. B. Swanson*

Natural Resources Education Project

The agricultural education specialist at SALRM has designed an instructional unit introducing natural resources management as a profession to secondary students of grades 7 through 12. The purpose of the materials is twofold:

1). present a realistic view of the concepts and techniques applied by professional natural resource managers, and

2). provide secondary teachers in various disciplines, biology, earth science, English, social studies, etc., with lessons applicable across the curriculum.

The specific lessons include: What is Natural Resources Management?; The Importance of Natural Resources Management; Natural Resources Management as a Social Science; Natural Resources Management as a Natural Science; The Role of Natural Resources Management in Society; Natural Resouces Management in Alaska; Specialties within Natural Resources Management; Careers in Natural Resources Management; and Agencies Responsible for Natural Resources Management. Each lesson contains an introduction, learning objectives, teacher references, student references, background information for the teacher, key words list, and suggested student activities. These materials will be completed and available for pilot use during the 1989-1990 school year. This document will become Agricultural Education Publication #5. *C. Kirts*

Publications

Journal Articles

Clay, S. A., Thill, D. C., and Cochran, V. L. 1988. Response of spring barley *(Hordeam vulgare)* to herbicides. *Weed Technology* 2:68-71.

Cochran, V. L., Horton, K. A., and Cole, C. V. 1988. Microbial death rate and limitations of N or C in wheat straw decomposition. *Soil Biology and Biochemistry* 20:293-298.

Engelbrecht, C. R. and Thomas, W. C. 1987. Agricultural Policy Implementation in Alaska. *Agricultural Administration & Extension* 26(1987):75-90.

Gallagher, T. J. and Epps, A. 1988. The great Alaska land subdivision revisited. *Journal of Soil and Water Conservation* 43(5):368-375.

Gallagher, T. J. 1988. Native participation in land management planning in Alaska. *Arctic* 41(2):91-98.

Granatstein, D. M., Besdicek, D. F., Cochran, V. L., Elliott, L. F., and Hammel, J. 1988. Long-term tillage and rotation effects on soil microbial biomass, carbon and nitrogen. *Biology and Fertility of Soils* 5:265-270.

Juday, G. P. 1988. State Legislative Initiatives on Natural Areas. *Natural Areas Journal* 8(2):107-114.

Juday, G. P. 1988. Old-Growth Forests and Natural Areas: An Introduction. *Natural Areas Journal* 8(1):3-6.

Karlsson, M. G., Heins, R. D., and Erwin, J. E. 1988. Quantifying temperature controlled leaf unfolding rates in 'Nellie White' Easter lily. *Journal of the American Society of Horticulture Science* 113:70-74.

Karlsson, M. G., Pritts, M. P., and Heins, R. D. 1988. Path analysis of growth and development in chrysanthemum. *HortScience* 23:372-375.

McNeil, M. A., Penfield, M. P., and Swanson, R. B. 1988. Sensory evaluation of pastry containing barley flour. *Tennessee Farm and Home Science* 146:4-8.

Mitchell, W. W. 1988. Registration of 'Nortran' Tufted hairgrass. *Crop Science* 28:1022.

Mitchell, W. W. 1988. Registration of 'Kenai' polargrass. *Crop Science* 28:1022-23.

Newman, C. W., Roth, N. J., Husby, F. M., Harrold, R. L., and Calvert, C. C. 1988. A comparison of Alaskan fish meals to soybean meal as protein supple-

ments for weanling rats. *Nutrition Reports International* 36 (6):1173-1183.

Pierson, B.J., Lewis, C. E., and Birklid, C. A. 1988. Observer differences in determination of crop residue cover in the Alaskan subarctic. *Journal of Soil and Water Conservation* 43(6):493-495.

Ping, C. L., Shoji, S., and Ito, T. 1988. The properties and classification of three volcanic derived pedos from Aleutian Islands and Alaska Peninsula, Alaska. *Soil Science Society of American Journal* 52:455-462.

Sharratt, B. S., and Glenn, D. H. 1988. Orchard floor management utilizing soil-applied coal dust for frost protection. Part I. Potential microclimate modification on radiation frost nights. *Agriculture and Forest Meteorology* 43:71-82.

Sharratt, B. S., and Glenn, D. H. 1988. Orchard floor management utilizing soil-applied coal dust for frost protection. Part II. Seasonal microclimate effect. *Agriculture and Forest Meteorology* 43:147-154.

Shoji, S., Ito, T. Takahashi, T., and Ping, C.L. 1988. Properties and classification of selected volcanic ash soils from Kenai Peninsula, Alaska, USA. *Soil Science* 145:395-413.

Sparrow, S. D., and Cochran V. L. 1988. Carbon and nitrogen mineralization in subarctic soils. *Biology and Fertility of Soils* 6:33-38.

Sparrow, S. D., and Sparrow, E. B. 1988. Microbial biomass and activity in a subarctic soil ten years after crude oil spills. *Journal of Environmental Quality* 17:304-309.

Sparrow, S. D., Redlin, M., and Sparrow, E. B. 1988. Comparison of methods for extracting adenosine triphosphate from three high-latitude soils. *Arctic and Alpine Research* 20:466-472.

Swanson, R. B., and Penfield, M. P. 1988. Barley flour level and salt level selection for a whole-grain bread formula. *Journal of Food Science* 53(3):896-901.

Van Horne, B., Hanley, T. A., Cates, R. G., McKendrick, J. D., and Horner, J. D. 1988. Influence of seral stage and season of leaf chemistry of southeastern Alaska deer forage. *Canadian Journal of Forest Research* 18:90-99.

Circulars and Extension Publications

Carling, D. E., and Rissi, P. 1988. Potato Variety Performance Alaska 1987. Circular 65. AFES, SALRM, University of Alaska Fairbanks. 10 pp.

Michaelson, G. M., and Ping, C.L. 1988. The Interpretation of Soil Test Phosphorus for Alaska Agricultural Soils. Circular 66. AFES, SALRM, University of Alaska Fairbanks.

Swanson, R. B., Lewis, C. E., Das, D. K., Hok, C. I., Workman, W. G., and Logan, R. 1988. The role of irradiation: can it benefit Alaska? Circular 64. AFES, SALRM, University of Alaska Fairbanks 28 pp.

WAGNER, P. J., MATHEKE, G. M., DINKEL, D. H., AND GRIFFITH, M. 1988. Summary of Vegetable Variety Trials, Fairbanks, Alaska 1978-1985. Circular 67. AFES, SALRM, University of Alaska Fairbanks. 48 pp.

Research Progress Reports

LEWIS, C. E., AND PEARSON, R. W. 1988. The relationship of history and statistics: Alaska's dairy industry. Research Progress Report. No. 5. AFES, SALRM, University of Alaska Fairbanks.

CARLING, D. E., MICHAELSON, G. J., AND PING, C.L. 1988. The effect of nitrogen fertilization rates on yields of transplanted and direct seeded head lettuce. Research Progress Report No. 6. AFES, SALRM, University of Alaska Fairbanks.

Agroborealis

BRUCE, L. B., AND HERLUGSON, M. L. 1988. Equations for predicting energy values of Alaska feedstuffs. *Agroborealis* 20(1):31-14.

LAUGHLIN, W. M., SMITH, G. R., AND PETERS, M. A. 1988. Effect of gypsum rates on bromegrass yield and chemical composition. *Agroborealis* 20 (1):35-37.

MATHEKE, G. E. M., AND GRIFFITH, M. 1988. Maximizing the vase life of cut roses grown in Alaska. *Agroborealis* 20 (1):15-20.

MATHEKE, G. E. M., AND GRIFFITH, M. 1988. Pruning strategies for greenhouse rose production in Alaska. *Agroborealis* 20 (1):21-24.

MCINTYRE, H. C. H., AND GRIFFITH, M. 1988. The importance of vase life in marketing locally grown roses. *Agroborealis* 20 (1):11-14.

MCINTYRE, H. C. H., AND GRIFFITH, M. 1988. Wholesale pricing of locally cut roses in Fairbanks, Alaska. *Agroborealis* 20 (1):5-10.

SPARROW, S. D. 1988. Inoculation of alfalfa in Alaska. *Agroborealis* 20(1):38-40.

SWANSON, R. B., LEWIS, C. E., HOK, C. I., AND DAS, D. K. 1988. Food irradiation and Alaska's food industries. *Agroborealis 20* (1):25-30.

Northern Engineer

SWANSON, R. B., DAS, D. K., HOK, C. I., AND LEWIS, C. E. 1988. Is food irradiation feasible in Alaska? some engineering considerations. *The Northern Engineer* 19 (1):21-26.

Abstracts

BOYCE, D., AND MCBEATH, J. H. 1988. Symptomology, etiology and ecology of cottonwood bud proliferation, a new disease found in Alaska. *Phytopathology* 78:1554.

CARLING, D. E., KUNINAGA, S., AND LEINER, R. H. 1988. Relatedness within and among intraspecific groups of *Rhizoctonia solani*: A comparison of grouping by anastomosis and DNA hybridization. *Phytoparasitica*: (In press).

Cochran, V. L., and Schlentner, S. F. 1988. Estimation of N fixation by Faba beans interseeded with oats. *Agronomy Abstracts* p. 232.

Cullum, R. F., Sparrow, S. D., Michaelson, G. J., and Ping, C. L. 1988. Effects of application rates and disposal techniques of dairy manures on oat forages grown in a subarctic environment. *Agronomy Abstracts* p.37.

Helm, D. 1988. A case history: premine inventory in interior Alaska. *Alaska Association of Environmental Professionals Annual Meeting.* Anchorage, AK. Mar. 25.

Husby, F. M., and Morrow, C. A. 1988. Utilization of tanner crab meal and chitin by ruminants. *Proceedings of the Fourth International Conference on Chitin and Chitosan.* University of Trondheim, Trondheim, Norway. Aug. 22-24.

Karlsson, M. G., Heins, R. D., Erwin, J. E., and Berghage, R. D. 1988. Biomass allocation patterns in chrysanthemum. *HortScience* 23:750.

Knight, C. W., and Sparrow, S. D. 1988. Soil nitrogen cycling in cropland of interior Alaska. *Agronomy Abstracts* p.239.

Lewis, C. E., Pierson, B. J., Knight, C. W., and Cullum, R. F. 1988. Effects of banding and broadcasting the complete nutrient for barley. *Agronomy Abstracts* p. 303.

Mehdizadegan, F., and McBeath, J. H. 1988. Partial purification and characterization of extracellular enzymes produced by snow mold fungi. *Phytoapthology* 78:1589.

Mehdizadegan, F., and Gough, F. J. 1988. The effect of time of application and survival of pseudomonas fluorescens on infection by *septoria tritici. Phytopathology* 78:1592.

McBeath, J. H. 1988. Sclerotia myceliogenic germination and pathogenicity of *Schlerotinia borealis.* IN: *Proceedings of the 5th International Congress of Plant Pathology* p. 201.

McBeath, J. H., Adelman, M., and Jackson, L. 1988. Screening wheat germ plasm for *Corynebacterium michiganese* subsp. *tessellarius. Phytopathology* 78:1566.

McBeath, J. H. and Adelman, M. 1988. A new efficient system for studying snow mold diseases. *Phytoapthology* 78:1616.

Michaelson, G. J., and Ping, C. L. 1988. Mehlich 3 extractable P and forage yield on the loess and volcanic ash-derived agricultural soils of Alaska. *Agronomy Abstracts* p. 243.

Pearson, R. W., and Lewis, C.E. 1988. The local agricultural industry in Alaska since statehood. Annual meetings of the Association of American Geographers, Phoenix, AZ. April 6-9.

Ping, C. L., Alexander, E., and Shoji, S. 1988. The toposequence of soils developed in Mt. Edgecumbe and on Baranof Island, Southeast Alaska. IN: *Agronomy Abstracts* p. 264.

PIERSON, B. J., KNIGHT, C. W., AND LEWIS, C. E. 1988. The effects of seeding date and nitrogen rate on barley yield. Annual meetings of the ASA-CSSA-SSSA, Anaheim, CA. Nov. 27-Dec. 3.

SHARRATT, B. S., AND CAMPBELL, G. S. 1988. Global radiation and soil thermal characteristics of colored small grain residue. *Agronomy Abstracts* p. 27.

SPARROW, S. D., KNIGHT, C. W., AND CONN, J. S. 1988. Fall and spring seeding of spring rapeseed in frozen soils. *Agronomy Abstracts* p. 140.

Proceedings

CARLING, D. E., AND WESTPHALE, P. C. 1988. Effect of seedborne inoculum of *Rhizoctonia solani* and formaldehyde on growth and yield of potato. IN: *Abstracts of Papers, 5th International Congress of Plant Pathology.* Aug. 20-27. Kyoto, Japan. p. 94.

COCHRAN, V. L., SPARROW, E. B., AND SPARROW, S. D. 1988. Effect of clearing, tillage and crop residue management on N and P mineralization in subarctic soils. IN: *Proceedings of International Conference of Dryland Farming.* Aug. 15-19. Amarillo, TX. (In Press)

ELLIOTT, C. L., AND MCKENDRICK, J. D. 1988. Avian use of reclaimed strip mines in interior Alaska. IN: *1988 National Symposium on Mining, Hydrology, Sedimentology, and Reclamation.* Dec. 5-9. University of Kentucky, Lexington, KY. (In Press)

GALLAGHER, T. J. 1988. Participation of Native people of Alaska in agency planning of public lands: An initial analysis. IN: *The Second Symposium on Social Science in Resource Management.* June 6-9. University of Illinois, Champaign-Urbana. (In Press)

JUBENVILLE, A. AND FOSTER, D. 1988. Self-managing park systems. IN: *Proceedings, Symposium On Managing Australian National Parks Under Financial Stringency.* July 8. Philip Institute of Technology, Bundoora, Victoria, Australia. (In Press)

JUBENVILLE, A. 1988. Long-distance tracks—A synthesis of the Alaskan experience. IN: *Proceeding, Long distance tracks workshop.* July 10. Philip Institute of Technology, Bundoora, Victoria, Australia. (In Press)

JUDAY, G. P., AND ALABACK, P. 1988. Selection of research natural areas on the Tongass National Forest. IN: *39th Arctic Science Conference Proceedings, American Association for the Advancement of Science Arctic Division.* Oct. 7-10. University of Alaska Fairbanks. Fairbanks, AK. (In Press)

JUDAY, G. P., AND BATTEN. A. 1988. Uncommon plants as a selection criterion for research natural areas on the Tongass National Forest. IN: *39th Arctic Science Conference Proceedings, American Association for the Advancement of Science Arctic Division.* Oct. 7-10. University of Alaska Fairbanks. Fairbanks, AK. (In Press)

MCINTYRE, H.C.H., PING, C.L., AND MICHAELSON, G.J. 1988. Alaskan peat: An economical alternative to imported blends. IN: *Proceedings of the Sev-*

enth Annual Alaska Greenhouse and Nursery Conference. Feb. 8-9. Palmer, AK. (In Press)

McKendrick, J. D. 1988. Soil fertility observations in arctic Alaska. IN: *117th Annual Meeting Society of Mining Engineers.* Jan. 25-28. Phoenix, AZ. (In Press)

McKendrick, J. D. 1988. Vegetative reproduction of *Arctophila fulva.* IN: *39th Arctic Science Conference Proceedings, American Association for the Advancement of Science Arctic Division.* Oct. 7-10. University of Alaska Fairbanks, Fairbanks, AK. (In Press)

Newman, C. W., Roth, N. J., Husby, F. M., Harrold, R. L., and Calvert, C. C. 1988. A comparison of Alaskan fishmeals to soybean meal as a protein supplement for weanling rats and swine. IN: *1988 Montana Nutrition Conference Proceedings.* January. Montana Agricultural Experiment Station, Bozeman, MT. (In Press)

Newman, C. W., Roth, N. J., Husby, F. M., Harrold, R. L., and Calvert, C. C. 1988. Protein quality of Alaskan fish meal. IN: *Annual Meeting of American Society of Animal Sciences.* July 19-22. Rutgers University, New Brunswick, NJ. (In Press)

Packee, E. C. 1988. Introductory comments. IN: *Development of Alaska's Boreal Forest Industry, Proceedings of a Second Symposium on the Management of Alaska's Boreal Forest.* Anchorage: Resource Development Council. (In Press)

Packee, E. C. 1988. Correlation of forest growth and yield with soil characteristics. IN: *Proceedings of the Alaska Forest Soil Productivity Workshop* USDA Forest Service General Technical Report PNW-GTR-219:37-42.

Ping, C. L., Michaelson, G. J., and McIntyre, H. C. H. 1988. The potential of horticultural peat in Alaska. IN: *Proceedings of the Seventh Annual Alaska Greenhouse and Nursery Conference.* Feb. 8-9. Palmer, AK. pp. 41-46.

Ping, C. L., Shoji, S., Ito, T., Kimble, J.M., and DeCorninick, F. 1988. Andisol/ Spodosol transition problems. IN: *Proceedings of the 5th International Soil Correlation Meeting* Oct. 1-14. New Brunswick, Canada-Northeastern USA. (In Press)

Sharratt, B. S., and Cochran, V. L. 1988. Agroclimatic characteristics of barley paired-row planting in the subarctic. IN: *Proceedings of International Conference on Dryland Farming* Aug 15-19. Amarillo, TX. (In Press)

Wallingford, D. E., and Packee, E. C. 1988. Alaska's interior forest. IN: *Management and Utilization of Northern Mixedwoods.* April 11-14. Edmonton, Alberta. Canadian Forestry Service Information Report NOR-X-296:41-47.

Yarie, J. 1988. Modeling approaches to the analysis of site productivity. IN: *Proceedings of the Alaska Forest Soils Productivity Workshop.* U.S. Forest Service Productivity Workshop. Pacific Northwest Research Station, General Technical Report PNW-GRT-219.

Theses, Student Professional Papers and Dissertations

KNIGHT, C.W.1988. Fate of Fertilizer Nitrogen in a Subarctic Agricultural Soil. Ph.D. Dissertation. University of Alaska Fairbanks.

MACH. D. D. The effect of open space on adjacent residential property values: Noyes Slough, Fairbanks, Alaska Professional Paper. University of Alaska Fairbanks.

SMITH, T. S. 1988. Patterns of activities and snow related behavior of wintering reindeer. M. S. Thesis. University of Alaska Fairbanks.

TOBIN, R. B. 1988 A model for wild and scenic river planning in Alaska. Professional Paper. University of Alaska Fairbanks.

WAGNER, P. J. 1988. Manipulation of flowering, fruit set, and fruit ripening in some melons (*Cucurbitaceae*). M.S. Thesis. University of Alaska Fairbanks.

Miscellaneous

BERGHAGE, R., HEINS, R., CARLSON, W., ERWIN, J., KARLSSON, M., AND BIERNBAUM, J. 1988. Tips on pinching poinsettias. *Greenhouse Grower* 6(8):14, 17, 19.

EARNEST. M. 1988. Agricultural Research at the Fairbanks Research Center (revised) AFES, SALRM, University of Alaska Fairbanks. Misc. Pub. 88-1.

EARNST, M. 1988. Annual Report 1988. AFES, SALRM, University of Alaska Fairbanks. Misc. Pub. 88-2.

ERWIN, J., HEINS, R., BERGHAGE, R., KARLSSON, M., CARLSON, W., AND BIERNBAUM, J. 1988. Why grow plants with warmer nights than days? *GrowerTalks* 51(12):48, 50-51.

GALLAGHER, T. J. 1988. Coastal Project Study, Task 4: Key Participants Survey. State of Alaska, Office of the Governor, Division of Governmental Coordination. 33p.

GALLAGHER, T. J. 1988. Regional Overview: Denali State Park Master Plan Report. State of Alaska. Department of Parks and Outdoor Recreation, Anchorage, AK 105p.

GALLAGHER, T. J. Liveable Winter Cities——in Alaska? *Alaska Planning* 6(1):4-5.

HEINS, R., ERWIN, R., BERGHAGE, R. KARLSSON, M. BIERNBAUM, J., AND CARLSON, W. 1988. Use temperature to control plant height. *Greenhouse Grower* 6(9):32-34.

HELM, D. J. 1988. Summarization of data on grazing lands of the Matanuska-Sustina Borough. Prepared by the Agricultural and Forestry Experiment Station in cooperation with Upper Susitna Soil and Water Conservation District and the USDA Soil Conservation Science. May 16. 97pp.

HELM, D. J. 1988. Pre-mining vegetation inventory - Wishbone Hill Project. Draft report. 109 pp.

HELM, D.J. 1988. Use of on-site mycorrhizal inoculum for plant establishment on

abandoned mined lands. First field season report. Prepared for USDI Bureau of Mines. Abandoned Mined Lands Program. Contract J0289003. 17pp.

JUDAY, G. P. 1988. Alaska Research Natural Area: 1. *Mount Prindle.* USDA Forest Service General Technical Report PNW-GTR-224. Portland, OR. Pacific Northwest Research Station. 34pp.

JUDAY, G. P., ALABACK, P., AND ORME, M. 1988. Research Natural Area Proposals for the Tongass Forest Plan Revision. Report of the Research Natural Area Steering Committee, Results of Research Natural Area Workshops. May 24-25 and July 21. USDA Forest Service Alaska Region. 79pp. plus 4 Appendices.

JUDAY, G. P. 1988. Alaska Research Natural Area: 2. *Limestone Jags.* Contract Report to the Bureau of Land Management, Alaska State Office. 102pp.

JUDAY, G. P. 1988. Alaska Research Natural Area: 3. *Serpentine Slide.* Contract Report to the Bureau of Land Management, Alaska State Office. 116pp.

MALONE, T. AND RICHMOND, A. P. 1988. Caring for Black or White Spruce Christmas Trees. AFES, SALRM, University of Alaska Fairbanks. Misc. Pub. 88-3.

MCKENDRICK, J. D. 1988. *Arctophila* feasibility study 1987 annual report. Standard Alaska Production Company, Anchorage, AK. 90 pp (appendices A through H, approximately 350 pp.) Contract report.

PING, C. L., AND MICHAELSON, G. J. 1988. A final report on Alaska statewide phosphorus test, field calibrations for 1984-87. Submitted to the Tennessee Valley Authority.

SPARROW, S. D. 1988. Agriculture in Alaska. *South Peace Forage Crop Association Newsletter.* September. p. 4.

SWANSON, R. B. 1988. Wholesomeness of irradiated foods. *Alaska Marine Resource Quarterly* 3(3):5-7.

YARIE, J. AND MEAD, B. 1988. Twig and foliar biomass estimation equations for major plant species in the Tanana River Basin of interior Alaska. U.S. Forest Service Pacific Northwest Research Station. Research Paper PNW-RP-401. 20p.

ZARLING, J. P., SWANSON, R. B. LOGAN, R. R., DAS, D. K., LEWIS, C. E. WORKMAN, W. G., TUMEO, M. A., HOK, C. I., BIRKLID, C. A., AND BENNETT, F. L. 1988. Alaska commodities irradiation project.: an option analysis study. Prepared for the State of Alaska, Institute of Northern Engineering. University of Alaska Fairbanks. Report 87.51.

Financial Statement

Expenditures — July 1987 through June 1988

The following is a statement of expenditures of federal and state funds for the fiscal year beginning July 1, 1987, and ending June 30, 1988 (FY 88).

Federal		
		(% of total)
Hatch Regular Formula Funds	$691,303	11.9
Hatch Regional Formula Funds	117,607	2.0
USDA–Agricultural Research Service	117,899	2.0
McIntire–Stennis Formula Funds	145,582	2.5
Other Grants and Contracts	746,189	12.9
State Funds	$3,991,022	68.7
TOTAL	$5,809,602	100.0

University of Alaska – 1988

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Associate Dean, School of Agriculture and Land Resources Management, and Associate Director, Agricultural and Forestry Experiment Station: G. Allen Mitchell

Professional Staff

Harry R. Bader, Visiting Assistant Professor of Natural Resources Law; Washington State University B.A. '84; Harvard Law School J.D. '88. Mr. Bader's research interests concentrate on wild lands management and policy. At UAF he has studied dog attacks and management proposals on Charlie River and Beaver Creek.

Cathy A. Birklid, Research Assistant; University of Alaska '77, A.A. B.B.A. Ms. Birklid began working for AFES in 1979. Her major responsibilities have included development and administration of market surveys concerning statewide demand for various agricultural projects. Ms. Birklid is now utilizing statistical software packages to analyze the effects of tillage methods, straw treatments, nitrogen fertilizer source, and seeding methods on barley production in the Delta area. She is currently examining the transportation network for seafood and agricultural commodities produced in Alaska.

Leroy Ben Bruce, Assistant Professor of Animal Science; New Mexico State University '74, B.S., '78, M.S., '79, Ph.D. Dr. Bruce was previously with the University of Hawaii at Hilo and South Dakota State University. Dr. Bruce's work in Hawaii was primarily teaching and research in such unusual feedstuffs as taro. In South Dakota, he was extension specialist in feedlot nutrition, providing service to cattle feeders statewide. His work with AFES is with beef cattle at the Palmer Research Center. His general areas of research interest are beef cattle nutrition and management; he is working specifically with cow-calf and feedlot research.

Larry Burke, Farm Superintendent; University of Idaho '66. Before joining AFES in 1980, Mr. Burke farmed in eastern North Dakota. He has also been a retail manager and big game guide. In 1987, he was named farm superintendent.

Rudy Candler, Laboratory Supervisor; Colorado State University '67, B.S.; University of Alaska Fairbanks '74, M.S., '87, Ph.D. Dr. Candler worked as a lab technician in the Mineral Industries Research Laboratory (1907) and the Forest Soils Laboratory (1971-1972, 1974-1978). In 1978 Dr. Candler was awarded a National Science Foundation grant to study metal-organic interactions in soils. He worked as a research associate from 1978 to 1982 when he returned to school full-time. Dr. Candler spent seven months as guest scientist at the University of Bayreuth, Federal Republic of Germany in 1985.

Donald E. Carling, Associate Professor of Horticulture; St. Cloud State University, Minnesota '67, B.A.: University of Missouri-Columbia '69, M.S.; '75, Ph.D Dr. Carling's research background is in plant pathology with emphasis on ultrastructural studies, plant endomycorrhizal relationships, and diseases of vegetable crops. He joined AFES in 1981 and has since concentrated a basic and applied research program on potatoes and vegetables. Applied research with potatoes includes variety testing and evaluations of cultural practices. Applied research with vegetables includes variety trials, nitrogen fertilization studies, and evaluation of transplanting as an alternative of direct seeding. More basic research includes the study of root disease of potatoes and vegetables caused by Rhizoctonia solani, and of the taxonomy of this important soilborne fungus.

Verlan L. Cochran, Soil Scientist/Research Leader Subarctic Agricultural Research Unit, USDA; Affiliate Associate Professor of Agronomy; California State Polytechnic College '66, B.S.; Washington State University '71, M.S. Mr. Cochran's research interests have included gaseous losses of fertilizer nitrogen, nitrogen transformations in soil, nitrogen use efficiency, fertilizer management and interactions of crops and weeds, and water-use efficiency in supplemental irrigation of dryland wheat. Mr. Cochran joined the AFES staff in 1985 after 19 years with USDA Agricultural Research Service at Pullman, Washington. His work with AFES is on crop residue management in reduced tillage for interior Alaska.

Jeffrey S. Conn, Research Agronomist, USDA; Affiliate Assistant Professor of Weed Science; University of Arizona '73, B.S., '76, M.S.; North Carolina State University '80, Ph.D. Dr. Conn's background of research is in weed science, physiological ecology, and remote sensing. He joined the Agricultural Research Service at the University of Alaska in 1980. His current research is in integrated weed control systems for reduced tillage agriculture, weed biology and ecology, and persistence of herbicides.

Robert F. Cullum, Assistant Professor of Agricultural Engineering; University of Tennessee, Knoxville '77, B.S., '82, Ph.D. Dr. Cullum's research background is in areas of structure in relation to environment and soil and water engineering. He joined the AFES research faculty in 1982 and has since concentrated on conservation tillage research in small-grain production for interior Alaska and waste-management systems for Pt. MacKenzie.

Robert A. Dieterich, Professor of Veterinary Science, Institute of Arctic Biology, University of California-Davis '61, B.S., '63, D.V.M.; Post-graduate training, University of Alaska Fairbanks, '68. Dr. Dietrich's research interests include: diseases of wildlife, applied methods for disease control in reindeer, methods for disease control in fur farming, equine medicine, and surgery.

Stephen M. Dofing, Assistant Professor of Agronomy; Kansas State University '78 B.S., University of Nebraska '80 M.S., '83 Ph.D. Dr. Dofing's research background is in genetics and plant breeding of agronomic crops. He served as Research Station Manager fora hybrid corn company, and as Assistant Professor of Agronomy at the University of Nebraska. He joined AFES in 1989 and has been responsible for variety

development and applied genetic studies in small grains, forage grasses, and legumes. Research in variety development includes the improvement of barley and other agronomic crops for yield and quality characteristics. Other research interests include germplasm evaluation and adaptation studies, and use of genetic male sterility for population improvement of barley.

James V. Drew, Dean, School of Agricultural and Land Resources Management, and Director, Agricultural and Forestry Experiment Station; Rutgers University '52, B.S., '57, Ph.D. Dr. Drew began his professional career at the University of Nebraska-Lincoln where he became professor of agronomy and, later, dean for graduate studies. His research in agriculture emphasized soil genesis and classification, and plant-soil relationships, as well as interpretations of soil surveys for agriculture and land management. Dr. Drew came to his present dual position in 1976. He is an American Society of Agronomy Fellow and an American Society for the Advancement of Science Fellow and has received numerous state and local civic and government appointments since joining SALRM.

John D. Fox, Jr., Assistant Professor of Land Resources; Trinity College '68, B.S.; University of Washington '70, M.S., '76, Ph.D. Dr. Fox came to the University of Alaska with experience in remote sensing and computer modeling in forest hydrology. He worked with the Institute of Water Resources on several projects including snowmelt-soil moisture interactions, modeling of air pollution, aquatic ecosystems, lake-level changes, and watershed geomorphology. Dr. Fox has continued his research interests in land-use hydrology and modeling natural resource systems with AFES, currently researching runoff relations of boreal forests. He teaches courses in watershed management, forest systems, forest management, resource measurements, simulation and modeling, and biometeorology.

Thomas J. Gallagher, Associate Professor of Regional and Land Use Planning; University of Oregon '69, BLA; University of Michigan '74, M.S., '77 Ph.D. Dr. Gallagher's research concerns ways to improve the management and planning of Alaska's land and resources. His specific research areas are in improving the effectiveness and efficiency of planning and permit coordination processes, of increasing the opportunity for the public to participate in public land management, and in understanding the history and problems of land planning in Alaska and other arctic countries. He teaches SALRM's required graduate courses in planning theory and practice and an undergraduate course in land use planning. Each year he also offers one course in environmental design or landscape architecture. In 1988 he served as SALRM's curriculum review coordinator overseeing the major review of the SALRM instructional program.

Anthony F. Gasbarro, Extension Forestry Specialist and Associate Professor of Extension, Cooperative Extension Service; Colorado State University '62, B.S.; University of Alaska '79, M.S. Mr. Gasbarro has worked in the areas of forest management, international forestry development, land-use planning, and extension forestry. He worked for 5 years with the US Forest Service both in California and Alaska, 2 years with the Peace Corps in the Dominican Republic, and 2 1/2 years with the Food and

Agriculture Organization of the United Nations in Rome, Italy. Since joining the university staff, Mr. Gasbarro has served as a forestry and land-use planning instructor and researcher. He is principal investigator of the Intensive Forest Management Program and currently holds a joint appointment between SALRM and the Cooperative Extension Service.

Charles W. Hartman, Executive Officer; Rutgers University '64, B.A., Geology; University of Alaska '67, B.S., Engineering. Mr. Hartman worked as a research engineer/hydrologist for the Institute of Water Resources from 1967 to 1974. In 1974, he became IWR's executive officer where he continued until 1979 when he transferred to SALRM in the same capacity.

Dorothy J. Helm, Plant Synecologist; University of Delaware '69, B.S., University of Michigan '70, M.S., Colorado State University '77, M.S., '81, Ph.D. Dr. Helm's research includes vegetation succession in relation to natural and man-caused disturbances along rivers, behind retreating glaciers, and on mined lands. These studies have encompassed soil and wildlife relationships as well as baseline vegetation inventories. She is currently investigating the role of mycorrhizae in vegetation recovery from disturbances, especially on mining-disturbed lands. Dr. Helm has also assisted agencies with range ecology observations and data synthesis. Her teaching experience at the University of Alaska Fairbanks includes principles of ecology, range management, and ecology of disturbed lands.

Mary Lou Herlugson, Research Associate in Animal Sciences; New Mexico Institute of Mining and Technology '74, B.S. Ms. Herlugson joined AFES in 1981 after five years in animal science research at Washington State University. She provides support to animal science faculty through data reduction, manipulation, and statistical and computer analysis and assists in design of research and in interpretation of results.

Patricia S. Holloway, Assistant Professor of Horticulture; Millersville University of Pennsylvania '73, B.A.; Washington State University '76, M.S.; University of Minnesota '82, Ph.D. Dr. Holloway's research background is in pomology and fruit breeding with major concentration on domestication and cultivation of the lingonberry. She joined SALRM in 1984 and teaches courses in plant propagation, general horticulture, vegetable crops, and greenhouse crops production. Her research involves the improvement of production of horticultural crops in Alaska with emphasis on the cultivation of Alaska native plants for ornamental and fruit-crop production.

Fredric M. Husby, Associate Professor of Animal Science; Washington State University '66, B.S., '69, M.S., '74, Ph.D. Since joining AFES in 1975, he has conducted nutrition research with cattle, dogs, sheep, and swine to determine the nutritional and feeding value of Alaska's barley and marine by-products, making it possible for AFES to make recommendations for feeding crab waste meals to livestock. He has also investigated the value of chitin in ruminant rations. His current research is aimed at evaluating barley protein quality and the feeding value of a new hulless mutant variety 'Thual' in swine and sled dog rations. Dr. Husby has developed and offered courses in introductory animal science, livestock feeds and feeding, and nutrition and me-

tabolism for undergraduates and graduates through the Natural Resources Management degree program.

Alan Jubenville, Professor of Resource Management; North Carolina State college of Agriculture and Engineering '62, B.S.; West Virginia University '64, M.S.; University of Montana '70, Ph.D. Dr. Jubenville joined the school in 1979 after nine years at the University of Wyoming. His primary teaching and research interest is in outdoor recreation management. He has developed a series of papers on basic management theory, authored several textbooks, and been involved in the study of several major state projects in Alaska, including Phase 1 of the Susitna Hydroelectric Project and the Kenai River Special Management Zone. He is the chairman of W-133 Regional Hatch Project, entitled "Benefits and Costs in Resource Planning." Dr. Jubenville has recently completed work on a textbook integrating theory into the management process during a concluded sabbatical leave.

Glenn P. Juday, Assistant Professor of Forest Ecology; Purdue University '72 B.S.; Oregon State University '76 Ph.D. Dr. Juday's research background is in community ecology, especially the structure of old-growth forests, natural area protection and management, and long-term environmental monitoring. He was Chairman of the Oregon Natural Areas Commission from 1973-76, and has served as Alaska Ecological Reserves Coordinator since 1977. He has been coordinator of the Rosie Creek Fire Research Project since 1983. Dr. Juday's work since joining AFES in 1982 has included the identification of important elements of natural diversity in Alaska, incorporation of important scientific areas into Research Natural Area proposals in major land management plans in Alaska, analysis of landscape-level processes responsible for natural diversity, and studies of forest structure. During a recently concluded special assignment project that included stops in 23 states and 4 provinces he analyzed natural area programs across North America. Dr. Juday has served as President of the Natural Areas Association since 1985, and was Guest Editor of a special 3-issue series on old-growth forests in the Natural Areas Journal.

Meriam G. Karlsson, Assistant Professor of Horticulture; The Swedish University of Agricultural Sciences '79, B.S.; Michigan State University '84, M.S., '87 Ph.D. Her primary research interest is the environmental physiology of greenhouse-produced crops. Since joining the University of Alaska Fairbanks faculty in 1988, Dr. Karlsson has concentrated her studies on flower initiation under low light and temperatures.

Carla A. Kirts, Assistant Professor of Agricultural Education; Virginia Polytechnical Institute and State University '76, B.S., '77, M.S.; University of Missouri-Columbia '81, Ph.D. Dr. Kirts's research background is in student-teaching management for preparation of vocational agriculture teachers and strategies to promote quality instruction. Currently, Dr. Kirts teaches courses in natural resources management, general agriculture, agricultural communications, and agricultural education. She also assists vocational agriculture teachers in Alaska with program planning and implementation. Dr. Kirts received the Honorary State Farmer Degree in 1983 from the Alaska Association of the Future Farmers of America (FFA) and the Honorary American Farmer Degree in 1986 from the National FFA.

Charles W. Knight, Instructor of Agronomy; Kansas State University '70, B.S., '71, M.S., University of Alaska Fairbanks '88, Ph.D. Mr. Knight's background in research is with chemical fertilizers and conservation tillage. He came to Alaska in 1971 and worked until 1973 as a research technician for AFES. From 1973 until 1978 he was superintendent of the East Central Kansas Experiment Field for Kansas State University. He returned to Alaska in 1978 to concentrate on soil and water conservation practices and fertility requirements in the Delta Agricultural Project. Mr. Knight is currently pursuing a Ph.D. degree in soil chemistry at the University of Alaska.

J. Stephen Lay, Publications Supervisor and Public Information Officer, SALRM, Trinity University, '69, B.A.; Ohio State University, '88, M.A. Mr. Lay has been with the University of Alaska since 1979, and with SALRM since January 1989. As head of publications, he oversees the production of the station's journal, Agroborealis, as well as a variety of other publications; as information officer for SALRM, Mr. Lay provides information to many agencies and publics.

Carol E. Lewis, Associate 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. Dr. Lewis was previously active in research for the U.S. Navy, applying high-frequency sound technology in explosive and medical research. A member of the AFES research faculty since 1973, her research efforts have been primarily in controlled-environment agriculture, feasibility of small-grain and livestock operations in Alaska, and the economic impacts of agricultural development in the state. At present, she serves as project leader for conservation tillage research in small-grain production conducted in Delta Junction, concentrating on the efficiency of tillage systems in terms of energy use and cost of production. Her teaching responsibilities are in the area of farm management.

Jenifer Huang McBeath, Associate Professor of Plant Pathology; National Taiwan University, Republic of China '65, B.S.; University of California, Davis '70, M.S.; Rutgers University '74, Ph.D. Dr. McBeath's research background is in plant virology, plant mycoplasmology, immunology, insect tissue culture, and electron microscopy. Dr. McBeath's first faculty position, in 1977, was at the Institute of Arctic Biology, UAF, for work on rust diseases of spruce trees. She joined AFES in 1980 and is currently conducting research on fungal and bacterial diseases of wheat and barley plants, anther culture and protoplast fusion of winter wheat, cold tolerant biological control agents of plant pathogens, witches' broom diseases of cottonwood and willow, spruce rusts, and wood decays. Dr. McBeath teaches courses in plant pathology and forest protection. She was an Associate Research Fellow, Academia Sinica, Republic of China, 1975; and a Postdoctoral Fellow, Thomas Jefferson University, 1976. In 1985-86, she was a visiting scientist at USDA-ARS, Beltsville Agricultural Research Center, Maryland.

Jay D. McKendrick, Associate Professor of Agronomy; University of Idaho '63, B.S., '66, M.S.; Kansas State University '71, Ph.D. Dr. McKendrick's Alaskan research activities include: tundra revegetation; secondary plant succession in Arctic tundra;

fertility of tundra soils; oil spill reclamation in Arctic and boreal zones; livestock, musk ox, and bison grazing; range plant nutritional qualities; hay quality; sand dune revegetation; Susitna Basin vegetation for the hydroelectric project; mine spoil reclamation; the effects of burning on browse quality; and range plant quality for Sitka blacktail deer. He has served as a consultant to industry on matters relating to the effects on vegetation of development activities. Dr. McKendrick has also served as a member of the National Academy of Sciences Committee on Alaskan Coal Mining and Reclamation and as a staff advisor to the National Governors' Association Range Resource Subcommittee.

Gary J. Michaelson, Research Associate; University of Arizona '74, B.S.; Iowa State University '81, M.S. Mr. Michaelson has a background in agricultural chemistry and soil fertility. He has conducted his work in soil testing and plant tissue analysis as Plant and Soil Analysis Laboratory supervisor at the Palmer Research Center. He is also currently working in soil fertility and fertilizer requirements of newly cleared Alaska soils.

G. Allen Mitchell, Associate Dean-SALRM, Associate Director-AFES, and Associate Professor of Agronomy; University of California, Riverside '71, B.S., '73, M.S., '77, Ph.D. Dr. Mitchell rejoined AFES in September 1987. He has previously served UAF as Agronomy Specialist with Cooperative Extension Service, and as Assistant Professor of Agronomy with AFES. Dr. Mitchell has a M.S. and Ph.D. in Soil Science with emphasis in Soil Fertility from the University of California, Riverside. He brings experience to AFES from several land-grant institutions, including the University of Arkansas where he was Director of both the Northeast and Southeast Extension and Research Centers, and Head of the Agriculture Department; and from the University of Georgia where he was Assistant Professor of Agronomy.

William W. Mitchell, Professor of Agronomy; University of Montana '57, B.A., '58, M.A.; Iowa State University '62, Ph.D. Dr. Mitchell's background of research is with grasses in natural ecosystems, with particular respect to ecotypical adaptation and teaching in biological sciences. He joined AFES in 1963 where he commenced studies on native grasses of Alaska, investigating the taxonomy, distribution, adaption, and cytological races of selected species. Dr. Mitchell conducted revegetation research in the Prudhoe Bay oil field, along the trans-Alaska pipeline route, and on Amchitka Island, leading to the release of native grass varieties for revegetation use. He is currently studying revegetation of surface-mined lands in interior and southcentral Alaska. His major activities now include research on application and management of grasses for forage uses in a number of agricultural areas in the state and turf studies at the Palmer Research Center.

Edmond C. Packee, Assistant Professor of Forest Management; University of Montana '62, B.S., Yale University '63, M.S., University of Minnesota '76, Ph.D. Dr. Packee's research background is in the coniferous forests of the Pacific Slope north of the redwoods, the Rocky Mountains, and interior Alaska as well as in the northern hardwood forests of the Great Lakes states. He also has forest management experience in northern Wisconsin and coastal British Columbia. Dr. Packee joined

AFES in 1983 and has concentrated on forest growth and yield, the silviculture of tamarack, and forest products' markets. He is a member of the Alaska Forest Tree Improvement Cooperative's Technical Committee." He is chairman of the International Union of Forestry Research Organizations Working Party S1.05-12, Northern Forest Silviculture and Management.

Michael T. Panciera, Assistant Professor of Agronomy; University of Guelph '77 B.S., '79 M.S.; Pennsylvania State University '82, Ph.D. Dr. Panciera was previously with the Agronomy Department of Ohio State University. Dr. Panciera was responsible for teaching Forage Crops courses and his research program focused on forage quality. His research assignment with AFES is Forage Crops and he is located at the Palmer Research Center. Dr. Panciera's research program will emphasize development of management alternatives to improve forage quality and reduce feeding costs for ruminant animals.

Barbara J. Pierson, Research Associate, Soils; Montana State University '77, B.S., '85, M.S., Ms. Pierson's research and work experience has been directed toward soil fertility and soil management problems. She was employed by the Soil Conservation Service prior to beginning graduate study. After joining the AFES staff in 1985, she is working primarily with conservation tillage systems and fertilizer management in research plots established in the Delta area.

Chien-Lu Ping, Assistant Professor of Agronomy (Soil Scientist); Chung-Hsin University, Taiwan '65, B.S.; Washington State University '73, M.S.; '76, Ph.D. Dr. Ping's research background is in soil chemistry; the movements of pesticides, heavy metals, and pollutants in soils; and related land-use issues. He was previously with the Washington State Department of Natural Resources, working on a statewide forest land-grading (survey) program to correlate forest productivity with soil types and to design soil-map units for urban planning in western Washington. He joined AFES in 1982 to investigate soil genesis and classification in Alaska. He also represents the experiment station in his participation in the National Cooperative Soil Survey program in Alaska.

Peter C. Scorup, Research Associate; Colorado State University '66, B.S. Mr. Scorup was a range conservationist with the Soil Conservation Service for 3 years and an instructor of agriculture and natural resources management at Colorado Mountain College for 2 years before joining the experiment station in 1972. His Alaska experience entails identification and verification of vegetation types using aerial photography and satellite data. Mr. Scorup has assisted with vegetation inventorying, mapping, and classification of the Susitna River Basin Cooperative Survey and the Seward Peninsula Reindeer Ranges.

Elena B. Sparrow, Soil Scientist, USDA, Affiliate Associate Professor of Soil Microbiology; University of the Philippines '62, B.S. Cornell University '66, M.S.; Colorado State University '73, Ph.D. Dr. Sparrow's research experience is in soil and environmental microbiology and plant-soil relationships. She has worked for the International Rice Research Institute, Depts. of Soil Chemistry and Soil Microbiology,

Philippines; the Arctic Environmental Research Station, Environmental Protection Agency; and as a consultant on research funded by United States Army Cold Regions Research and Engineering Laboratory, Alaska Projects Office. She was an International Rice Research Institute Scholar to Cornell University in 1964, a Rockefeller Institute travel grantee in 1969, and a postdoctoral fellow at Colorado State University in 1973. She has worked and is currently working with AFES and ARS staff on microbial biomass and decomposition, nutrient cycling, and oil spill pollution studies.

Stephen D. Sparrow, Jr., Associate Professor of Agronomy; North Carolina State University '69, B.S.; Colorado State University '73, M.S.; University of Minnesota '81, Ph.D. Dr. Sparrow's research background is in soil microbiology, plant-soil relationships, and soil fertility. He worked for AFES as a research technician from 1973-1977, went to Minnesota to attend graduate school in 1977, and returned to Alaska in 1981. Currently he is doing research in the area of nitrogen cycling in Alaskan agricultural soils and on legume-Rhizobium relationships in the subarctic.

Ruthann B. Swanson, Assistant Professor of Food Science; University of North Carolina-Greensboro '77, B.S.H.E.; University of Tennessee '81, M.S., '86, Ph.D. Dr. Swanson recently completed a study of irradiation of Alaskan food products. She has also conducted extensive research into the use of Alaskan hulless barley in bakery goods and Alaskan food consumption patterns. She is currently assessing the quality of Alaskan produced reindeer meat.

Wayne C. Thomas, Professor of Economics; California State Polytechnic University '65, B.S.; University of Nevada '67, M.S.; Washington State University '71, Ph.D. Dr. Thomas's academic background is in agricultural economics. Since joining the University of Alaska Fairbanks faculty in 1971, he has conducted research into land management issues, the economics of Alaskan agriculture including reindeer, and the role of government in the agricultural development process. Dr. Thomas has participated in research activities supported by the United Nations and was named a Senior Fulbright Scholar to Australia in 1980. He served the university as acting vice chancellor for academic affairs in 1987-1988.

Gwendo-Lyn Turner, Research Associate; Humboldt State College '70, B.A.; University of California '75, M.S. Ms. Turner's background includes research in aquatic plant ecology concerning agricultural and domestic wastewater pollution. Her Alaska experience has been with various environmental monitoring programs and studies on the North Slope for industry, providing program development, field sampling and report preparation and review support. She has been with the Experiment Station since July 1988, working on revegetation programs on the North Slope.

Keith Van Cleve, Professor of Forestry (Soils); University of Washington '58, B.S.; University of California, Berkeley '60, M.S.; University of California, Berkeley '67, Ph.D. Dr. VanCleve has a background in research and teaching in soil-plant relations with research emphasis on the Alaskan taiga. He was formerly associated with USIBP Tundra Biome and taiga forest ecosystems research programs funded by the National Science Foundation. Dr. Van Cleve is in charge of the SALRM Forest Soils Laboratory.

His current research interests deal with the structure and function of subarctic forest ecosystems.

Robert B. Weeden, Professor of Resource Management; University of Massachusetts '53, B.S.; University of Maine '55, M.S.; University of British Columbia '59, Ph.D. Dr. Weeden's research interests are in resource policy analysis, particularly in the renewable-resources field. He teaches advanced wildlife management (through a joint appointment with the Department of Biology, Fisheries, and Wildlife), environmental impact analysis and decision making, and natural resources policies and legislation. Dr. Weeden began a 26-month term as Head, Department of Biology, Fisheries, and Wildlife in May 1986.

Paul M. Windschitl, Assistant Professor of Animal Science; South Dakota State University '81, B.S., '83, M.S.; University of Minnesota '87, Ph.D. Graduate work at SDSU involved the use of dried whey in dairy cattle rations and its effect on rumen bacterial metabolism. Graduate work at the University of Minnesota centered around protein and amino acid nutrition of high producing dairy cows. Of particular concern was the amount of rumen degradable versus undegradable ("by-pass") protein in the diet. Future work will include the use of fishmeal and urea as protein sources in dairy cattle diets and effects of barley and wheat on rumen fermentation. Also of interest is the use of feed additives (i.e. niacin, yeast) in dairy cattle diets.

Frank J. Wooding, Professor of Agronomy; University of Illinois '63, B.S.; Kansas State University '66, M.S., '70, Ph.D. Dr. Wooding's background is in soil fertility, chemistry, physics, and management; and crop physiology and production. He joined AFES in 1970, where he has studied crop adaptation in the subarctic, cereal grains, oil-seed crops, turfgrass management, revegetation of disturbed land, and the effects of off-road-vehicle use on soils and vegetation. He is currently involved with soil and plant problems associated with development of new lands in the subarctic.

William G. Workman, Associate Professor of Economics, School of Management; University of Wyoming '69, B.S.; Utah State University '72, M.A., '78, Ph.D. Dr. Workman's research background is in natural resources and agricultural economics. His recent work includes valuation and allocation of nonmarket resources, land-use conflicts at the urban fringes, and reindeer grazing issues on public lands. He teaches courses in economic theory and natural resources economics and is coordinator of the M.S. program in Resource Economics in the School of Management.

John A. Yarie, Visiting Assistant Professor of silviculture and Forest Ecology; West Virginia University '71, B.S.; University of Maine '74, M.S.; University of British Columbia '78, Ph.D. Dr. Yarie has a background of research in forest nutrient cycling and plant-soil relationships. His current research interests deal with an analysis of the factors influencing forest productivity.

1988 Annual Report

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