1985 ANNUAL REPORT

Agricultural and Forestry Experiment Station

School of Agriculture and Land Resources Management

University of Alaska-Fairbanks

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University of Alaska-Fairbanks

ANNUAL REPORT

For the year ending December 31, 1985

Fairbanks, Alaska 99775-0080

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Letter of Transmittal

The Honorable Bill Sheffield
Governor of Alaska
Juneau, Alaska 99811

Dear Sir:

I submit herewith the annual report of the Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks, for the period ending December 31, 1985. 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
Director

Fairbanks, Alaska
June 30, 1986

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Purpose

The Alaska Agricultural and Forestry Experiment Station (AFES) has statewide responsibility for developing and disseminating research results to benefit Alaskans involved in agriculture, forestry, and land resources management. These include farmers, foresters, land managers, employees of state and Federal agencies, and, indirectly, the public at large which benefits through the wise use of land resources. The purpose of this annual report is to provide information about the role of AFES in obtaining research results for land resource development and conservation in Alaska.

Specifically, the research objectives of the Agricultural and Forestry Experiment Station are to: (1) increase the efficiency of production systems for food and wood products, (2) improve processing and marketing of Alaska's food and wood products, (3) improve resource inventories and land-use planning for agriculture and forestry, and (4) develop resource management for improving the quality of life, including revegetation procedures, pollution control, landscaping and home gardening, and outdoor recreation.

Research completed at AFES is published in scientific journals as well as in experiment station bulletins and circulars, conference proceedings, books, and in the station's journal, *Agroborealis*. Scientists at the experiment station also participate frequently in conferences, workshops, and other public information programs involving subjects ranging from greenhouse management to small grain production to reindeer herding to forest management to the management of outdoor recreation. Through these programs, as well as through advisory committees, feedback is obtained by experiment station scientists about problems that urgently need research attention. This information is used in developing the research agenda for the station.

Agricultural research has a long history in Alaska. The first agricultural experiment station in the territory of Alaska was estab-

lished in Sitka by the United States Department of Agriculture in 1898. Subsequently, agricultural experiment stations were established by the Federal government in other parts of the territory. In 1931 and 1932, the experiment stations established near Fairbanks and Palmer in 1906 and 1917, respectively, were transferred from Federal ownership to Alaska's land-grant college, the Alaska Agricultural College and School of Mines. In 1935, this institution became the University of Alaska. Thus, by the end of 1986, the experiment station at Fairbanks will have completed 80 years of service to the citizens of Alaska.

Administratively, AFES is associated with the School of Agriculture and Land Resources Management (SALRM), University of Alaska-Fairbanks. This association provides direct linkage between research and teaching in agriculture, forestry, and natural resources. Scientists who conduct research at the experiment station also teach courses, present seminars, conduct field trips, and advise undergraduate and graduate students. Thus, students receive the latest information and skills from the researchers who are perfecting them.

This annual report is divided into three major sections: plant and animal science, forest management, and resource management. Each section begins with a research highlight to examine one particular area of study. Summaries are provided for the remaining projects in each section and list the personnel responsible. The report concludes with a list of publications for 1985, a presentation of the faculty and professional staff for SALRM, and a financial statement. □

This one-pass disker/seeder is being used in research to find ways to enhance retention of soil moisture and improve weed control while, at the same time, reducing soil erosion by wind in the Delta Junction area of interior Alaska.

Plant and Animal Science

Conservation Tillage

The Agricultural and Forestry Experiment Station and the Agricultural Research Service, USDA, have cooperated in conducting a research program on conservation tillage in interior Alaska. Nationally, conservation tillage is recognized by the Joint Council on Food and Agricultural Sciences as the most significant technology being developed for producing crops while simultaneously controlling soil erosion. Reduced-tillage and no-till systems can manage the crop residue cover on the land and conserve energy, labor, water, soil, fertilizer, and organic matter.

In Alaska, conservation tillage research is primarily concerned with the production of barley, the major commercial field crop in interior Alaska. However, unique conditions including a short growing season, marginal water supply, weeds and diseases, cool soils, soil fertility, and production economics prevent the direct transfer of conservation tillage technologies to Alaska from more southerly states.

Initial research, begun in 1979, investigated three tillage methods (no till, minimum tillage, and maximum tillage) in a barley-rapeseed-fallow management system in interior Alaska. Significant results were that:

(1) The no-till system produced crop yields comparable to those produced in tilled soil in all cases except where perennial weeds were present.

(2) Residual crop stubble left on the soil surface by the no-till system did not delay soil warming in the spring, but actually increased the warming due to retention of snow which insulated the soil from extreme heat losses in the winter.

(3) Fallowing was not an effective means of conserving soil moisture for the succeeding crop.

(4) Maximum tillage resulted in a loose, fluffy seedbed which often remained colder than minimum-tilled and no-till soils early in the growing season.

Continuing research on conservation tillage is designed to determine the effect of tillage, crop-residue management, and type of planting equipment on the yield and quality of continuously cropped barley. Four tillage systems range from one that does not disturb the seedbed to one which causes maximum seedbed disturbance. These are: no tillage, chisel in the fall, disk in the spring, and disk in the fall and spring. Three methods of managing crop residue are considered: all crop surface residue and stubble removed, only surface residue removed, and no residue or stubble removed. Finally, there are three types of planters: a double-disk, press-wheel planter which causes virtually no soil disturbance; a disker-seeder which operates similar to a disk; and a hoe drill which has a ridge-furrow effect on the seedbed. The duration of the study is 5 years. The 1985 field season completed the second year. Trends indicate that some form of disturbance of the seedbed produces the highest yields, and quality of barley is improved when depth of seeding can be most precisely controlled.

Soil temperature, available solar radiation, and length of growing season are critical to crop growth. To determine the interaction of tillage and residue management techniques within these parameters, an automated data-logger is used. Data are collected and processed year-round, stored on cassette tape by the data-logger, and then analyzed using a microcomputer.

Soil nutrient requirements of a barley crop, especially the placement of fertilizer, are being evaluated in conjunction with the use of conservation tillage. Questions asked by farmers are: How much phosphorus (P) must be used, where in relation to the seed should it be placed, and will there be a residual effect over a period of years? and how much of the complete fertilizer requirements can be placed with the seed? P fertilization is being evaluated by using five rates of applied P fertilizer and two methods of application. Soil P levels are being monitored to determine residual effects after three years of production. A study considering banding four rates of a complete

fertilizer mix from 0 to 400 pounds per acre was begun in 1985. Two types of complete fertilizers with a nutrient ratio of 20-10-10 are being compared: a complete pellet with ammonium nitrate as the nitrogen (N) source and a blend in which urea is the N source.

Although research is an important component of the mission of the Agricultural and Forestry Experiment Station, the broad mission of the School of Agriculture and Land Resources Management is a triad of research, instruction, and public service. The effectiveness of the conservation tillage program is enhanced by the fact that it embodies these three major functions. For students interested in field-crop production and for farmers seeking further in-depth knowledge, the School of Agriculture and Land Resources Management offers courses in agronomy, soils, and farm management which incorporate research results from the conservation tillage program. Extension programs are conducted throughout the year to familiarize farmers with research results and to provide them an opportunity to suggest their needs to researchers. The research area at Delta Junction plays an important part in extension field days. Research studies were designed at field scale in order that they can be utilized for demonstration purposes. Experiment station field days and other tours are well attended during the growing season. Overall, the conservation tillage program sponsored by the USDA and the Agricultural and Forestry Experiment Station will provide long-term benefits to the University of Alaska and farmers seeking to maintain economically viable yields of barley while conserving the soil resource.□

Cereal Breeding and Production

The primary objective of the barley improvement program continues to be the combination of disease resistance with the early maturity and high yield essential for successful grain production in Alaska. Materials displaying field resistance at Palmer and Delta to prevalent problem diseases have been assembled from widely differing sources in order to provide a broad-based genetic background from which to select relatively adapted lines for entry into the breeding program.

Resistance to barley stripe appears to be available in early, relatively adapted materials. Scald remains the number-one disease problem, since most resistant selections from composite crosses and other breeding programs appear to be too late in maturity for dependable production. Initial selections from hybrids having early-maturing backgrounds will be available for field evaluation in 1986. Material with a history of resistance to net blotch has also been assembled for field evaluation next season. Additional important characteristics under evaluation for barley improvement include increased straw strength, improved protein quality, and greater total protein production.

Field performance data at Palmer have provided information concerning forage and grain yield of early-maturing oat selections from the breeding program. Yield responses compare favorably with the better-performing, north-adapted oat materials currently available from other areas. The most promising selections will be subjected to additional testing along with new selections from the breeding program.

Significant progress was recorded toward the predominant goal of the wheat-breeding program, the development of earlier-maturing, high-yielding varieties. Materials were selected for incorporation into the next breeding cycle, where early-maturing lines will be combined with late-maturing germplasm with enhanced grain protein content and baking quality. Much of the late-maturing materials failed to mature in 1985.

An additional variety of early-maturing wheat, as yet unnamed, will be available to seed producers in 1986. A barley line demonstrating superior agronomic performance will be increased for release in 1986. Unfortunately, this line seems as lacking in disease resistance as varieties currently available. An early-maturing oat selection with high grain yield and acceptable forage yield will also be increased. *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 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 interior Alaska farmers. During 1985, twenty-two barley, ten oat, and twelve wheat varieties and experimental lines were evaluated in replicated standard trials at Fairbanks and Delta Junction. The Delta Junction site was situated on recently cleared forest land which had been summer-fallowed the previous year. The Fairbanks site was situated on fall-tilled oat stubble land which had been in production for 56 years. With the exception of about 6 days in late May and the last 10 days of July, the growing season at both locations was cool and wet. These conditions resulted in delayed maturation of all grains and made harvesting difficult.

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 as follows: 'H349-348 (ACA2566)' barley, 108 bushels per acre; 'Athabasca' oats, 114 bushels per acre; and 'MS273-150 (ACA2571)' wheat, 92 bushels per acre. The highest yields for each of the crops for the medium-to-late maturity class were as follows: 'Abee' barley, 117 bushels per acre; 'Calibre' oats, 139 bushels per acre; and 'MS57-144 (ACA2570)' wheat, 105 bushels per acre. At Delta Junction, the highest yields

in each of the crops for the very early-to-early maturity class were as follows: 'Datal' barley, 105 bushels per acre; 'Toral' oats, 197 bushels per acre; and 'Rovaniemi Sel. 70-W' wheat, 58 bushels per acre. The highest yields in each of the crops for the medium-to-late maturity class were as follows: 'Empress' barley, 79 bushels per acre; Calibre oats, 222 bushels per acre; and 'Taava' wheat, 65 bushels per acre.

At Fairbanks, the adverse climatic conditions for the 1985 growing season particularly favored experimental lines of barley and wheat obtained from Norway. At Delta Junction, where growing conditions were even less favorable, Datal barley and Calibre oats gave outstanding performances. Datal is a very early-maturing, 6-row barley developed by the plant-breeding program at Palmer, Alaska. Calibre is a recent Canadian oat release. *F.J. Wooding.*

Small-Grain Production in the Tanana Valley of Interior Alaska

Resistance to lodging, or the capacity of stems to withstand the adverse effects of rain and wind, is a desirable characteristic in grain crops. Lodging can reduce yields by restricting translocation of nutrients from leaves and stems to developing grain heads. Yield may also be lost in the field due to failure of harvesting machines to pick up low-lying grain heads. Lodged grain dries slower in the field, which, in turn, delays harvest operations, increases after-harvest drying costs, and, in some cases, may result in lower quality grain.

Varieties which mature very early are essential for successful barley production at northern latitudes. Lodging is a consistent problem with these varieties, particularly when trying to achieve high yields. Thus far, breeding programs have been unable to incorporate stiff-strawed characteristics with early maturity. Ethephon, sold under the tradename Cerone®, is a plant growth regulator which can effectively reduce crop height, increase straw strength, and prevent lodging in barley. Cerone is applied as a foliar application between

the time the flag leaf is first visible up to the swollen boot stage of growth. The chemical breaks down inside the plant tissue to form a natural plant hormone called ethylene. This substance shortens the last internodes of the stem, particularly the one just below the grain head.

In 1984, a field study was initiated at Fairbanks, Alaska, to determine the effectiveness of Cerone in a subarctic environment. Barley, grown at high fertility, was subjected to spray applications of Cerone during the early boot stage of growth. Cerone was applied at rates of 0, 0.5, 1.0, 1.5, 2.0, and 4.0 pints per acre. The control treatment, receiving no Cerone, lodged severely. Cerone rates of 1.5 pints per acre or higher controlled lodging.

Lower rates of application reduced, but did not prevent, lodging. However, it was the two lower rates of Cerone that resulted in higher grain yields. Cerone rates of 0.5 and 1.0 pint per acre produced grain yields that were 19.3 and 12.9 percent greater than the control treatment, respectively. Rates of 1.5 pints per acre or greater had no noticeable effect on yield when compared with the control. Grain-quality factors such as protein content, test weight, 1,000-kernel weight, and germination rate did not differ significantly from the control.

Results from this investigation indicate that Cerone may be of value to barley growers in Alaska. However, additional research is needed to define more clearly the benefits and limitations of this product. This research was performed on only one barley variety at only one location and does not account for yearly variations in weather. Preliminary results for 1985 field trials indicate that weather may influence the effectiveness of Cerone. Specifically, cool, wet growing conditions at the time of application may drastically reduce the response of barley to Cerone. *F.J. Wooding.*

Cultural Practices for Rapeseed in Alaska

The success of spring rapeseed production in interior Alaska depends upon the crop's ripening to a harvestable stage prior to

heavy snowfall in the autumn. To ensure early, uniform ripening, the seed must be placed in moist soil at a shallow depth (.5 to 1 inch) early in the spring. The objective of this study is to determine whether spring rapeseed can be produced successfully from seed planted in late autumn or early spring when the soil is cold or frozen. Under ideal circumstances, this early-planted seed germinates as soon as the surface inch of soil is warm enough, thus giving it an earlier start than rapeseed planted early to mid-May. It should also allow the young plants to make maximum use of spring meltwater. Also, this technique would widen the time window of planting, which is extremely narrow in interior Alaska.

Two rapeseed cultivars, 'Candle' and 'Tobin', are each planted at weekly intervals from late September until the snow depth exceeds 6 inches. Weekly plantings are resumed in the spring as snow is leaving the fields and continue through the first week of May. Plant population counts are made during the seedling stage, and maturity notes are taken throughout the growing season.

The results from the first two field seasons showed that plant populations and seed yields from spring plantings greatly exceeded those from autumn plantings. No particular time of planting in the spring was found to be superior overall to any other spring-planting date, although the very early plantings sometimes did not do as well as the later plantings. Rainfall patterns seemed to have a greater effect on crop maturity than did planting date. In 1985, we tested the effects of no-tillage planting into protective crop residues as a possible means of improving plant survival from autumn and early-spring plantings. However, for all planting dates, no-till plantings were greatly inferior to bare-ground plantings, both in terms of plant stand and seed yields. Also, the fall seedings again produced poorer stands and lower yields than did the spring plantings. The study is continuing with additional tests designed to help determine why fall-planted seed does not survive well. *C.W. Knight and S.D. Sparrow.*

Conservation Tillage and Crop Residue Management

AFES has conducted conservation tillage and residue management research in cooperation with the Agricultural Research Service, USDA, since 1983. The primary study within the research program considers the effect of tillage, crop residue management, and type of grain planter on yield and quality of barley. Four tillage systems: no tillage, chisel in the fall, disk in the spring, and disk in the fall and spring are included. Residue management consists of three treatments: all crop surface residue and stubble removed, only surface residue removed with stubble left standing, and no residue or stubble removed. Two types of planters are used on all tillage treatments: a double-disk, press wheel planter which causes virtually no soil disturbance, and a hoe drill which has a ridge-furrow effect on the seedbed. The third planter is used only on the no-tillage and chiseled plots. It is a disker seeder which operates similar to a disk.

In 1984, highest yields (1.3 tons per acre) were obtained when surface residue was removed and stubble was left standing in the fall and plots were disked once in the spring. The type of planter used did not affect yield but did affect quality. The double-disk drill gave the best control of seeding depth, and its use resulted in the highest quality grain. In 1985, the type of planter again showed no significant difference among yields. There was no significant difference in plots which were tilled, but there was a significant difference between tilled plots and those not tilled. Yield from tilled plots averaged 1.3 tons. Chiseled plots displayed the highest yield at 1.4 tons per acre; disked once lowest at 1.28 tons per acre. Grain in no-tilled plots averaged a yield of 0.9 tons per acre. Residue treatment also did not affect yield. Again, the double-disked drill led to the highest quality grain. Low yields on plots not tilled were the result of ineffective control of perennial weeds using only herbicides. This was particularly the case in plots with the greatest amount of residue remaining over the winter months.

An automated data-logger is used to monitor soil temperatures

throughout the year. There was little variability among tillage and residue treatments throughout the 1985 growing season. Temperatures remained at 45 to 50 degrees Fahrenheit in the rooting zone. The only noticeable difference was in early May when frost in plots with surface residue removed and stubble left standing and receiving no fall tillage had receded more rapidly than that in other plots.

Two other studies are designed to evaluate 1) levels of phosphorus (P) application, method of application, and the residual effect of P on barley yield and 2) the effect of placement of the total applied nutrient requirement of barley with the seed. Preliminary results concerning P application indicate at least 20 pounds per acre of P_2O_5 should be applied during seeding operations. Broadcasting or banding has produced similar yield results. Residual effects will be evaluated in 1986 and 1987. The first year of the study concerning placement of the total nutrient requirement of barley with the seed was in 1985. The growing season was unusually cool and wet. Four rates of a complete fertilizer mix from 0 to 400 pounds per acre were used. Two types of complete fertilizers with a nutrient ratio of 20-10-10 were compared: a complete pellet with ammonium nitrate as the nitrogen source and a blend with urea as the nitrogen source. Results indicated that yields continued to increase up to the rate of 400 pounds per acre banded with the seed. The complete pellet performed better than the urea mix with yields of 1.05 tons per acre versus 0.86 tons per acre. *C.E. Lewis and R.F. Cullum.*

The Effect of Tillage and Straw Management On Soil Microbial Activity

Soil microorganisms have an important role in soil fertility and tilth. They break down soil organic matter and crop residues thereby releasing plant nutrients. They also produce polysaccharides which bind soil particles together in stable aggregates which improve soil tilth and stability against wind and water erosion. Certain organisms produce urease, an extracellular enzyme which functions to hydrolyze urea to ammonia; this is the first step in making the nitrogen (N) in urea available to plants. Nitrifying microorganisms then con-

vert ammonia to nitrate through a series of steps. Both ammonia and nitrate are available to plants, but nitrate is more mobile in the soil and is generally considered the most available form of N.

The rate and time of microbial activity is important to good plant nutrition. Microorganisms decomposing grain straw need extra N early in the decomposition process, but release this over an extended period of time as the straw is decomposed. Phosphorus (P) and many of the micronutrients are also released slowly during decomposition.

Nutrient cycling during crop-residue decomposition has received much attention in warmer climates, but little work has been done in agricultural soils as far north as Alaska. An attempt was made in May of 1985 to begin to understand the changes in microbial activity during the growing season of spring barley. Soil samples were obtained monthly from a 2-year-old tillage study, and levels of specific microbial enzymes and populations of nitrifying bacteria were monitored. One objective was to determine if there were measurable differences caused by tillage and/or crop-residue management after only two barley crops.

We were unable to detect significant differences in microbial activity as a result of tillage method or as a result of crop-residue removal. There was a trend toward lower soil organic matter with narrower carbon (C):N ratios with extensive tillage compared to no tillage. We did find that, regardless of tillage or straw-management practices used, there were high levels of urease activity, indicating that the urea fertilizer applied in early May was converted rapidly to ammonia. The number of nitrifying organisms was sufficient for rapid conversion of ammonium nitrate; therefore, urea fertilizer appears to become rapidly available to the crop. The enzymes phophotase and dehydrogenase, which reflect general microbial activity in soil organic matter and crop residue decomposition, increased dramatically between May and June and then declined until harvest.

Rapid increases in microbial activity usually require additional inorganic N for protein synthesis. The N is released slowly as the microbial population declines. The pattern of activity measured would indicate a high demand for N until late June followed by a slow release of N in late July and August. Therefore it appears that

microbial needs for inorganic soil N are greatest at a time when the crop also requires a large amount of N. Further studies are planned in 1986 to determine how much fertilizer N is tied up by microorganisms and when that N becomes available to the crop. *V.L. Cochran.*

Weed Control Research

Weed quadrats were used to determine the effects of tillage, drill type, and straw management treatments on weed species composition and cover. Perennial grasses, especially bluejoint reedgrass (*Calamagrostis canadensis*), were more prevalent when tillage was reduced to less than two diskings per year. In no-till plots, barley yields were reduced to zero by the grasses. Grass cover was less in plots planted by drills such as a disker-seeder which disturbs soils more. Experiments were performed for a third year to determine the effect of postemergence herbicides on barley grain maturity. Unlike the first 2 years in which some herbicides delayed grain maturity, there were no significant effects in 1985. Several weeks of unusually wet weather followed the herbicide applications in 1985. In previous years it was dry at this time, and several of the herbicides set back barley growth. A method for determination of dinoseb residues by gas chromatography was found, and soil samples are now being analyzed to determine the soil persistence of this herbicide. Germination tests were conducted on seed exhumed after burial for 1 year as part of a long-term seed longevity study with eighteen weed species. *J.S. Conn.*

Low-Temperature Physiology of Crop Plants

Winter rye plants were grown at 68 and 41 degrees Fahrenheit in growth chambers programmed for either 8- or 16-hour photoperi-

ods. The growth and development of leaves, roots, and tillers were measured for all four sets of plants. Plants placed at 41 degrees Fahrenheit and subjected to 16-hour photoperiods initiated production of new leaves, roots, and tillers after 3 to 4 weeks. In contrast, plants placed at 41 degrees Fahrenheit and subjected to 8-hour photoperiods entered a lag phase that lasted 6 to 8 weeks before initiating the production of new leaves, roots, and tillers. Thus, the process of cold acclimation appears to be related to the total amount of light received by the plant as well as to the environmental temperature. Root growth was significantly different at 41 degrees Fahrenheit. Rates of root elongation and secondary development, such as branching, slowed at that temperature. In combination with results on shoot growth at 41 degrees Fahrenheit, these results show that the cold acclimation process is differentially controlled between the root and shoot. A better understanding of the process of cold acclimation is necessary to identify appropriate characteristics to be used in selection programs for crop improvement. *M. Griffith.*

Horticultural Crop Improvement for Interior Alaska: Vegetable Variety and Cultural Practices

Trials of ten or more varieties were conducted for eight vegetable crops, including those with commercial potential such as the crucifers, carrots, and potatoes. One variety which has shown great promise is 'Shogun' broccoli. In order to determine appropriate cultural practices for this crop, a study was conducted to compare the yields of Shogun, a late-maturing cultivar, with 'Green Valiant', an early-maturing cultivar, at three spacings (12, 16, 20 inches) and at three fertilizer rates (1000, 1500, 2000 pounds per acre, using 10-20-20). Preliminary results indicate that the yields per acre are increased at the smallest spacing even though individual head sizes are reduced. A study comparing the growth and development of Shogun broccoli plants with Green Valiant plants revealed that the

increased head size observed in Shogun broccoli was correlated with a longer growing season to reach maturity and with reduced production of lateral shoots and leaves in this cultivar. The results of our broccoli studies can be applied directly to the development of commercial production techniques. *M. Griffith.*

Potato Variety Trials

Replicated yields trials with forty varieties of potatoes were conducted under irrigated and nonirrigated conditions. Rainfall was deficient through July, and yields in nonirrigated plots were well below average as a result. Cooler than average temperatures through June also had a depressing effect on yields. Specific gravity readings were below annual averages. Irrigated plot yields were comparable to 1984 yields. Top yields were 15.2 and 10.5 tons per acre in the irrigated and nonirrigated plots respectively. 'Bakeking', 'Green Mountain', 'Kennebec', and 'Superior' were among the top-yielding varieties in irrigated and nonirrigated plots. 'Rosa', 'Shepody', and '3-79-270-81' also yielded well and may possess value as commercial varieties. Rosa is a round white with red eyes, while Shepody and 3-79-270-81 are long whites. 'Belrus', 'Butte', 'Nooksack', 'Norgold Russet', and 'Russette' performed poorly in irrigated and nonirrigated plots. August and September had more rainfall than average, but nonirrigated plots were too badly damaged by earlier drought to respond. Harvest was made difficult by the late-season rainfall, and bacterial soft rot was observed in the harvested crop. Storage rots no doubt will cause losses for some commercial growers. *D.E. Carling.*

Cultural Practices for Field-Grown Lettuce

Lettuce transplants (varieties 'Ithaca' and 'Salinas') were placed in the field at three locations at weekly intervals throughout the 1985 growing season. Each variety was also direct seeded, and yields were compared for each harvest date. 1985 results generally agree with 1984 results which indicated harvest would occur 20 days earlier with transplanted plants compared to seed planted at the same time. Transplanted stands were more uniform and had fewer missing plants than the corresponding seeded plot. Performance of transplants indicates placement in the field prior to May 1 is not advantageous. Transplants placed in the field prior to May 1 survive but develop no more rapidly than those placed in the field as much as 20 days later. The use of transplants may be a feasible alternative to direct seeding. Studies are underway to determine economic feasibility.

Studies were made of nitrogen (N) fertilization of lettuce utilizing NH_4NO_3, $CaNO_3$, or urea at 50, 100, and 150 pounds N per acre applied to early-, mid-, and late-season plantings. Results were varied but suggest urea may be a suitable N source for use on lettuce. There was also an indication that high rates of NH_4NO_3 may depress yields. Studies will be repeated to confirm observed trends. *D.E. Carling.*

Yield Reduction Potential of Rhizoctonia Disease of Potato

Yields of potato plots seeded with tubers contaminated by sclerotia of *Rhizoctonia solani* AG-3 were compared with similar plots seeded with tubers free of *R. solani* contamination. Varieties 'Alaska 114', 'Bakeking', 'Kennebec', and 'Superior' were studied, and yields of

all but Bakeking were reduced by fungal contamination. Yield differences observed were highly significant. Other parameters measured included stem counts and canker development. Stem numbers varied among varieties with respect to *R. solani*. Superior and Bakeking had more stems, and Kennebec had less if seed pieces were contaminated. Cankering increased from 200 percent in Bakeking to 600 percent in Alaska 114, when contaminated seed was used. These data demonstrate the type and extent of damage seedborne *R. solani* inoculum can cause. Seed which is free of *R. solani* should be used if possible. *D.E. Carling.*

Plant Disease and Nematode Studies

Surveys for indigenous plant-parasitic nematodes were expanded to include larger areas of southcentral and interior Alaska than were previously studied. Sampling was also done on those parts of Kodiak Island reachable by road. Preliminary data indicate the occurrence of plant parasitic nematodes at nearly all sampled locations. There are also indications that Kodiak Island populations may differ from populations recovered from various mainland sites. Further processing will be required before specific identities will be known. It is clear that adapted populations of plant parasitic nematodes are able to tolerate the boreal conditions of the region. Whether or not they cause significant harm to their hosts is not yet known.

Pathogenicity of *Rhizoctonia solani* isolates recovered from potato plants and soil was determined on potato, cauliflower, and wheat. All anastomosis group-3 (AG-3) isolates were pathogenic on potatoes but had no effect on cauliflower or wheat. AG-2-1 isolates were highly to nonpathogenic on cauliflower but mildly or nonpathogenic on potato and wheat. An unidentified group of multinucleate isolates was mildly pathogenic on all hosts tested. Binucleate *R. solani*-like fungi were also mildly or nonpathogenic on all hosts. Groups other than AG-3 appear to pose no significant threat to potatoes while AG-2-1 appears to be most damaging to cauliflower. Both groups are aggressive parasites on their respective hosts. *D.E. Carling.*

Horticulture Crop Improvement for Interior Alaska: Fruit Improvement for Alaska

Thirteen varieties of perennial strawberries which had been moved to new beds overwintered with mortalities ranging from 0 to 81 percent. High mortality in some varieties may have been a result of late summer herbicide treatment (Terbacil® plus DCPA®) and transplant shock. Weed control from this herbicide treatment was very good. These results are important because commercial production of hardy perennials in Alaska is limited by the lack of appropriate weed control measures. Two new strawberry varieties, 'Skwentna' and 'Talkeetna', were obtained from the Plant Materials Center, Palmer, Alaska, and will be evaluated for hardiness, production, and fruit quality. Survival rates of twenty-five varieties of apple and crabapple planted in 1983 to 1984 ranged from 17 to 100 percent. Many tree limbs were broken by the heavy winter snows, and tip-burn was common. Six varieties bore fruit in the 1985 season. These results are exciting because few perennial fruit crops can be grown in interior Alaska. *M. Griffith.*

Horticulture Crop Improvement for Interior Alaska: Ornamental Variety Trials

Trials of 300 annual flower cultivars obtained from commercial and experimental sources were conducted in a demonstration garden open to the public. The flowers were evaluated on flower quality, overall appearance, transplant shock, and bloom period. A list of the cultivars and their seed sources is available to the public, and two tours were conducted this past summer to acquaint producers of bed-

ding plants and home gardeners with the range of flowers which can be grown successfully in interior Alaska.

Weed control is a problem in the production of herbaceous perennials. Good weed control requiring only minimal hand weeding was achieved by treating the perennial beds with Premerge® prior to spring emergence of plants and by using Round Up® (wick-applied to aisles) during the season.

Twenty-five new woody perennials obtained from the Plant Materials Center, Palmer, Alaska, were planted for evaluation. These plantings included six varieties of apple to test for hardy rootstocks in addition to plantings of Pyrus, Prunus, Acer, Betula, Cornus, Rhamnus, Sorbus, Ribes, Hippophae, and Potentilla. A new variety of hardy Forsythia released by the University of Vermont is also under evaluation. The results of these trials can be used by landscapers seeking new materials for perennial plantings. Treflan® was used as a post-planting herbicide on the woody perennial beds and resulted in fair to good weed control. *M. Griffith.*

Production of Cut Roses in a Greenhouse Using Simulated Waste Heat

Cut-flower roses were produced throughout the year for the fourth consecutive year using 95 degree Fahrenheit water to heat the greenhouse soil in the rosebeds. Roses were hedge pruned by rows to 40 inches on five dates (row 5 on 7/1/85, row 4 on 7/15/85, row 3 on 8/1/85, row 2 on 8/15/85, and row 1 on 8/30/85), and data on flower yields were collected. In the first flush following pruning, rose yields were highest in row 5, and yields decreased with later pruning dates. All rows were soft pinched on 11/1/85 to increase yields for Christmas. At that time, row 2, which had completed its first flush, had the most shoots ready for soft pinching, whereas row 5, which had completed its second flush, was second in shoot number. The practice of hedge pruning will allow a grower to increase rose sales by timing rose production to coincide with holidays.

Vase-life studies were conducted using eight rose varieties and ten preservative solutions. The best preservative dissolved in local tap water was Floralife® adjusted to an approximate pH of 3.5 with citric acid. Mean vase life using the most effective preservative was: 'Royalty', 14 days; 'Samantha', 12 days; 'Eterna', 12 days; 'Romance', 11 days; 'White Satin', 10 days; 'Sonia', 10 days; 'Angelique', 9 days; 'Golden Fantasy', 8 days. This information will be used to help potential growers determine the quality of cut roses produced in Fairbanks. In addition, the information can be used directly by local florists who wish to prolong the vase life of cut roses sold locally.

A 1-year rose-marketing study designed to determine consumer response to rose quality and pricing began on 1/15/85. The prices for roses imported into Fairbanks from the west coast of the U.S. fluctuated seasonally by 385 percent during 1985. *M. Griffith.*

Survival Differences among Forages at Different Locations

Forage trials established with perennial grasses in different areas of the state have revealed winter hardiness and other adaptive differences of particular entries. The trials have included entries of timothy, meadow fescue, red rescue, reed canarygrass, creeping foxtail, meadow foxtail, bromegrass, and orchardgrass. Trials have been established in the following areas: Delta Agricultural Project, Pt. MacKenzie, upper Susitna Valley near Talkeetna, and Funny River east of Soldotna. The trials have not been identical in their inclusion of entries.

The Scandinavian countries have been a source of a number of varieties for use or trial in Alaska. Oslo, Stockholm, and Helsinki are at the same latitude as Seward, Alaska, but major portions of Norway, Sweden, and Finland occur north of this latitude.

Meadow fescues are in common use in the Scandinavian countries, particularly for pasture purposes. Meadow fescue varieties from Scandinavia placed in trial near Delta Junction failed to survive their

first winter (1983-84) after seeding. These countries were not included in other trials.

A number of timothies were entered in trials at all locations. The Delta location has provided the most severe test for these grasses. The Canadian variety 'Climax' was eliminated in the first winter (1983-84). Six Scandinavian varieties in the test experienced more or less severe injury in the following winter. Most recovered, however, after the first harvest was taken on 25 June and produced fair to good second-harvest yields. 'Engmo' timothy, a cultivar selected for use in northern Norway, was the hardiest of the timothies. The same timothies have survived the winters at the other, more southern, trial locations without showing serious injury, attesting to the differences in winter stress at the different locations. The plantings at Pt. MacKenzie and near Talkeetna, in particular, have benefited by good snow covers that have remained in place throughout much of the winter season.

Differential survival was demonstrated in 1985 by four red fescues at the Delta location. Whereas the entries 'Boreal' from Canada, 'Reptans' from Sweden, and 'PI 274619' from Poland manifested severe winter injury when the first harvest was taken on 25 June 1985, 'Arctared' fescue of Alaskan origin was healthy. The injured fescues recovered to produce a sizable second harvest.

Meadow foxtail and 'Garrison' creeping foxtail, two related grasses, demonstrated a differential in survivability as influenced by adaptation to soil types. Under the more stressful winter conditions at Delta, creeping foxtail survived better than meadow foxtail. Under the more acidic and high phosphorus(P)-fixing characteristics of the Susitna Valley soils, meadow foxtail survived better than did creeping foxtail.

'Hattfjelldal' orchardgrass, a variety selected for use in Norway, was completely eliminated by winter injury at Delta, was severely injured at Funny River, and was seriously injured at Pt. MacKenzie, though it recovered in mid- to late summer at the last-named site.

Reed canarygrass of Minnesota origin was completely winter killed at Delta, sustained serious injury at Funny River, but endured without obvious stand reduction at Pt. MacKenzie.

Of three bromegrasses in the Delta trial, 'Polar' brome, which contains indigenous Alaska germ plasm, endured the stressful 1984-85 winter much better than 'Manchar' (possibly Manchurian in origin)

and 'Carlton' brome of Canada.

These results demonstrate the more stressful winter characteristics of Alaska when compared to the Scandinavian countries. Careful selection is necessary when choosing a perennial grass for a forage crop. Differences in latitude, the probability of maintaining a good snow cover throughout the winter, and soil characteristics are all factors for consideration. Varietal differences within a species can be significant, even among entries selected for use at northern latitudes. *Wm. W. Mitchell.*

Two Strains of Reed Canarygrass from Northern Norway Surpass North American Varieties in Winterhardiness

Reed canarygrass is a tall-growing forage grass that is native to both North America and northern Europe. This species is more tolerant of moderately acidic soils and poorly drained conditions than most other forage grasses. It is believed that an adapted, winterhardy reed canarygrass possessing other good agronomic characteristics as well could be useful on considerable acreage of croplands of those types in Alaska. Unfortunately, experimental evaluations in Alaska from 1905 to the present time have demonstrated that all varieties and regional strains commonly grown successfully throughout the conterminous United States and Canada are inadequately winterhardy for dependable use in most agricultural areas of Alaska.

In a cooperative mutual exchange of grass and legume seed lots between Alaska and Norway, two strains of reed canarygrass called 'Hansvoll' and 'Rovik' were received from Norway. These were planted in rows and broadcast plots in the spring of 1984 so they could be compared for winterhardiness with ten United States and Canadian varieties and with several numbered accessions from Sweden, Denmark, and the Soviet Union.

Winter survival differences in spring of 1985 were very dramatic. All of the United States and Canadian varieties sustained very severe winterkill. In contrast, the Rovik and Hansvoll strains from northern

Norway survived the winter very well. Although the winter was not extremely severe from the standpoint of cold stress, it is nonetheless apparent that the strains from northern Norway offer much more winterhardy germ plasm for use in Alaska than is available in North American varieties.

This discovery within reed canarygrass parallels a principle evident in other grass and legumes species: for best winter survival in Alaska, ecotypes, cultivars, or regional strains should be obtained from the northernmost extent of the natural or cultural range of the species, wherever that may occur in the world. This ensures that the crop germ plasm will be inherently adapted to north-latitude seasonal patterns of temperature and photoperiod and the interrelationship of these dominant plant-governing influences. *L.J. Klebesadel.*

Superior Winterhardiness of Alfalfas over Red and Alsike Clovers Confirmed

Two strains of alfalfa, four varieties of red clover (*Trifolium pratense* L.), and fifteen varieties and collections of alsike clover (*T. hybridum* L.) were seeded in rows replicated four times on 18 June 1984. One red clover variety was from Kentucky; all twenty other entries compared were from northern origins that included Alaska, Canada, Iceland, Norway, Sweden, and Finland. When seedlings were 1 to 2 inches tall, rows were thinned to leave seedlings 4 to 6 inches apart for easy identification of individual plants. Rows were 30 feet long and 18 inches apart.

In the spring of 1985, living and dead plants were counted in each row and percent winter survival calculated for each legume. Winterkill was 100 percent with all red and alsike clovers. In contrast, winter survival of an Alaskan strain of Siberian alfalfa (*Medicago falcata* L.) was 99 percent, and survival of 'Denali' alfalfa (*M. sativa* L.) was 98 percent. Denali is a subarctic-adapted variety of the variegated type developed at AFES.

The winter did not impose extreme cold stress on overwintering plants; lowest temperature recorded at the Matanuska Research

Farm was minus 16 degrees Fahrenheit on two consecutive days in February. Freeze-thaw temperature fluctuations were common, however, and very little snow cover was present during most of the winter to insulate plants from prevailing air temperatures.

In seeking to identify or develop dependably winterhardy legumes for use in Alaska, these results suggest that higher levels of winterhardiness are to be found in alfalfas than in red and alsike clovers. *L.J. Klebesadel.*

New Bluegrass Cultivars from North-Latitude Origins Look Good in Preliminary Evaluations

'Lavang' is a cultivar (variety) of Kentucky bluegrass (*Poa pratensis* L.) that has been developed at the Holt Agricultural Research Station near Tromsø (69.6 degrees N) above the Arctic Circle in Norway. 'Dormie' is another cultivar of Kentucky bluegrass selected in Canada from an introduction that originated in the Murmansk area (69 degrees N) at the northern tip of Russia's Kola Peninsula.

Both of these cultivars were included in an experiment comparing numerous grasses in rows planted on 31 May 1984 (six replications). Rows were thinned to individual plants 6 to 8 inches apart at the early seedling stage. The planting was in a location exposed to maximum winter stresses at the Matanuska Research Farm.

In the spring of 1985, living and dead plants were counted in all rows and percent winter survival calculated for each grass. Percent winter survival for grasses were Lavang 100 percent, Dormie 98 percent, 'Nugget' 100 percent, and 'Arctared' 100 percent. Nugget Kentucky bluegrass and Arctared red fescue (*Festuca rubra* L.) are extremely winterhardy cultivars selected and released by AFES. These preliminary, favorable indications of winterhardiness in Lavang and Dormie suggest that both should be evaluated for various uses in Alaska. Foliage of both was free of disease during 1985.

We noted that Dormie showed extremely active vegetative spread from growth of rhizomes (underground stems), considerably more than Nugget, Lavang, or Arctared. This suggests that Dormie may

be useful in plantings intended for revegetation and control of soil erosion. Dormie is reputed to be highly resistant to snow-mold fungus, a frequent problem with turfgrasses in the Tanana Valley area of Alaska. *L.J. Klebesadel.*

Determining Optimum Seeding Rates to Use For Establishing Forage Grasses in Alaska

Much controversy of late has surrounded the setting forth of seeding rates to be recommended to Alaska growers for ideal establishment of forage grasses. Unfortunately, a great many operator, climatic, soil, and other factors influence ideal seeding rates; some of these are controllable, others are not.

When we calculate theoretical distribution of seeds per square foot using the number of seeds per pound in combination with seeding rate, one would tend to recommend much lower seeding rates than we actually need. Conversely, if all soil and weather conditions and operator competence were ideal, we could plant lighter rates than we usually require under our typical, less-than-ideal conditions. Many factors serve to discourage ideal seed germination and seedling survival. Predominant among these is Alaska's normally deficient rainfall during May and June. Added to this is the frequent failure of farmers to perform short-sequence, till-plant operations that minimize loss of soil moisture already present in the soil. As a result, they lose much valuable soil moisture to evaporation during tillage for seedbed preparation, moisture that should be conserved for seed germination and seedling growth.

To use more seed than needed to establish an ideal stand is wasteful; on the other hand, to use less than needed also can be very unwise. Establishment of a thin or uneven grass stand leads to lowered future forage yields and frequently results in the invasion of open spaces by very competitive weeds. The weeds are much less desirable than the grass for forage use; moreover, many can mature seed quickly to cause reinfestation of the soil. Many grow so rapidly that they overgrow and destroy a new grass seeding.

Many costs are incorporated into the preparation and planting of a forage crop in Alaska, as elsewhere. These include operator time, costs of fuel, fertilizers, herbicides, seed, land rental or taxes, equipment rental or depreciation, etc. Failure of a seeding to become well established for future production can represent wasted expense and the loss of several weeks (if replanted) or perhaps an entire growing season.

Costs of seed, compared to all other expenses involved in forage-crop establishment, are generally quite low. To economize in the direction of planting too little seed can be "penny wise and pound foolish." Despite all the uncertainties that can affect grass establishment, it behooves researchers to set forth recommendations based on experience and experimental data that can be used with reasonable assurance of success by growers in Alaska.

A four-replicate experiment planted in May l984 in an ideal seedbed compared 'Engmo' timothy seeded at 2, 4, 6, 8, and 10 pounds per acre (pure live seed basis), and three different bromegrasses, each seeded at 5, 10, 15, 20, and 25 pounds per acre. Very timely rains, more ideal in amount and distribution than usually occur, supplied moisture for seed germination in the weeks just after planting. An herbicide was used to control broadleaf weeds. Seeding-rate effects were evaluated in first-cutting forage yields harvested on 27 June 1985.

In every case except 'Manchar' bromegrass, the highest rate of seeding resulted in highest forage yield. With Manchar, a slightly higher yield was obtained with the 20-pound seeding rate than with the highest rate.

This does not mean that continued increases in seeding rates would increase forage yields, for exceeding the heaviest seeding rates used in this experiment might well lead to excessively dense stands, undesirable extent of interplant competition, and lowered forage yields. *L.J. Klebesadel.*

Devising an Optimum Management "Recipe" For Maximum Bromegrass Seed Production

'Polar' bromegrass has been found to be unusually responsive to certain management practices that influence heading and seed production. Of the major fertilizer elements, nitrogen (N) has been identified as crucially important in fostering increased seed yields. However, when N was applied in the spring of the year of seed harvest (as is commonly done for forage production) there was no increase in numbers of seed heads. Much of the crop was comprised of vegetative, leafy stems that produced no seed heads.

Almost by chance we discovered that N must be applied in the summer of the year *before* the seed crop is desired in order to stimulate production of seed heads the following year. The objective of work now in progress and not completed is to identify precisely the ideal time and rate that N should be applied in one growing season to maximize seed head numbers and, hence, seed yield in the following growing season.

Preliminary results reveal that N application on 29 August 1984 was vastly superior to later applications on 17 September and 1 October in stimulating heading and seed production during 1985. N applied 17 September and 1 October was .5 and .25 as effective, respectively, as N applied 29 August. Preliminary extrapolations indicate that, for each day N application was delayed after 29 August 1984, approximately 5 pounds of seed yield per acre was sacrificed in 1985 yields.

This continuing investigation will evaluate effects of a wider array of application dates and rates to identify optimum N application time and amount. Recommendations derived from future results will provide brome seed growers with information vitally needed to maximize seed yields and monetary returns. *L.J. Klebesadel.*

Fate of Fertilizer Nitrogen in Agricultural Soils in Interior Alaska

A 3-year study was begun in the spring of 1982 to examine the fate of fertilizer nitrogen (N) in an agricultural soil in interior Alaska. The results of this study will be used to make recommendations to farmers concerning management practices to make best use of fertilizer N.

The field portion of the study was completed in 1984. The study was conducted on the AFES research site in the Delta Agricultural Project. The objectives of this study are to 1) estimate gaseous losses of N from soil (i.e. ammonia volatilization and denitrification); 2) determine nitrate leaching losses and, hence, potential pollution of ground water from urea and nitrate fertilizers; 3) measure crop uptake and determine efficiency of fertilizer N utilization by barley plants; and 4) determine net seasonal immobilization and mineralization of N in a field soil.

Two sources of fertilizer N, urea and calcium nitrate, applied at a rate of 90 pounds N per acre, were compared. The effect of fertilizer incorporation versus surface application was also assessed. Urea labeled N-15 was used to determine the fate of fertilizer N. Soil and plant samples were collected throughout each growing season and analyzed for different forms of N.

Most of the soil and plant samples have been analyzed, and the resulting data are presently being compiled and summarized. No losses of N due to ammonia volatilization were detected during any of the three field seasons. In each of the 3 years, all urea had been hydrolyzed to ammonium within two weeks of application. In 1982, nitrification occurred rapidly in the urea plots: within four weeks of application, ammonium had dropped to low levels in these plots, and nitrate levels were similar to those in the nitrate plots. In 1983 and 1984, ammonium levels in the urea plots remained high for 6 to 8 weeks after application, as did total inorganic N levels in the N-fertilized plots. The early part of the 1983 growing season was very

dry, and 1984 was an unusually cool season. These conditions probably slowed the rates of nitrification, immobilization, and plant uptake of N as compared to the 1982 season.

Nitrate levels remained low below the 12-inch depth throughout the study, indicating that little or no leaching of nitrate occurred. Average grain yields of the N-fertilized plots were 49, 63, and 61 bushels per acre for 1982, 1983, and 1984, respectively. There was no difference in either yield or fertilizer-use efficiency between urea and nitrate plots or between plots in which the N was incorporated and those with the fertilizer left on the surface. Each year, whole plant samples harvested at physiological maturity contained approximately 40 percent of the N-15 urea fertilizer that had been applied that season. This indicates that approximately 40 percent of the fertilizer N applied in a given year is used by a barley crop in that year. Further study is being conducted to determine how much of that fertilizer N is used by crops in subsequent years. *S.D. Sparrow and C.W. Knight.*

Anhydrous Ammonia as a Fertilizer for Alaska

Anhydrous ammonia is a very high analysis nitrogen (N) fertilizer and is usually cheaper on a per-unit-of-N basis than are other N fertilizers. Anhydrous ammonia is manufactured in Alaska at Kenai, but at present all of it is shipped out of state and is not available locally. Because anhydrous ammonia is potentially a cheaper source of N than other N fertilizers, Alaskan farmers are interested in using it as a fertilizer for production of small grains. Should demand for anhydrous ammonia become high enough in Alaska, it would be made available to Alaska farmers. For this to happen, however, information is needed on the effectiveness of anhydrous ammonia as a fertilizer in Alaska.

The primary objective of this study is to determine whether the use of anhydrous ammonia as a N fertilizer for small grains is feasible in interior Alaska. The secondary objectives are 1) to compare barley response to anhydrous ammonia with that of urea and ammonium

nitrate, all applied at the same rate of N, 2) to compare barley response to fall-applied anhydrous ammonia with that of spring-applied anhydrous ammonia, and 3) to determine nitrification patterns of anhydrous ammonia in an acid and a neutral soil in interior Alaska.

Two sites in interior Alaska, one on an acid soil near Delta Junction and one on a neutral soil at Fairbanks, were selected for study. Anhydrous ammonia is applied at a rate of 90 pounds N per acre in the fall and in the spring, and urea and ammonium nitrate are applied in the spring, also at 90 pounds N per acre. Barley is used as the test crop. Soil samples are collected throughout the growing season from the plots, and plant samples are collected at physiological maturity. The soil samples are analyzed for ammonium and nitrate to determine the rate of nitrification (conversion of ammonium to nitrate). The plant samples are analyzed for total N in order to determine plant N uptake from the different fertilizers. Also, at the end of the growing season, grain yields and grain N contents are measured.

In 1985, the first year of the study, no differences were noted in grain yield for the different fertilizers and the different application times at Fairbanks. At Delta, anhydrous ammonia applied in the fall produced the highest average yield, whereas spring-applied anhydrous ammonia produced lower yields. Also, plants in the spring-applied anhydrous ammonia plots measured lower than did those in other plots. It is likely that at Delta, the spring-applied anhydrous ammonia was not converted into nitrate in time to produce good plant growth and grain yield, whereas the fall-applied anhydrous ammonia was nitrified earlier and produced relatively good grain yields. Whether or not this is the case will be better known when the soil and plant analyses are complete. These analyses are now underway. The study will continue in 1986.

Should this study show that anhydrous ammonia is a good N fertilizer for production of small grains in Alaska, considerable savings in fertilizer costs could result for the Alaskan farmer. Knowledge of the nitrification rates of fall- and spring-applied anhydrous ammonia will lead to efficient management practices for this fertilizer in interior Alaska. *S.D. Sparrow.*

Extraction of Phosphorus from the Major Agricultural Soils of Alaska

The crop land in Alaska has increased five-fold in the past 10 years. The agricultural soils in this large state vary considerably from volcanic ash to loess-derived soils. The phosphorus(P)-sorption capacities of the soils also are known to vary widely, but little data are available on the nature of soil P and the performance of P extractants on these soils. A laboratory and growth chamber study was conducted to investigate the suitability of seven P extractants for use on Alaska's agricultural soils. Ten representative soils were collected from the agricultural regions of Alaska: five were volcanic ash derived, and five were loess derived. Response of barley (*Hordeum vulgare* L. var. 'Weal') to soil test P levels was determined in the growth chamber. Soil P levels were established from P-isotherm curve data and soil P levels were determined using Morgan, Bray 1, Bray 2, Mehlich 1, Mehlich 2, Mehlich 3, and Olsen extracting reagents.

The volcanic ash soils contained 47 percent more native P and had P-sorption maximas 157 percent higher than the loess soils. The volcanic ash soils required over four times the P applied for maximum yield than the loess soils. Oxalate extractable (amorphous) iron (Fe) plus aluminum (Al) was highly correlated to P-sorption among the ten soils. The Mehlich 3 extractable P at maximum yield was most highly correlated with oxalate Fe plus Al, followed by Bray 1 and Mehlich 2. The Morgan extractable P was the lowest of all extractants for all soils and P-addition levels. Mehlich 3 extractable P correlated well with yield for the soils. Mehlich 3 test levels to attain maximum yield were highly correlated to oxalate extractable Fe plus Al. Extractable P by Olsen and Bray 1 extractants was most variable over the ten soils. It was concluded that the Mehlich 3 extractant is both suitable and desirable for use due to its high correlation to percentage maximum yield and the predictability of desired soil test P levels with soil oxalate extractable Fe plus Al. Additionally, Mehlich 3 holds potential for future use as a multielement extractant. *C.L. Ping.*

Phosphorus Sorption by Major Agricultural Soils of Alaska

Surface soils from ten soil series representing five great groups were collected from Alaska. These soils were selected from the important agricultural areas covering a wide geographic distribution. These soils can be divided into two distinct groups based on their parent material: loess and volcanic ash. Phosphorus (P) sorption maxima were calculated based on the Langmuir isotherms. The volcanic ash soils (Cryandept and Cryorthods) showed an average P-sorption maxima of .15 ounce per pound and loess soils averaged .06 ounce per pound. Both groups have similar portions of P in the organic form (19 percent) and occluded form (8 to 9 percent). The nonoccluded P in the volcanic ash soils and the loess soils was 68 and 43 percent, respectively, and the calcium-P was 4 and 29 percent, respectively.

Regression analysis indicated that aluminum (Al) and iron (Fe) are primarily responsible for P sorption. The dithionite extractable Al is responsible for P sorption in volcanic ash soils, while oxalate extractable Al is responsible for P sorption in loess soils. Dithionite and oxalate extractable Fe probably play a secondary role in P sorption. The sorption isotherm, regression analysis, and the P-fractionation data provide the agronomist with useful information to estimate the P requirement of newly cleared soils. *C.L. Ping.*

Soil-Fertility Requirements for Crop Production In Cold Climates

Four years of experimentation with the addition of potassium (K), phosphorus (P), and lime to barley at Pt. MacKenzie were concluded in 1985. Soil K levels were sufficient the first year after clearing, but

significant response to added K was observed each year thereafter. The 19.6- and 39-pounds-K-per-acre rates resulted in the largest yield increases each year for limed and unlimed plots, respectively. Over the four years, highest yields were obtained with the addition of 19.6 pounds K per acre with 9.8 tons lime per acre. Initial extractable soil K levels were maintained with the annual application of 58.7 pounds K per acre, although total K removed by barley exceeded replacement by nearly 53.4 pounds K per acre. After the first 2 years of cropping, the soil pH dropped 0.46 units without liming; 9.8 tons lime per acre maintained the initial soil pH.

Barley forage yield responded to increasing P rates over the first 3 years of cropping. Response to P additions up to 26.7 pounds per acre were observed the first year, increasing to over 40 pounds P per acre by the third year. On soils with an initial pH of 5.5 or lower, pH drop due to cropping and fertilization may become limiting to barley growth. Seasonal precipitation was found to be highly correlated to overall yield level for the period of study. Forage tissue K concentration was increased by K additions and decreased by P additions. Liming increased tissue Ca contents at the higher rates of P addition. Overall liming increased yields an average of 45 percent. *C.L. Ping.*

Evaluation of Methods for Extracting Adenosine Triphosphate from Alaska Soil and Litter

The adenosine triphosphate (ATP) content of soil is often used as an index of the mass of living microorganisms (microbial biomass) in soil. The soil microbial biomass acts as a repository of many plant nutrients in the soil. Therefore, a knowledge of the size of the microbial biomass is needed in order to understand better the cycling of many plant nutrients in the soil.

The measurement of the ATP content of the soil is considered to be one of the most reliable and simplest methods for determining the soil microbial biomass. The main problem for researchers attempting to measure ATP in soil is that there is no method for ex-

tracting ATP which is efficient for all soils. Numerous methods have been devised for extracting ATP from soil, but none of these has been tested in Alaskan soils. We decided to test six different methods for extracting ATP from an Alaskan agricultural soil, a taiga soil, and a tundra litter. These methods were chosen for testing because they have been shown to be efficient in other soils, they are widely used by researchers, or they are quick and simple. We also tested our own modifications with some of these procedures. Of the methods tested, two seem to be most efficient for extracting pure ATP and cellular ATP from the soil. Both of these procedures use a strong acid and a detergent for extracting the ATP. We are attempting to make adaptations to these methods to make them more usable for Alaskan soils and litter.

This research will lead to the development or adoption of a method for extracting ATP for soil. This will aid researchers who are studying the role of microorganisms in Alaskan soils. *S.D. Sparrow.*

Fertility Effects on Ryegrass at Pt. MacKenzie

Two ryegrasses, common annual and 'Aubade', a Westerwold type, were grown at four fertilizer rates at Pt. MacKenzie in 1984. Both ryegrasses were profusely heading types. Fertilizer was applied as 18-18-18 at 200, 350, 500, and 650 pounds per acre when plots were seeded; all plots received 90 pounds nitrogen (N) per acre as urea after the first harvest, preparatory to a second harvest. The trial was repeated in 1985 utilizing the same plots fertilized at the same rates. However, the cultivar 'Terli', a leafy type of ryegrass, was substituted for common annual.

The first fertilizer increment, from 200 to 350 pounds per acre, increased first-harvest yields about 0.40 ton per acre in both years. Each succeeding increment was much less effective, increasing yields less than 0.10 ton per acre in the first harvest. In the second harvest, the first fertilizer increment increased yields about 0.15 ton per acre and each succeeding increment about 0.10 ton per acre. Total dry matter yields equaled about 2.00 tons per acre at the lowest

fertilizer level and 2.75 tons per acre at the highest level. The Westerwold type, Aubade, exceeded common annual in yield in 1984. In 1985, Aubade exceeded the leafy variety Terli in the first harvest; they about equaled each other in the second harvest. The leafy type produced much more grazable regrowth after the second harvest than did the Westerwold type.

N contents of 1984 first-harvest herbage were positively related to amount of fertilizer applied. Phosphorus (P) and potassium (K) contents also were positively affected, at least through the 500-pounds-per-acre level. Crude protein levels ranged from about 6.5 percent for herbage fertilized at 200 pounds per acre to 11.5 percent for herbage fertilized at 650 pounds per acre. The first harvest was taken when the ryegrass was in the fully headed to anthesis stage, later than it should have been for good quality.

With all plots receiving 90 pounds N per acre prior to the second harvest, N concentration of second-harvest herbage did not vary according to initial fertilizer treatments, nor did P and K concentrations. Crude protein contents of second-harvest ryegrass, cut in the head-emergence stage, varied from about 14.8 to 16.9 percent.

In a separate trial testing the effects of sulfur(S) on three ryegrasses, applications of 20 pounds S per acre failed to produce any increases in yield or in plant quality.

An application of about 350 to 400 pounds per acre of a fertilizer such as 18-18-18 or 20-20-15 is indicated by this research in order to produce good first-harvest yields of ryegrass at Pt. MacKenzie. Higher applications may be justified to produce small increases in yield, depending on the value of the enhanced quality effected by these increases. *Wm. W. Mitchell.*

Phosphorus-Level Effects on Establishment of Perennial Grasses at Pt. MacKenzie

The soils in the Pt. MacKenzie Agricultural Project area have been determined to be high phosphorus (P)-fixing soils, owing in part at least to their volcanic ash content and often their low pH (relatively

high acidity). The soils vary in pH from about 5.2 to 6.0, which is a critical range with respect to the adaptability of a number of plants. This same pH range is also critical in terms of P availability. Below pH 5.5, P fixation increases sharply. In the absence of lime, increasing application rates of P is the only avenue available to optimize yields of perennial forages. Preliminary work with cereals for forage production at Pt. MacKenzie has shown responses to P, but a clear definition of P rates required to meet sufficiency levels for perennial grasses is lacking for the Pt. MacKenzie area soils.

Bromegrass is sensitive to low pH soils and has been an uncertain performer at Pt. MacKenzie. First-harvest yields, in particular, have been below those of a number of other grasses. Improvement of growth has occurred in mid- to late summer, possibly in response to an amelioration of antagonistic factors with the warming of the soil. In some plots, however, stand reductions have resulted in deterioration of yields.

A trial was established in 1985 to test the response of 'Manchar' bromegrass, 'Engmo' timothy, and reed canarygrass to four rates of P with nitrogen (N) and potash applied at 90 and 80 pounds per acre, respectively. Phosphate (P_2O_5) was applied at 40, 80, 120, and 160 pounds per acre, supplying 17.6, 35.2, 52.8, and 70.4 pounds of P per acre, respectively.

In the overall treatment effects, 80 pounds P_2O_5 produced a significant 57 percent increase in yield over the 40-pound treatment, and 120 pounds significantly increased yields 35 percent over the 80-pound treatment. The 160-pound treatment did not increase yields over the preceding treatment level. The 120-pound treatment increased yields significantly over the lower-level treatments for each grass. Reed canarygrass, the highest yielder, produced from 1.29 to 2.24 tons per acre of dry matter over the range of treatments; Engmo timothy produced 0.58 to 1.20 tons per acre; and Manchar bromegrass produced from 0.15 to 1.04 tons per acre.

These results showed a definite response to increasing levels of P up to 120 pounds P_2O_5 per acre in the year of establishment. They also indicated over 2 tons dry matter per acre can be obtained of reed canarygrass in the year of seeding. Samples have been submitted to the laboratory for analysis to determine possible fertilizer

effects on plant quality. The same fertilizer treatments will be applied in succeeding years to determine cumulative effects on yields and quality of forage and on the potential build-up of soil-test P in the very high P-fixing soils. *Wm. W. Mitchell.*

Effects of Livestock Grazing on Soil Fertility

Alaska's bluejoint reedgrass rangelands annually produce 1500 to 3500 pounds per acre of forage. In the absence of some removal process, i.e., grazing, mowing, burning, that forage accumulates as litter at the soil surface. Decomposition changes the litter to humus, thereby releasing a portion of its mineral nutrients. Those humus and litter layers can be likened to a fertility reserve in the soil, holding and providing mineral nutrients for seasonal plant growth. The rate of nutrient release is governed largely by temperature and moisture; and the amount released is governed by length of the growing season. Because Alaska's climate is cool and its growing season short, litter and humus build faster than decomposition; hence, a balance favoring organic matter and peat formation usually predominates.

Questions of how livestock grazing affects the soil fertility balance in such ecosystems prompted an investigation. A typical, ungrazed, bluejoint grassland on the lower Kenai Peninsula was sampled during the first week of September. A like portion of the range which had been fenced and grazed heavily (.87 acres of grassland allocated per 500-pound beef cattle yearling for 90 to 100 days per year for 5 years) was simultaneously sampled. Twelve cores, 5.75 inches in diameter, were collected from soils in each of the two units and separated into respective litter, humus, and underlying mineral portions. The subsamples were ultimately dried, weighed, and analyzed for available nitrogen (N), phosphorus (P), and potassium (K). Organic matter, pH, and total N were also measured.

Data for litter and humus fractions were examined for both concentration and absolute amount. This study revealed the magnitude of alterations in soil fertility for short-term heavy grazing of a relatively

pristine boreal-zone grassland. Most changes amounted to losses of .25 to .5 of the factors measured. Organic matter, total N, and available P were affected to the greatest degrees. Available N and K were affected to lesser degrees. A tendency for mineral soils to increase in acidity while overlying litter and humus decrease with grazing suggests that some of these nutrients may have moved to deeper soil horizons. Only available P, however, was somewhat elevated in mineral soils of the grazed unit. Because P is a relatively immobile soil nutrient, that observation remains suspicious. The treatment duration and study were too short to identify the soil's fertility equilibrium for long-term livestock grazing.

Future studies should include a re-examination of these two sites in order to measure any changes following the removal of livestock grazing. Other studies should involve an array of grazing intensities including intermediate levels between no grazing and heavy grazing. Variability estimates indicated that ten soil cores was an adequate sample for the two units in this investigation; however, grazing uniformity for light and moderate stocking rates on bluejoint grasslands is relatively low. Adequate sampling of those treatments may, therefore, require larger sample sizes than those used in this study.

An investigation identifying where quantities of nutrients that disappear from the litter and humus layers relocate is certainly in order. Of equal importance is documenting bluejoint grassland resiliency under the influences cattle grazing. *J.D. McKendrick.*

Characteristics and Feed Value of Barley and Western Protein: Supplements for Swine

In a regional cooperative study, the protein quality of Alaskan crab, halibut, salmon, and two herring meals are being evaluated for chemical composition and feeding value. The two herring meals were produced from, and are therefore representative of, two on-board fishing vessel methods of herring preservation prior to processing for roe at a shore-based facility. One method is the salt packing of

herring carcasses while the second is a frozen method of carcass preservation. Following removal of the roe, the carcasses are ground, cooked, oil extracted, and dehydrated. The resulting meals have significantly different levels of salt. It was of interest to determine if the salt content may affect feeding value of the two herring meals.

Proximate and amino-acid composition have been completed and rat-feeding trials are in progress to determine protein efficiency ratios, biological value, digestibility, and growth performance. Percent crude protein, fat, ash, and calcium on a dry-matter basis for crab, halibut, salmon, herring plus salt, and low-salt herring meals were: 32.4, 3.6, 41.3, 11.9; 51.2, 19.4, 22, 8.5; 62.9, 13.5, 15.9, 4.2; 65.3, 11.3, 16.1, 5.9; and 69.2, 13.3, 14.6, 4.6, respectively. Since salt can lower the feeding value of fish meals, the salt content was estimated from sodium analysis for crab, halibut, and salmon meals at 5.4, 1.6, and 4.3 percent, respectively. Herring plus salt and low-salt herring meals contained 5.9 and 1.3 percent, respectively. Of the essential amino acids, tryptophan was the only one not determined, and the content of the most important amino acid, lysine, of the five meals was 1.2, 3.5, 3.0, 5.8 and 5.4 percent for crab, halibut, salmon, herring plus salt, and low-salt herring meals, respectively. The methionine-cystine content of the five meals was 2.3 percent, as was the threonine level.

Although the high salt level was expected in the herring plus salt, additional samples of crab and salmon meal should be analyzed for salt, since levels above 4 percent in those two meals are not routinely reported. When salt exceeds 4 percent, the level of fish meal inclusion in livestock diets should be reduced to limit salt intakes. With the exception of low lysine in the salmon meal, all amino acids compare favorably with those reported in the literature, and lysine and sulfur amino acid levels for these fish meals would indicate that the Alaskan meals are typical of the high-quality protein expected in fish meals as protein supplements. *F.M. Husby.*

Improving Dairy Cattle through Breeding with Special Emphasis on Selection

Although milk sales are the primary source of income on most commercial dairy farms, dairymen often consider transmitting ability for other traits when selecting sires for use in dairy breeding programs. These might include stature, mammary traits, and feet and legs. Multiple-trait selection, however, will reduce the expected genetic gain for individual traits. Consequently, if nine traits, including milk production, are considered, one would expect to make less genetic progress for milk production than if milk production were the only basis for selection.

This experiment was initiated in 1968 to study single-trait selection for milk production and consequences on other traits ignored in selection. Two groups of dairy cattle have been generated in the AFES herd using sires transmitting either average or superior milk production. After six generations of selection, 75 cows in the high group and 114 cows in the average group have completed first lactation. Average milk production in the high group has been 15,440 pounds per lactation; production in the average group has been 13,618 pounds per lactation. Milk from the high group averaged 3.14 percent fat; the average group averaged 3.70 percent fat. Group differences in animals size and conformation have been small, although animals within both groups appear to be smaller at comparable ages in later generations than those in earlier generations. It appears that type scores will not be improved without placing some emphasis on transmitting ability for desirable type characteristics in sire selection. *L.B. Bruce.*

Acceptability of Straw and Salmon Meal in Rations for Milk Production

Alaskan roughages used in diets for dairy cattle include grass and small-grain crops which are relatively low in crude protein (CP), often 10 percent or less. Consequently, concentrates used in these rations for lactation must be 18 percent CP or higher to achieve approximately 16 percent CP in the total diet. In this study, thirty holstein cows in weeks 3 through 19 of lactation were fed one of fifteen different rations in a 3 by 5 factorial design. The first factor was roughage: 100 percent barley/oat silage, 50 percent barley/oat silage plus 50 percent strawmix (a straw, beet pulp, molasses, and mineral mixture), or 100 percent strawmix. Soybean meal was replaced with salmon meal as the major protein source in the concentrate. Replacement was 0, 25, 50, 75, or 100 percent. Milk production, percent fat, and 4 percent fat-corrected milk were unaffected by any of the rations. Animal weight was also unaffected. One more group of fifteen cows will be added to this study in 1985-86.

A total of forty holstein heifers and forty holstein steers have been fed the five concentrate diets listed above, in groups of four, from 8 weeks to 1 year of age. No differences have been found for weight, wither height, or paunch and heart girth among animals that have completed the trial to date. *L.B. Bruce.*

Plant and Marine Waste Complementarity In Dairy Cattle Rations

Dairy cattle require high levels of protein in their feed to maintain milk production. Alaska's roughage sources are low in protein, 7 to 10 percent crude protein (CP), compared to such roughages as alfalfa with 17 percent CP. Therefore the concentrate portion of the Alaska dairy cow's diet must be high in protein as well as energy.

Alaska salmon meal, at 60 percent CP, is a considerably more concentrated protein source than soybean meal at 48 percent CP. The relatively high level of oil in salmon meal, compared to plant meals, also adds energy to the ration. There has been concern, however, that this oil will cause a reduction in the fat content of milk produced from cows fed concentrates containing salmon.

Our study is designed primarily to determine the effects of replacing soybean meal with salmon meal in the dairy cow's concentrate. We have placed cows on five different concentrate rations with 0-, 25-, 50-, 75-, or 100-percent replacement of soybean meal with salmon meal. A total of forty-five cows will be studied over a period of 3 years. Fifteen cows have completed the first year on the experimental rations. Preliminary and unanalyzed data from three cows per concentrate suggest that there are no differences in milk production or fat content across concentrates. Over the next 2 years, the data from thirty more cows will be added. Additionally, laboratory feed and weighback analyses will quantify any differences in intake between the experimental concentrates.

Next summer we will augment our main lactation study with an intense study on twenty Holstein cows. This will include five cows in each of four treatment groups in a 2 by 2 factorial: 1) salmon meal as the only protein supplement fed 2 weeks prepartum to 4 weeks postpartum then switched to soybean meal for 6 weeks; 2) soybean meal as the only protein supplement fed 2 weeks prepartum to 4 weeks postpartum then switched to salmon meal for 6 weeks; 3) salmon meal as the only protein supplement for the entire period; and 4) soybean meal as the only protein supplement for the entire period.

In a second phase of our study, eighty Holstein calves (forty steers and forty heifers) will be raised from 8 weeks to 1 year of age on the same experimental concentrates as those used for the lactating cows. Twenty heifers and twenty steers are now on these rations. These animals are weighed and measured monthly to study any differences in growth related to the experimental concentrates.

Finally, in the second and third years of the study, forty yearling Holstein steers will be finished for slaughter using either salmon meal or soybean meal as a protein source in the finishing ration. *L.B. Bruce.*

Digestibility of Sled Dog Diets Containing Alaskan Hulless Barley and Herring Meal

The United States pet population and pet food industry has expanded significantly in the last two decades. Present dog and cat population estimates are 49 and 50 million, respectively. More than 5 million tons of pet food is produced annually at a value of $5 billion. The value of dog and cat food has increased from $2.6 billion in 1976. Since approximately 20 percent of the US pet food production occurs in Illinois, the ingredients are predominantly corn, soybean meal, meat meal, meat and bone meal, chicken by-products, animal and poultry fat, and beet pulp.

Recently, dog sled racing has been officially named Alaska's state sport. In 1981, the Fairbanks North Star Borough animal shelter estimated there were 60,000 dogs in an area populated with 57,000 people. The average 40-pound dog requires about 1 pound of dog food to maintain its body weight. However, a sled dog racing in the coldest winter months may require 3.5 times the maintenance level, and it has been estimated that dogs on the long-distance race, the "Iditarod Trail," may consume seven times their maintenance requirement.

Barley and fish meals have been available in Alaska as substitutes for meat and bone meal and corn in dog diets, but no information has been reported on the digestibility of these ingredients in the literature. A hulless barley 'Thual' has been developed in Alaska, but the feeding value for livestock and dogs has not been previously determined.

This study was designed to compare the digestibility of three dog diets formulated with barley as the carbohydrate source, herring meal as the main protein source, and human-quality pork lard as the major energy source. Two diets were formulated with Thual barley and the third with a covered barley. All diets were processed by dry extrusion, and one of the Thual barley diets had the barley extruded twice. All diets were formulated to contain 30 percent crude protein

and 20 percent fat and were balanced to provide minerals, vitamins, and fiber. Two commercially available high-protein, high-fat diets for working dogs were included as positive control diets. Three sprint and three distance mature sled dogs averaging 50 pounds of body weight were allotted to individual pens on solid concrete floors. With the exception of one commercial dog food fed at 15 ounces daily, all test diets were fed at 12 ounces daily each morning with free-choice water. A 6-day diet adjustment period was followed by a 5-day total fecal collection period. Feces and dietary samples were dried at 220 degrees Fahrenheit, and dry matter digestibilities were calculated.

Percent dry matter digestibility for the Thual barley, double-cooked Thual, covered barley, and two commercial diets were 77.4, 80.4, 73.2, and 75.5 percent, respectively. The covered barley diet had a lower digestibility than the Thual barley diet that contained double-cooked Thual barley. All the barley diets contained greater than 50 percent barley plus herring meal and were comparable to the commercial diets containing corn, meat meal, or chicken by-products. Hulless barley would be preferable to a hulled barley but double cooking to improve starch gelatinization did not significantly improve the digestibility of the total mixed diet. However, the barley nitrogen-free extract (sugars and starches) was improved by double cooking. These trials would indicate that Alaskan barley and herring meal at the levels tested can be successfully included in the diet of a mature working dog. *F.M. Husby.*

Beef Production in Alaska

Feedstuffs grown in Alaska are typically deficient in selenium. A study was conducted with ten head of Alaskan beef cows during the winter of 1985 to compare two methods of selenium supplementation. The cattle were pastured the summer of 1984 on grasses with low selenium content. For the winter season, the cattle were gathered and blood samples taken. Blood analysis for selenium showed the average content to be 20 parts per billion (ppb). The normal is about

100 ppb. The cattle were then split into two groups, one fed a ration containing .5 pounds per head per day of selenium-rich soybean meal and the other group a ration composed entirely of selenium-deficient Alaskan feeds. Three of the cows in each dietary group were then rejected once a month with 10 milliliters of injectable selenium.

The cattle were weighed and blood samples taken monthly. Dietary intake was closely monitored. The feeding and injections began in mid-December and carried through until April. During that time period, the monthly injections of selenium raised the selenium content of cow blood to 70 ppb, and the soybean meal raised blood levels to 50 ppb. These treatments improved the cows' selenium status, but they were still below the desired level of 100 ppb. The study shows that selenium can be successfully supplemented with a selenium-rich dietary supplement or by injection, but further research needs to be conducted to determine the correct supplementation levels. *L.B. Bruce.*

Mathematical Evaluation of the California Net Energy System

Use of net energy to balance beef cattle diets for specific intakes and average daily gains is difficult because feeds are utilized differently for maintenance and gain. Rations balanced on net energy for gain (NEg) only, on an average of NEg and net energy for maintenance (NEm), or on a weighted average of NEg and NEm are approximations which may be erroneous. Coefficients were derived for use in the quadratic formula which precisely calculates percentages of two feeds needed to meet required NEg and NEm.

The first feed is solved directly by the quadratic formula, and the other feed is solved by subtraction. Comparison of diets balanced with the quadratic method to NEg only, total digestible nutrients (TDN), NEg and NEm averaged, and a weighted average of NEm and NEg shows the quadratic to be the only method to give precise answers. TDN and averaged NEg and NEm provide accurate formulations for only a few dietary cases. Using only NEg for formula-

tion provides more accurate percentages than TDN or NEg and NEm averaged. Weighted average is best approximation to the quadratic, but requires accurate estimates of level of feed intake and the level of intake above maintenance relative to maintenance. The quadratic form requires only an accurate estimate of intake and provides precise feed percentages for the net energy system. *L.B. Bruce.*

Applied Reindeer Management

The University of Alaska-Fairbanks continues to work closely with the Alaska Reindeer Herder's Association (RHA) in providing research, instruction, and extension. This working relationship has existed in this program since RHA secured legislative appropriations for applied reindeer work. Following the suggestion of RHA, much of the resources previously going into range research are being shifted into animal health, animal stress, and economic issue research.

Two animal health areas received major effort this year. First was the continuation of reindeer treatment with the injectable drug Ivermectin to prevent internal parasites. An additional 10,000 or more reindeer were treated this year. The second area focused on brucellosis and consisted of two major efforts. During the summer of 1985, over 80 percent of one large herd was injected with an experimental brucellosis vaccine, with the remainder of the herd to be treated during the 1985-86 winter. This second effort involved moving twenty-five reindeer from the Seward Peninsula to Fairbanks so that their resistance to brucellosis could be assessed following their vaccination some 40-plus months before.

A major effort in the area of reducing handling stress focuses on building and evaluating two fawn separators at two locations in the spring. The concept is to separate mechanically, fawns from adults as they move into a corral system. This has been done previously by hand with increased stress on all animals and injury and/or loss of fawns. Another project in stress management consisted of modi-

fying the pneumatic antler cutter blades so that they accept large antlers.

The marketing area received a boost in assisting RHA to establish a marketing cooperative which may hold sales during the 1986 season. Significant effort has gone into a computerized record-keeping system for individual reindeer. During this past year, programs have been written which allow analysis of the data for both health and management decisions. Renewed interest in meat sales has resulted in a major effort to look at field slaughter and inspection needs. This area will continue to be a priority in the next year or two. *A.C. Epps.*

Epidemiologic, Pathogenic and Serologic Investigations of Brucellosis in Alaska

Brucellosis is endemic in the herds of reindeer, caribou and their predators in Alaska. The disease is caused by *Brucella suis* type 4 and is specific to circumpolar areas of the world. The organism has been isolated from reindeer, caribou, bears, fox, and sled dogs plus there is serological evidence of the disease in arctic ground squirrels, seals and polar bears. The organism appears of be widespread and survives well in an Arctic environment. Control of the disease is being attempted by the use of a vaccine developed by our laboratory and the USDA laboratories at Ames, Iowa. This killed homologous vaccine in adjuvant has demonstrated good protection in the laboratory and is currently being tested in 3,500 reindeer on the Seward Peninsula of Alaska. Control of brucellosis in reindeer will aid in the development of the reindeer industry which is an important part of the Native peoples' income in Alaska. *R.A. Dieterich.*

Digestibility of Tanner Crab Meal and Chitin by Cattle

Previous research at AFES determined that crab meal could be an effective protein supplement for cattle rations. Additional studies indicated that chitin, a polysaccaride in crab shell, was a fibrous component of shellfish meals and that, following a diet adaptation period, rumen microorganisms may adapt to a diet containing chitin. Results from both *in vivo* nylon bag and *in vitro* two-stage digestion techniques indicated that protein and chitin were utilized by rumen microflora. Chitin digestibility determined by both methods was only about 2.5 percent in cattle that had not previously been exposed to crab meal diets but increased to 20.8 percent in cattle following a 6-week, crab meal diet adjustment period. However, shellfish meals contain approximately 21 percent chitin, and the results only reflected the rumen phase of the digestive tract. Therefore, a second study was designed to determine the total digestion of crab meal and crab meal chitin.

Digestibility of tanner crab meal and bromegrass hay fed to four fistulated beef cattle was determined using lignin as an internal digestibility indicator. Enzyme assays to determine chitinolytic activity were performed on tissue removed from the digestive tract of six head of cattle fed crab meal plus barley or bromegrass hay plus barley. There was no significant difference in the acid detergent fiber or crude protein digestibility between crab meal or hay diets, respectively. Chitin digestibility, calculated from acid detergent insoluble nitrogen, was not increased following a diet adaptation period. Slight to negligible chitinase enzyme activity was recorded in rumen wall and cecal and rumen fluid. Chitinase activity was greater in the abomasum, and only moderate amounts were detected in the duodenum and pancreas.

These results would indicate that, under the conditions of this study, chitinolytic enzymes in the rumen were too dilute to have any effect on the breakdown of tanner crab meal chitin. The earlier study may have had the effect of concentrating chitin-degrading microorganisms in the nylon bags or *in vitro* incubation flasks, and

that, in the whole rumen environment utilized in this study, the microorganisms had sufficient nutrients supplied from other dietary sources and did not preferentially utilize chitin. These two studies may indicate that chitin-utilizing microorganisms are inducible and that crab meal may be more efficiently utilized in marginally adequate diets. *F.M. Husby.*

Cooperative Feed-Testing Service

During the past year, 119 feed samples submitted by farmers have been analyzed for nutrient content including dry matter, crude protein, calcium, phosphorus, acid-detergent fiber, and *in vitro* dry matter disappearance. Metabolizable energy is calculated from these data for each sample. Results are reported on an as-received and dry matter basis. AFES returns results to the submitting farmer and to Cooperative Extension Service personnel. This program is providing researchers and extension agents with base values for many of the feeds grown in Alaska.

The number of samples analyzed last year dropped slightly, from 140 in 1984 to 119 in 1985. This may be because the AFES laboratory did not accept samples in June or July as equipment was being moved to the new laboratory at the Matanuska Research Farm. June and July, however, are traditionally months with very few requests for analyses. Over 70 percent of the samples received were roughage. Thirty-four percent of all samples were received in September (sixteen samples) and October (twenty-five samples). Sixty-one percent of the samples were submitted through the Matanuska-Susitna CES office. *L.B. Bruce.*

Matanuska Valley Breeders' Association

The Matanuska Valley Breeders Association (MVBA) is a nonprofit corporation, organized by Alaska's dairymen in 1948 to increase the genetic potential of dairy herds by using the superior sires available through artificial insemination. MVBA makes available semen from both dairy and beef bulls. In 1985, MVBA became the state organization responsible for Dairy Herd Improvement, a national program maintaining production records through monthly milk testing. The extension responsibilities for this program is handled by the Cooperative Extension Service, and the day-to-day functioning of the program is done by MVBA's board of directors.

The AFES dairy scientist serves as the manager of MVBA, handling monthly billings, payments, and ordering supplies and semen. Animal sciences personnel provide breeding services as well as delivery of semen, liquid nitrogen, and artificial-insemination supplies. In the past year these technicians have gone on breeding calls for 305 dairy cows and 34 beef cows, not including those in the UAF herd. They have also delivered 3,230 units of semen and refilled eight liquid-nitrogen refrigerators approximately every 4 days. *L.B. Bruce.*

Alaska Crop and Livestock Statistics

The Alaska Crop and Livestock Statistics Program is a cooperative effort of AFES, USDA Statistical Reporting Service, the Alaska Division of Agriculture, and the University of Alaska Cooperative Extension Service. The program compiles agricultural statistics disseminated by the Alaska Crop and Livestock Reporting Service, PO Box 799, Palmer, AK 99645, for use by farmers and agricultural agencies. AFES assists by supplying technical help, climatic data, and product information. *S.H. Restad.*

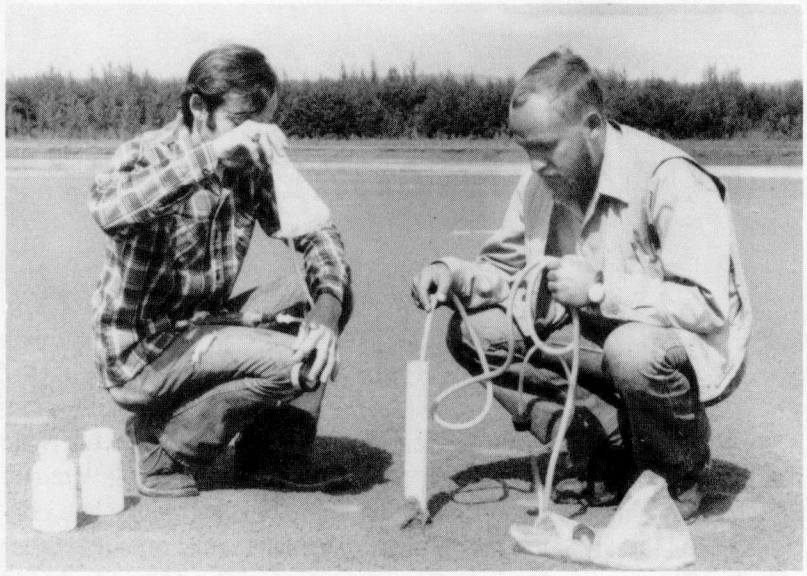
The forest floor is a key component controlling nutrient flow in forest ecosystems. The sampling illustrated in this photo is designed to evaluate short-term changes in forest floor chemistry of nitogen (ammonium and nitrate) and to relate nitrogen flow to forest floor decomposition processes.

Forest Management

The Forest Soils Laboratory

The principal objective of research conducted by the Forest Soils Laboratory at the Agricultural and Forestry Experiment Station is to evaluate the importance of physical, chemical, and biological controls of soil fertility in the productivity of forest ecosystems in interior Alaska. The interior forests of Alaska offer unique opportunities to examine forest development. Located at relatively high latitude (north of 60 degrees north latitude), these ecosystems experience greater extremes of climate than forests encountered in other geographic regions of North America. Seasonal temperatures may range over nearly 130 degrees Fahrenheit, from winter lows of 40 degrees below 0 Fahrenheit to summer highs near 90 degrees Fahrenheit. Day length varies from less than 4 hours on December 21 to more than 21 hours on June 21. Mean annual air temperature at Fairbanks is about 27 degrees Fahrenheit. Because of the cold regional climate, soil temperature also is cold. In locations where annual soil temperature is less than 30 degrees Fahrenheit, perennially frozen soil, or permafrost, occurs. In the forested zone of interior Alaska, permafrost is discontinuous in distribution. It is encountered on cooler north aspects and in poorly drained lowland locations. In addition to low temperatures, the region receives relatively low precipitation compared with other forested regions—approximately 11 inches per year. This is due to its northern location as well as its being in the shadow of the Alaska Range.

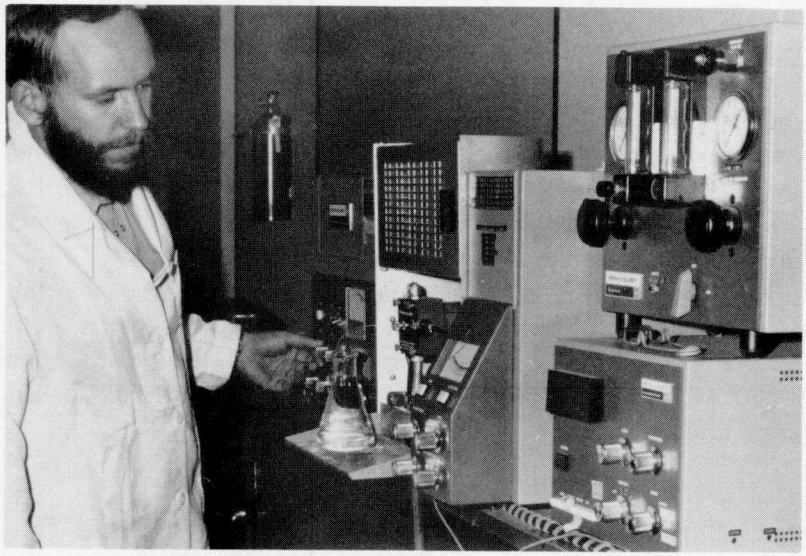
Interior Alaska displays the characteristics typical of a continental climate with the added feature of long day length combined with warm air temperatures during the growing season. The result is forest pro-



Graduate student training is an important component of research programs at the Agricultural and Forestry Experiment Station's Forest Soils Laboratory. Here, students are obtaining a sample of the soil solution from the time zero stage of the primary successional vegetation sequence on the Tanana River floodplain near Fairbanks.

ductivity which, on certain sites, compares favorably with that encountered in forests at more temperate latitudes. The research challenge is to understand how the unique environmental controls, especially the supply of nutrients and water from the soil, affect forest productivity.

We have taken an ecosystem approach to studying the question of soil control of forest productivity. As an index of the structure and function of forest system, the distribution and cycling of chemical elements important in plant nutrition have been examined. The work has been conducted in examples of each of the major forest types in interior Alaska. These research efforts have been multidisciplinary in order to address the most important questions concerning controls. Because of the relatively small number of workers, the research also has been conducted on an interagency basis. Research groups which have cooperated in the work include: The Institute of Northern Forestry, USDA Forest Service; Bureau of Land Management; Fort



Chemical analysis of water, soil, and plant tissue is carried out in support of research projects dealing with productivity and nutrient cycling in interior Alaska forest types. Above, a soil solution sample is analyzed for the major macro- and micronutrient metal ions using atomic-absorption spectrometry and direct-current plasma emission spectrometry.

Wainwright, US Army; and the Institutes of Arctic Biology and Marine Science, University of Alaska, Fairbanks.

Results of this research show that productivity among the major forest types in interior Alaska is strongly related to soil temperature. Black spruce is encountered at the cold end of the spectrum followed by white spruce, paper birch, and quaking aspen on increasingly warmer soils. Net annual above ground tree productivity increases from a low of 625 pounds per acre in black spruce to about 3.5 tons per acre in quaking aspen.

In addition to the temperature control of forest productivity, our results indicate that nutrient element cycling and, consequently, soil fertility also increase in conjunction with increasing soil temperature. Thus, black spruce forests are encountered on the most nutrient-deficient soils compared with white spruce, birch, and aspen forests.

The Forest Soils Laboratory in conjunction with the Institute of Northern Forestry has assumed a coordinating role for much of this

research. Long-term funding has come from the McIntire-Stennis program for forestry research and the state of Alaska. Additional funding has come from the National Science Foundation in the form of multiple-year grants to study the structure and function of black spruce ecosystems in relation to other fire-affected taiga ecosystems, the role of salt-affected soils in primary forest succession on the Tanana River floodplain of interior Alaska, and earlier grants obtained under auspices of the USIBP Tundra Biome Program.

Results of this research have been published as articles in the scientific literature, as chapters in symposium proceedings, as a special issue in the Canadian Journal of Forest Research, and as a book providing a synthesis of the structure and function of Alaskan taiga forests.□

Controls of Nutrient Dynamics in Subarctic Forest Ecosystems

Nitrogen (N) mineralization and nitrification were examined in the forest floor and mineral soil to establish the seasonality of N supply and examine differences in N dynamics among forest types on primary and secondary successional sequences. Ammonium is the dominant form of N in these materials in most forest types, being up to several hundredfold more concentrated than nitrate. However, following logging, or fire or in early primary successional ecosystems, nitrate assumes dominance and may attain the concentrations of ammonium encountered later in forest development. The reason for a shift in N dynamics is not clear at this time, but the trends follow results from disturbed forest systems in temperate latitudes. In primary successional, floodplain ecosystems, soil N dynamics reflect changing species composition of the plant community. Highest rates of nitrification are encountered in the alder stage (15 to 25 years after time zero). By the time balsam poplar dominates (50 years after time zero), nitrification has declined to levels encountered in mature white spruce forests at 200 years of age. The general pattern of soil N with succession appears to be as follows: the most dynamic and rapid supply occurs in early to midsuccession, with nitrate dominating in early, postdisturbance ecosystems and in early primary successional stages dominated by alder. In late successional forests, ammonium is the primary form of N available for plant use. The most productive vegetation types are those supported by the greatest N supply.

Work on the role of salt-affected soils in primary succession on the Tanana River floodplain emphasized instrumentation of study sites in the respective successional stages. Triplicate profiles were established at each of three locations representing early to late succession. Continuous records were obtained from mid-June to mid-September for the following parameters using Campbell CR7 data loggers: soil temperature, moisture content, moisture suction, salinity

of the soil solution, and depth to ground water. The early successional stage (5 years old) displayed highest soil temperatures to the 20-inch depth, reflecting the sparse canopy and lack of an insulating organic layer on the mineral soil surface. Temperature ranged from 68 to 77 degrees Farenheit on the soil surface in this stage of succession compared with 50 to 57 degrees Farenheit on the soil surface under a complete canopy of alder at 25 years. Highest soil moisture contents, lowest moisture suction, and greatest salinity also were encountered at all depths in the youngest successional stage. These conditions largely reflected the shallow depth to ground water (less than 3 feet) on this lower terrace. Depths to ground water in the 25- and 200-year-old stages were 3 to 5 feet and in excess of 6.5 feet, respectively. Surface soil salinity exceeded 2 dS per meter toward the end of the growing season only on the youngest soil. The potential influence of capillary rise of water from the ground water table on the development of surface salt deposits appears to be of importance only in the lowest terrace. Soil solution analysis from the lowest terrace showed high contents of iron (Fe) and manganese (Mn), reflecting an anaerobic environment and, consequently, increased mobility of these elements. Saturation extract analysis of early successional soil profile samples showed approximately ten to twenty times the concentration of Ca and SO_4 in the surface 10 inches of soil as that found at greater depths. These conditions reflect the pedogenic accumulation of these chemicals in floodplain soils.

The principal emphasis in nutrient-cycling research has been to examine control of system processes among forest types. In this regard, temperature played the role of dominant controlling environmental variable. This result indicates that among the ecosystems and processes evaluated, temperature more nearly approached a limiting value, probably a lower limiting value compared with forest floor and mineral soil chemistry. It is logical to consider temperature the dominant control of taiga forest processes, for no activity occurs until temperature exceeds a minimum threshold, regardless of substrate chemical composition. At the warm end of the scale, moisture may limit development of taiga forests and be the most important control of tree growth for types developing on warm south aspects. The importance of soil chemistry may be more clearly defined as our data base increases. The control which forest floor

chemistry exerts on system processes may be greater within than among forest types. *K. Van Cleve.*

Silvics

Selecting the tree species best suited to the site is the most important decision a forest manager must make. A perusal of the literature and field observations in Alaska and Yukon strongly demonstrate the paucity of silvical information available for the tree species native to the northern boreal forest of North America and the lack of knowledge about Eurasian species suitable for timber management, Christmas tree production, and/or urban landscaping. Efforts during 1985 have emphasized tamarack and other larch species.

A search of the literature documents that tamarack, although a host to many of the North American wood-rotting fungi, is much less susceptible than the other native tree species. Of considerable concern to Alaska, is the larch canker, a pathogen native to Europe and portions of Asia. This pathogen is now well established in the Maritime Provinces of eastern Canada where it is causing serious stem deformation and mortality. Until more is known about this pathogen, great care must be taken when importing larch material into Alaska—material must be certified as being either free of the pathogen or from areas known to be free of the pathogen. Material not meeting either of these criteria should be quarantined.

Three unpublished reports were located which list tree species potentially suited to boreal Alaska. Observations in northwestern Canada and Scandinavia suggest that real opportunities exist for increasing the productivity of some forest land by introducing exotic species from the proper areas. Small trials in Alaska support these observations. Several sites in the Tok area underlain by sandy gravel, at an elevation of 1,500 feet, were checked for suitability for test plantations; a final selection will be made in early 1986. The Tok plantations are a cooperative effort with the Alaska Division of Forestry and the Agricultural and Forestry Experiment Station.

Two collections of black spruce cones were made in eastern Alaska for the Institute of Northern Forestry of the USDA Forest Service. Each collection consisted of a minimum of twenty-five individual trees; seed from each tree in the collection will be tested separately in order to obtain maximum genetic information.

A major concern for the management of tamarack is the larch bark beetle which is present throughout the range of tamarack. Epizootics have occurred in Alaska with considerable tamarack mortality. Excessive mortality has occurred in the Canadian Maritime Provinces since the late 1970s; one province reports that more than 60 percent of the tamarack trees in the infested area have been killed in less than 10 years. The management implication for Alaska is twofold: 1) the larch bark beetle may control the management regimes for tamarack and ultimately end-product size, and 2) selection of sites most suitable for tamarack may be more critical than for other native tree species and thus limit opportunities. *E.C. Packee.*

Costs of Selected Forest Management Activities in Interior Alaska

During the past year, the Intensive Forest Management Project focused on collecting and analyzing production and cost data related to site preparation, planting, and cable yarding. This research is aimed at state and private land managers who are beginning to manage intensively interior Alaska's forest lands.

Site-preparation production rates and costs using a TTS-35 Disc Trencher compared favorably with those for similar equipment being used throughout Canada. The analysis of planting production rates and costs will enable Alaska to determine the overall feasability of this activity when seedling survival rates are determined at a later date. Research on cable yarding focused on providing production data and costs of using a small cable yarder to harvest fire-killed white spruce. Preliminary data indicate that, while costing more than ground yarding, this equipment can cost effectively yard wood from areas inaccessible to ground equipment. *A.P. Richmond, A.F. Gasbarro.*

Forest Products

Results indicate that the forest products industry in the Boreal Forest Region of Alaska has not reached its potential. Major impediments include a lack of knowledge concerning competitors, markets, and product potentials. Some Alaskan operators are quite efficient and some have found excellent market niches; however, the majority are marginally successful at best.

British Columbia, Yukon, and the United States' Pacific Northwest are major suppliers of softwood lumber to interior and southcentral Alaska. British Columbia, the major supplier of spruce-pine-fir (S-P-F) (mostly white spruce and lodgepole pine), accesses Alaska via barge through Prince Rupert or Seattle. S-P-F is also trucked from Ft. Nelson and Watson Lake via the Alaska Highway. The Pacific Northwest is the primary supplier of Douglas fir, western hemlock, Sitka spruce, and ponderosa pine and accesses Alaska via barge from Seattle. North coastal British Columbia also supplies a quantity of western hemlock and Pacific silver fir. Much of this imported lumber could be replaced by Alaskan white spruce.

Rail/barge routes from supply regions to Anchorage were identified and transportation costs estimated. Approximate rates for 1984-1985 through Seattle ranged from $64 to $84 per million board feet (MBF) for Douglas fir to $52 to $67 per MBF for S-P-F. Rates for S-P-F from Prince George through Prince Rupert ranged from $66 to $76 per MBF; rates from mills closer to Prince Rupert were lower. Trucking rates for Ft. Nelson to Fairbanks were reportedly as low as $55. The implication for Alaskan producers is that their costs (production and delivery) for the same quality of lumber cannot exceed Canadian or U.S. production costs (including profit) by more than $50 to $70.

A concern of many Alaskan and Pacific Northwest lumber producers is the "low stumpage" charged Canadian operators; United States producers believe Canadian stumpage is subsidized and believe a tariff or quota should be imposed. However, the impact of reducing access of Canadian producers to usual United States

markets could result in greater competition for Pacific Rim markets—much to the detriment of the ailing Southeast Alaska lumber industry.

Preliminary information suggests that comparison of stumpage prices between the United States and Canada will be difficult because of fundamental differences in philosophies. Canadian provinces use various appraisal approaches; however, in the majority of cases, the stumpage value is routinely pegged or adjusted to reflect current market values for the finished product. In the United States the bidding procedure favors anticipated future values with little opportunity for market adjustments. The concern over timber subsidies provided to the industry by the Canadian federal or provincial governments appears to be specious; this is especially true for the western provinces but may not be true for some of the eastern provinces, particularly in the pulp and paper sector.

The size of the Canadian forest resource is not commonly recognized in the United States. The volume of standing timber in British Columbia equals that of Washington, Oregon, Idaho, Montana, and either California or coastal Alaska together. Hence, British Columbia is a price-maker and the United States' Pacific Northwest is a price-taker for many species and grades of lumber.

A literature survey has identified aspen as a basic feed material for ruminant livestock; it has been used successfully elsewhere in North America and appears to have potential in Alaska. The aspen, as chips or finer material, is typically supplemented with protein and other nutrients. Fish and/or crab meal, derived from waste products of the fishing industry, can provide the necessary protein and some of the other nutrients. *E.C. Packee.*

Wood-Preserving Treatments for Alaska

Long-term studies of wood preservative treatments have been conducted at the AFES Palmer Research Center. During the summer of 1954, various preservative treatments were applied to native Alaskan woods. White spruce (*picea glauca*), balsam poplar (*Populus balsamifera*), paper birch (*Betula papyrifera*), and aspen (*Populus*

tremuloides) were selected as being the predominant species in interior Alaska. Each preservative treatment was represented by twelve posts, 3 to 7 inches in diameter, of each aforementioned species for a total of forty-eight posts per treatment. Posts were then planted randomly in a fence row and checked annually with 60 pounds of pull at the 4-foot level. Out of eight total treatments, two are still maintaining a high proportion of solid posts. A double-diffusion treatment of copper sulfate ($CuSO_4$) followed by sodium chromate ($NaCrO_4$) still has 92 percent of the original posts in serviceable condition.

The next most successful treatment was a solution of 5 percent pentachlorophenol (Penta®) in stove oil. Results for this treatment show 96 percent of the original posts remain in serviceable condition, but with a much higher rate of deterioration than the double-diffusion treatment. A direct relationship exists between the amount of chemical retained per cubic foot of post and the life expectancy. None of the other six wood-preserving methods tested compare favorably with the double-diffusion or Penta treatment. *L.D. Allen.*

Predicting the Growth and Yield of Forest Stands In Interior Alaska

Growth and yield information is essential for the management of the native tree species of the boreal forest of interior and southcentral Alaska. Preliminary results suggest better growth rates on many sites than previously assumed: one implication of this finding is a brighter economic potential for intensive timber management.

A preliminary assessment of field data shows that established seedlings (0.5 foot tall) of black spruce and then white spruce require the most time to reach breast height, an average of 12 or more years for the former and 6, 8, or more years for the latter. Tamarack and the hardwoods typically take 2 to 4 years. One management implication from these data is the high probability of white spruce being overtopped by hardwood competitors.

Height-over-age curves are being constructed for each species; major emphasis has been on tamarack. Preliminary efforts indicate

that the site index curves for tamarack in Alaska differ greatly from the published site curves for tamarack in the Great Lakes states. Hence, new curves are needed to estimate site productivity. The majority of data have been collected from the Tanana River Valley and a major concern has been locating a sufficient number of stands containing tamarack over 50 years old.

Sites were selected for three sets of plantations (two white spruce and one tamarack). Site preparation, consisting of double-pass discing at right angles with a disc-trencher (TTS-35) was completed during the summer of 1985. Two-year-old seedlings are available for spring 1986 outplanting at five spacings: 4 by 4, 6 by 6, 8 by 8, 10 by 10, and 12 by 12 feet. These plantations will provide long-term survival, growth, and yield information and identify the optimum spacing between trees.

A review of published energy values for boreal species suggests the general ranking (based on a standard cord): birch = tamarack> black spruce> white spruce > aspen = balsam poplar = black cottonwood. Actual values varied among reports, and the rankings often varied. Firewood prices commonly do not reflect the differences in energy content. Energy content of fuelwood should be of concern to the consumer since current fuelwood prices frequently do not reflect energy content.

Work was initiated for tamarack. One hundred sample trees were cut into 4-foot lengths; age, height, and diameter information were obtained and graphed to provide a profile of each stem. In addition, another 175 trees were sampled for bark thickness. Individual cubic-foot tree volumes calculated from these data are used to estimate the volume of timber in a harvest unit or sale.

Information from this research is important for effective timber management and economic modeling. It is essential for sound multiple-use management including not only timber management, but also, wildlife habitat manipulation, recreational site maintenance and rehabilitation, landscape architectural planning, and vegetation management along transmission lines, roadsides, and other rights-of-way. *E.C. Packee.*

Twig and Foliar Biomass Profile for Understory Vegetation Of Forested Communities of Southeast Alaska

Regression equations are being developed for the major understory species found in southeastern Alaska to predict twig, foliage, and combined biomass. The equations will be used to predict biomass from visual estimates of percent cover by 1-foot layers for a vertical profile extending from ground level to 16 feet. These equations will be combined with the vertical-profile measurements made by the US Forest Service, Forest Inventory and Analysis Unit, to develop detailed profiles of the amount and availability of understory species. These profiles are then useful in determining the quality of wildlife habitat in various communities across the state. *J. Yarie.*

Analysis of Long-Term Forest Productivity Using Computer Simulation Models

FORCYTE-10, an ecosystem-based, forest management, growth and yield model was selected to investigate the effects of intensive management of taiga white spruce on future site productivity. A series of management simulations made with the model indicated that intensified management may increase site productivity, but the increase may be, in part, a result of the nitrogen (N) input by alder that invades the site after clearcutting.

In an additional series of simulations designed to look specifically at the importance of alder, it was indicated that, in both whole-tree and stems-only harvesting schemes, symbiotic N fixation was shown to be important in maintaining ecosystem productivity. Additionally as a result of using stem-only harvesting, the added importance of maintaining a pool of easily mineralized N on the site after clearcutting was indicated.

A second model, LINKAGES, which embodies a different philosophy is now being calibrated for interior white spruce ecosystems. The results of this model will then be compared to those obtained from FORCYTE. This work is also being carried out as a part of the cooperative effort with the IEA Forestry Energy Project CPC10, The Nutritional Consequences of Intensive Forest Harvesting on Site Productivity. *J. Yarie.*

Coordination of the Rosie Creek Fire Research Project

Coordination of the Rosie Creek Fire Research Project (RCFRP) for 1985 included preparation and approval of an Interagency Collection Agreement for funding Forest Service participation, execution of three new subcontracts, editing of the 1984 Early Results proceedings, and overview and reporting functions.

There were nineteen investigators carrying out seventeen research projects in three broad topic areas. Studies of post-fire responses that were at or near completion included the following topics: emperical wood yield recovery, wood-inhabiting beetles and borers and their woodpecker predators, and a predictive model of tree survival. Regeneration silviculture studies began in earnest in 1985, with new studies initiated on the effects of microsites on seedling recruitment and site preparation. After a delay in a salvage logging, plantation layout was completed for stand density trials, site preparation, and provenance selection studies; these sites await tree planting May 1986. Studies of the natural environment which continued covered the topics of microenvironment monitoring, nutrient cycling, revegetation and shrub biomass, and phosphorus availability.

The May 1983 fire burned 8,600 acres of old-growth white spruce, aspen, birch, black spruce, and mixed hardwood-conifer stands. Partially burned white spruce were subject to especially heavy attack from cerambycid roundheaded root and wood borers. Salvaged trees were riddled with holes (wood borer tunnels). Although the salvaged wood met market resistance and was severely price discounted, little structural strength was lost.

Black-backed woodpeckers have congregated in the burn as specialized predators of wood borers. These woodpeckers live in two modes: (a) low endemic populations in old-growth and (b) opportunistic aggregations at the margins of recent burns. Wood decay fungi have continued to reduce wood quality except in dry, standing dead snags. White spruce seedling establishment was greatest on mineral soil substrates; it was inhibited on organic surfaces mainly due to mortality from drying. Burned sites that were near a surviving forest edge received relatively heavy white spruce seed rain; white spruce seedlings did become established on organic substrates on such sites, but it is not yet clear whether that was due to effects of shade or to probabilistic effects (high seed rain overcoming drying mortality). Calamagrostis (grass) competition with white spruce seedlings was locally severe and required that heavy disturbance be overcome.

A special symposium of the Arctic Science Conference was devoted to results of the RCFRP in September. Special newspaper and radio coverage was produced. Proceedings of the December 1984 Early Results conference were published. *G.P. Juday.*

Research Areas Coordination

This project covered a group of related activities involving the selection, documentation, and use of specific tracts for natural resources and scientific research as well as the coordination of these activities among the private, state, and Federal sectors.

A model project involving planning, site selection, and field documentation for Research Natural Areas (RNAs) on the Tanana Valley State Forest was carried out. Seven areas were proposed and integrated into the State Forest Plan; four sites were visited and intensive data were collected at three. The Johnson Slough Bluffs and Volkmar Bluffs proposed RNAs are steep, south-facing grasslands representative of the warmest and driest habitats in interior Alaska. They had not been studied previously; both support several rare or uncommon plant species, including *Silene williamsii*, *Erigeron*

caespitosus, and *E. glabellus*, as well as several previously undescribed endemic bee species. At least sixty-six species of vascular plants were collected in the proposed Rosa-Keystone Dunes RNA, which is made up of a series of fossil dunes adjacent to the Trans Alaska Pipeline. Hollows between tall dune slip-slopes there include as much as 200 feet of local relief. Vegetation in the hollows is characterized by a treeline and alpine vegetation, probably caused by extreme temperature inversion and local occurrence of ultra cold temperatures.

Other features identified for inclusion in the network of RNAs include habitat for flying squirrels, goshawk, brown creeper, tree swallow, and mountain bluebird. Most of these species were found to require combinations of old-growth forest and water features, and some are under pressure because of loss of winter habitat outside of Alaska. Two RNA candidates for these species, Caribou Crossing and Cathedral Bluffs, were identified. A clearwater slough along the silt-laden Tanana River used as a spawning habitat by coho salmon was also identified. Geologic features important for the RNAs include a dune-impounded lake and an adjacent oxbow lake, dune blowouts, a natural thermokarst pond, and palsas. Two sites containing these features, Shaw Creek Tamarack and Oblique Lake RNAs, were located.

This project contributed to plans for an "Alaska Heritage" information system, a cooperative state-private natural feature and natural areas information system. Funding was approved by the legislature, but it was not implemented because the appropriation was vetoed. A supplemental comprehensive natural area information management system was planned; it involves a three-tier site description, a site-specific bibliography, and a site index and search system. *G.P. Juday.*

Forest Succession at Columbia Glacier

A terrestrial environment research team, composed of UAF and Forest Service researchers, was formed to look at forest succession

in the wake of the retreat of Columbia Glacier. The US Geological Survey has also provided assistance in the effort. Columbia Glacier may be the last rapidly retreating tidewater glacier in a forest environment in the world; it is one of the most popular visitor destinations in Alaska. Along an ice front 5 miles wide and as much as 1,200 feet thick, the glacier retreated 1 mile by the end of the 1984 season and is now 3 miles or more from its terminal moraine, creating new land for forest development. The lower glacier has also thinned markedly, exposing new land surfaces.

The team visited the glacier in August 1985, conducted preliminary research, and prepared and submitted an integrated research plan and proposal for further work at the site. Two permanent vegetation transects were established in 1985. One extends from old-growth forest to the l985 ice edge on the east-margin lowlands of the terminus region. The other transect is located at Terentiev Lake, a jokulap or glacier outburst lake on the west margin 4 miles from the terminal moraine. A few members of the team made a brief visit to a nunatak 14 miles upglacier from the terminal moraine.

Microbial decomposition and nutrient-cycling activity were discovered on all ages of freshly-exposed moraine tested on the transects; no land surface emerging from the ice proved to be sterile. Despite a surface layer of angular rock embedded in what appears to be mud, most new surface soils belong to loamy or sandy textural groups. The time available for plant colonization did not follow a concentric pattern marking yearly retreat along the lobes of the ice; secondary disturbances such as outwash events, lake infilling, and mass wasting reinitiated plant succession over significant areas. Successional communities of vegetation generally did predict the number of years since a given site was disturbed.

Terentiev Lake may be refilling for the last time. Plant colonization was observed all the way down to and below the August 1985 level of the lake, indicating succession can be well underway in just 12 to 18 months. The flora of nunatak sites far upglacier is not impoverished but is very similar to that of the subalpine ridges on the fjord walls just above the terminus, evidence that the extended position of Columbia Glacier probably occurred some time relatively late in the Holocene epoch. *G.P. Juday.*

Water Balance Procedures for a Boreal Forest Watershed

This study has resulted in the initial collection of hydrometeorological data on the 16-square-mile Spinach Creek watershed and the development of a water balance model that incorporates soil freezing and thawing as a function of freezing and thawing degree days. The Stefan equation modified for layered soil systems (St. Paul equations) was used in conjunction with Johansen's method of estimating soil thermal conductivity. Model testing to date has involved sensitivity analysis and review of simulations by hydrologists experienced in arctic and subarctic hydrology. The next phase of model testing will focus on the simulation of actual snowmelt runoff from the Spinach Creek watershed.

Use of the Parshall Flume permitted an improved record of streamflow from Spinach Creek and, although the flume was overtopped twice, good data for spring runoff were obtained. Summaries of field data and results of simulation experiments are being prepared and should be valuable to Alaskan resources management agencies dealing with the interaction of resource development and hydrologic systems. This model may also provide a framework for technology transfer as future research improves our understanding of cold regions heat and mass transfer processes. *J. Fox.*

Decomposition in Arctic Terrestrial Environments: Rates and Quality

The goal of this project, begun in 1985, is to further elucidate decomposition processes attributed to soil fungi in an Arctic terrestrial environment as those processes relate to the structure and function of decomposition in cold-dominated peat soils. The approach examines the presence and abundance of total fungal hyphae by a

modified Jones and Mollison technique and viable fungal hyphae by the fluorescein diacetate (FDA) technique in relationship: (1) to the presence and activities of catabolic enzymes (i.e., chitinase, peroxidases, proteases, and cellulase) present in the soil complex and produced by the fungi (enzyme activities will be measured by Ander and Eriksson methods); (2) to the gravimetric loss of organic litter components (i.e., cellulose, hemicellulose, lignin, acid and neutral solution solubles, and remaining residuals) the decomposition of which is largely attributed to soil fungi in moist but not saturated peat soils (litter components are to be measured using Van Soest and Wine techniques); and (3) to the total concentrations of nitrogen in the decomposing system in relation to the overall rate of component weight loss. Nitrogen will be measured by C-H-N and/or Kjeldahl analysis methods. Litter bags will constitute the experimental pool from which most measurements will be taken. Correlation and multiple regression analyses will then be performed on the various data combinations to determine rates and function interdependence in an attempt to further define the structure and function of decomposition and associated processes attributed to the fungi at northern latitudes. *G.A. Laursen.*

The evaluation of the recreational potential of Alaskan wildlands is essential to the efficient allocation of our vast natural resources. These graduate students were part of a recreation inventory team for the proposed Susitna Hydroelectric Project.

Resource Management

Resource Management Research

Resource management encompasses many resource uses—from the more traditional market goods, such as agriculture and forestry, to nonmarket goods, such as wildlife, recreation, and open space. In Alaska, outdoor recreation is a significant resource use in terms of its contribution to the economy and its contribution to the general welfare of the people of the state of Alaska.

The state offers many natural attractors to recreationists—from Mt. Denali to the Harding Icefield, from the world's largest king salmon of the Kenai River to the king-sized grayling of Ugashik Lake, and from the isolated, backpacking opportunities of the Brooks Range to the more accessible ones of the Alaska Range. Opportunities for outdoor recreation appear limitless, but, without the identification of specific opportunities and the development of management prescriptions to maintain or enhance them, there will be fewer and fewer available in the future.

Research in outdoor recreation at AFES is designed to study significant recreational opportunities and problems within the state and to provide research results to the decision-makers. This research program is integrated into the educational program of the school, and most of the major studies were conducted as thesis research by graduate students. Thus, not only are we providing data for decision-making, we are also training new scientists and managers. In addition, research results are presented in experiment station publications available to the public, and seminars to interpret results are presented for land managers. New information about managing Alaskan resources is also incorporated into undergraduate instruc-

tion in the School of Agriculture and Land Resources Management, primarily as case studies.

Some of our earlier research involved social and economic impacts of proposed conservation units under the D-2 legislation. More recently, research has focused on management programs at specific locations. Most of the studies have been funded by federal and state agencies. The two most prominent studies were the Recreational Use of the Susitna Hydroelectric Project, and the User Perceptions of Appropriate Management Strategies for the Kenai River.

The Susitna Project involved three separate studies: a recreation plan for the use of the reservoir, the aesthetic impact of all the proposed development, and the impact on existing land use patterns. The recreational use study included a field survey of potential development sites, determination of suitability of those sites for various recreational facilities, and a mail survey of Railbelt residents to determine their preferred level of recreational development. The survey offered the participants five different development scenarios associated with the reservoir. The results indicated that most people preferred some minimal level of development that would allow them to enjoy available recreational opportunities. Exit interviews with a sample of survey respondents indicated, however, that the primary, preferred opportunities were land-based, i.e., hunting, canoeing small lakes, hiking the dry trails, and not those provided by the impounded glacial waters. These preferences were integrated into a final, recommended *Recreation Plan for the Susitna Hydroelectric Project*.

The study of aesthetic resources assessed the visual impacts of the total project. The procedure used was a modification of the Visual Management System (VMS) used by the US Forest Service. The modification involved the concept of visual absorption where different landscapes have differential absorption factors in terms of visual impacts from a given development. Using the modified VMS, an assessment of the visual impacts of all proposed developments was made and mitigative measures recommended.

The assessment of the impact on existing land use required the use of the oral history technique to identify existing patterns of use. Interviews were used to isolate specific activities, their geographic location, and the social and economic forces that direct each particular activity. By understanding the forces that shaped the particular

land uses, we were better able to estimate the impacts of the Susitna Hydroelectric Project and suggest mitigative measures.

The Kenai River Management Study measures visitor reactions to a series of potential management actions on the river. The array of potential management actions were obtained through interviews with agency personnel. On-site observations helped to identify the major user types, or sampling strata: boat anglers, guided boat anglers, river floaters, and bank anglers. A representative sample for each user group was obtained and a questionnaire mailed to each respondent.

The results showed that river floaters preferred high management control over user behavior, while the remaining three user types preferred moderate to low control. Boat anglers preferred the least management control. Of the thirty-one management actions under consideration, twenty-eight showed significant differences in the perception of appropriatness between the four major user types.

The respondents also rated the importance of seventeen concerns management had identified on the river. In theory, concerns over how the river is presently being managed should be reflected in the evaluation of appropriate management strategies. The concerns that were rated most critical were: loss of salmon-spawning habitat, lack of proper boating etiquette, safety in highly conjested areas, overall safety on the river, and loss of streambank due to accelerated erosion.

There was no significant difference between the user groups in response to these items. The concerns that did show the most variation in response between groups were the level of noise pollution and the number of private boat launches. These were important concerns to the river floaters and bank anglers but not to the boat anglers and guided boat anglers.

An overview of the study and the results were presented to the Kenai River Advisory Board. These results included the differential user group response, or social impacts, of the various management strategies that could be incorporated into the recommended management plan. The response of the board to the study and presentation was positive.

Other studies completed were:

1. Recreational Use of Water-Filled Gravel Pits
2. The Effects of Slope and Vegetation Type on Trail Erosion
3. Alaskan Wild River Planning Model
4. Synthesis and Application of a New Recreation Opportunity Model to the National Petroleum Reserve, Alaska
5. Skier Preferences for Environmental Settings and Specific Management Programs.

One of the important results of our research in outdoor recreation is a theoretical management model which first isolates and then integrates the roles of the recreationists and the recreation manager. This theoretical work is part of the W-133 Regional Hatch Project studying the nonmarket economic benefits of opportunities in public outdoor recreation. Typically, economists have tried to estimate value (benefits) of recreational activities, e.g., camping. But there are many styles of camping and many environmental settings in which one could camp, even without a given style. The value the economists have estimated has had such wide confidence limits that the results were not meaningful to decision-makers. The theoretical work at AFES has pointed out the need to value only the recreational opportunity provided by management. The opportunity consists of the environmental setting, particularly the natural attractors, and the management actions applied to that setting, such as facilities, services, resource management programs, and regulations.

Typical management decisions are incremental ones. What are the net benefits to society for another boating access or visitor center or extended ranger patrols in campgrounds? Costs of these programs are straightforward calculations. The benefits are those derived from the new program, in conjunction with the particular environmental setting. The last phrase is important because it denotes a multiplicative model in terms of how people choose a particular recreational opportunity. Let's use an example of the value of the potential development of scenic overlooks along a highway:

	Rating (0-1)
1. Overlook of Mt. Denali	
a. Developed facilities	1.00
b. Undeveloped facilities	0.75
2. Pastoral river scene	
a. Developed facilities	0.75
b. Undeveloped facilities	0.75
3. Black spruce bog	
a. Developed facilities	0.10
b. Undeveloped facilities	0.00

The value of zero indicates that the decision to participate is a *product* of the environmental setting and the management program. In an additive model (where each component adds to the value), it would be extremely rare to obtain a zero rating because, if there were sufficient natural attraction associated with the site, at least some people would find the management program acceptable. In other words, the value of the opportunity is primarily a function of the environmental setting regardless of who uses it. The management program determines who is actually attracted to the site and, thus, who enjoys the benefits of the setting. This information will identify for managers the effects of particular incremental decisions, even if no actual data are collected to measure the net benefits to society. Also, this should affect the experimental designs of projects which measure benefits, spatial/temporal patterns of use, or user response to management programs.

This model has been presented to various land management agencies in Alaska along with examples of implications in specific cases. These agency/university interactions provided management models concepts, philosophies for the agencies, and insights into management problems requiring additional research by AFES.□

Soil Building on Revegetated Minespoil

Revegetation plots of a number of grasses were established on coal-seam overburden material in 1980 at the Usibelli Coal Mine. The spoil material was derived mainly from sandstone with some silt and clay contents and fragments of coal. The plots were fertilized when seeded in the spring of 1980 at 49-105-49 pounds per acre of N-$P_2 0_5$-$K_2 0$, respectively, and again in the spring of 1981 at 70-70-53 pounds per acre, respectively. The plots were not fertilized again. The plantings were replicated three times in plots measuring 4 by 10 feet. When the plantings were evaluated for coverage in the summer of 1985, soil samples to about the 4-inch depth were also taken under different conditions of vegetation for analysis of nutrient characteristics.

One of the most enduring grasses for revegetation purposes in Alaska is 'Arctared' fescue. This selection, made at AFES, is considered indigenous to Alaska. After 4 years' growth without fertilization, Arctared provided 53 percent live coverage at the Usibelli Mine trial at Healy. Leaf length (height) averaged about 5 inches. Accumulated litter to a depth of 4 to 5 inches provided over 90 percent coverage.

Soil samples taken from the Arctared plots were compared with samples taken from bare minespoil that had never been vegetated or fertilized and from bare plots that had been seeded and fertilized, but whose seeded cover had failed. Analyses for pH, ppm of nitrogen (N), phosphorus (P), and potassium (K), and percent organic matter (O.M.) are as follows with the figure for bare soil first, bare plot second, and Arctared plot third in each case: pH: 6.73, 6.83, and 6.51; N: 2.9, 2.6, and 17.4; P: 3.1, 33.7, and 41.6; K: 33,46, and 77; and O.M.: 1.07, 1.03, and 1.58. There is a suggestion of a lowering of pH under the vegetated plot, with values still remaining well in the range favorable for growth. The effects of fertilization are evident in

the bare plots and appear further enhanced, presumably by the effects of recycling, in the Arctared vegetated plots. Organic matter content was increased about 50 percent under vegetation. The presence of coal, collected to a greater extent in the vegetated plot than on bare soil as the result of wind action, produces some unknown effects. Nevertheless, inspection of the soil profile assures one that well-adapted grasses, such as Arctared fescue, are effective soil builders on low-fertility sites like minespoils. The extent to which nutrients are recycled and become available from the accumulated litter may determine how well Arctared and other revegetation species can perform without further fertilizer input. *Wm. W. Mitchell.*

Arctophila Feasibility Project

Understanding biological and ecological relationships of Alaska's Arctic ponds and wetlands is becoming increasingly important to the petroleum industry. Mitigations for alterations to wetland habitats of migratory waterfowl and other birds are required as oil field developments proceed. Large numbers of North America's migratory birds and waterfowl spend their summers in Alaska's Arctic where they nest and raise their young. Losing all habitats used for reproduction would ultimately eliminate these bird populations. The chance that such an extreme condition could occur is low, considering the current scope of industry developments in the Arctic and commitments by both industry and government to habitat protection. Actually, the prospect of increasing wetland habitats for these birds and waterfowl is good, as important elements of wetlands are discovered.

A research project to study Arctic pendant grass (*Arctophila fulva*) was initiated by SOHIO Alaska Petroleum Company, the U.S. Fish and Wildlife Service, and the Alaska Agricultural and Forestry Experiment Station in 1985. This grass grows in Arctic ponds preferred by tundra swan; Arctic loon; and some geese, ducks, and shorefeeding birds. It is known that detritus produced by *Arctophila* is a food base for insects and other invertebrates that are eaten by some

birds. During portions of the summer, *Arctophila* leaves and perhaps stems appear to be grazed by birds. These evidences suggest it has primary and/or secondary ecological functions important to wetland birds in the Arctic. Because *Arctophila's* role in the ecosystem is poorly understood, one phase of our research is to determine its importance to birds breeding in the Alaska Arctic.

Arctophila grows as an emergent in water to depths of about 28 inches. It also occurs on some drained sites. In water, it propagates vegetatively and is either the dominant or only vascular plant present. On drained sites, its capacity for sexual reproduction improves, and vegetative growth is usually suppressed by competition from other plants. This year we discovered *Arctophila* colonizing certain disturbed sites on which it did not occur 14 years ago when our Arctic studies began. Learning how *Arctophila* survives in various habitats and colonizes new sites and why it is conspicuously absent from some ponds is central to this project. A search for answers for reducing unnecessary losses of the grass and promoting its establishment in disturbed wetlands is central to this research.

A team of graduate students will be working on separate, but complementary, aspects of this research during the next three to four years. *J.D. McKendrick.*

After-Fire Plant Succession on a Boreal Zone Rangeland

Boreal zone vegetation responds to disturbances by shifting composition from woody to herbaceous plants. That shift has implications for both domestic and wild grazers because changes occur in available forage quality and quantity. Mineral and in vitro dry matter disappearance (IVDMD) levels for plant regrowth on several differently disturbed sites of a boreal-zone shrubland near Delta Junction, Alaska, were examined to discover what effects burning, scraping, fertilizing, and seeding had on forage quality. Averaged results among plant species indicated burning increased digestibility and decreased manganese (Mn). Scraping and burning increased nitrogen (N), phosphorus (P), calcium (Ca), and iron (Fe), and decreased

zinc (Zn) and Mn. Combined effects of burning, scraping, fertilizing, and seeding to grasses increased N, P, potassium (K), Fe, and IVDMD and decreased Ca, magnesium (Mg), sodium (Na), Zn, and Mn. The consistent decline in Mn probably results from losses of heath plants, which usually acumulate Mn and other heavy metals. Declines in Ca reflect an increase in grasses, which are generally low in Ca. Improved IVDMD, N, P, and K occurred from increases in juvenile shrub growth, nutrient cycling rates, and fertilization. Fe increases may have resulted from differences in rooting depths and exposure to mineral soil due to removal of thick organic mats by scraping. *J.D. McKendrick.*

Characterization and Classification of Volcanic Ash Derived Soils in Alaska

Soils derived from volcanic ash are extensive in southcentral Alaska, the Aleutian Islands, and portions of southwestern and southeast Alaska. A field study was conducted to examine the morphology of these volcanic ash soils, and samples were taken for laboratory analysis. This study is being conducted in cooperation with Tohoku University, Japan. Alaska and Japan will provide the data base for the classification of cold Andisols. Many of those soils were previously classified as Spodosols, and a few are Inceptisols. The new laboratory and field data indicate that all of them meet the criteria of the newly proposed Andisol order, and most of them meet the definition of either of the two suborders: Borands and Aquands.

Further analysis of field and laboratory data available in both countries suggested the proposed great group in Circular 7 of International Committee on the Classification of Andisols (ICOMAND) was in need of revision. The following great groups of Borands are proposed: Placoborands, Hydriborands, Alluborands, Melanoborands, Fulviborands, Vitriborands, and Haploborands. These soils are characterized by low bulk density, high phosphorus retention, and high content of amorphorus aluminum or pyroclastic material. The characterization and classification of these soils are important to farm

management in relation to fertility and tillage, engineering interpretations for road building, cut and fills, on-site disposals, and mined land reclamation. *C.L. Ping.*

Characteristics of Climate and Assessment of Impact on Agriculture and Other Renewable Resources

Construction was completed on two automated weather stations during 1985. Station number one was erected at the AFES Palmer Research Center, where it provides information to agricultural researchers, farmers, engineers, utility companies, and the US Department of Agriculture. Station number two is located Pt. MacKenzie in close proximity to nineteen state-backed dairy operations.

Collected data from both sites include air temperature, wind direction, wind speed, relative humidity, precipitation, net solar radiation, global solar radiation, and soil temperatures 4 inches under sod and fallow. Readings are taken every minute and summarized every 24 hours. Data are then summarized on a monthly basis.

This project is producing a detailed record of climatic information from two locations in Alaska. Weather records for Pt. MacKenzie were previously unavailable. A format for an annual climatic bulletin has been prepared in order to disseminate this information. *L.D. Allen.*

Utilization of Alternate Energy Sources in Alaska

Studies conducted at the AFES Palmer Research Center have been designed to compare heat-conserving practices in small greenhouses. Four years of data show that the most promising treatment for increasing greenhouse crop yield, under certain conditions, was soil heating by electric fan circulation of warm overhead air

through soil tubes. Utilizing the soil as a thermal storage medium increased temperatures by 10 degrees Fahrenheit, thereby improving plant growth and yield. Other treatments showing some merit include circulating overhead air into the soil using solar-powered fans and 20-gallon barrels of water stacked along the north greenhouse wall as a thermal storage medium. Both of these treatments improved yields under certain conditions, but would probably be best suited to areas of Alaska where electriciy may be unavailable. *L.D. Allen.*

Effects of Application Rates and Disposal Techniques of Dairy Manure on Oat for Forage Yields Grown in a Subarctic Environment

The development of dairy farms in the Pt. MacKenzie area of Alaska prompted concern regarding adequate methods and techniques for disposal and utilization of dairy manures so as to do no harm to the environment. This project continues to evaluate the use of both dairy manure and urea at application rates sufficient to supply nitrogen (N) at three rates (40,80, and 160 pounds per acre) when applied to plots 40 by 75 feet by three techniques (broadcast, incorporate, and inject). Land that was placed into second-year cropping on a newly cleared area was selected for the production of oat forage.

The first-year results of oat yields showed no significant differences in the urea plots; however, the urea plots with all three N rates produced significantly more oat forage than did the plots with the low and medium manure rates. Also, the amount of urea applied had no significant effect on yield. The general trend among techniques when ranked by highest yield was incorporate, broadcast, and injection.

Due to the nature of the cool soils and environment, we expect that the manure plots will release more of the ammonium (NH_4+) and nitrate (NO_3-) to the oat forage in the second and third year. Forage yields should increase with the additional amounts of manure applied in the second year. The nitrate levels will also increase in the

soil under these treatments. Soil analyses for nitrate will determine if application rates are too high under these subarctic conditions. The first-year soil samples are currently being analyzed. *R.F. Cullum and C.L. Ping.*

Economics of Agricultural Development

The changing environment of Alaskan agriculture has become the subject of recent public discussions and has led to a review of the present situation with suggestions for the future. The major land disposal programs for agriculture have ended, at least temporarily. The development thrust toward market penetration overseas has also been muted. Very little development is now occurring beyond the normal progress of the Delta and Pt. MacKenzie projects. The planning associated with state government appears more short term and includes an emphasis on support for in-state marketing, means to provide moratoriums on land and clearing payments, and a continuation of a few land sales for small agricultural parcels.

Possible areas that state government may wish to consider in trying to support Alaskan agriculture include: land title, farm development, loan-fund participation, development of new lands, and support for a broadly based agriculture. These can be summarized as follows. If uniform titles are to be given for agricultural lands, then some form of agricultural-rights-only title must be employed, or agriculture in the Matanuska-Susitna area will virtually disappear. Careful planning, including contingencies, must take place before farm development, loan-fund participation, and development of new land will succeed. Any farming venture should be encouraged by state government and given consideration in the state farm loan program as long as it is evaluated as a business proposition. Such an approach will promote a broadly based agriculture.

A study of the policy processes and measures of assistance to agriculture is continuing. Policy, assistance, and trade are closely interrelated for agriculture and agricultural development. It is clear that the measurement and comparison of rates of assistance to

agriculture in different countries is becoming a significant issue in the way in which trade negotiations take place since agricultural trade has numerous mechanisms of domestic protection. Research is focusing on analysis of rates of assistance to agriculture using a spatial equilibrium model. The work is directed toward a better understanding of the problems of comparing rates of assistance between countries as a basis for further investigation of the factors which influence governments to supply assistance and industries to demand assistance. This is a cooperative study with the University of New England, Armidale, N.S.W., Australia. *W.C. Thomas.*

Management Systems for Small-Grain and Livestock Production in Interior Alaska

Development of agriculture in interior Alaska is focused on providing a feed-grain base, primarily barley, for a growing livestock industry. Both livestock and grain producers must, in the long run, be able to recover all costs in order to remain in operation. Therefore, the price of grain must be low enough to allow livestock producers to sell their product competitively while recovering costs, and yet be high enough for the grain producer to remain in business. The determination of this cost/price relationship in terms of production inputs for both the grain and livestock producer is one of the major objectives of this research.

Surveys have been distributed since 1983 to farmers who are producing barley in Alaska's interior to determine the management systems used, including costs of production. Fixed costs of depreciation and interest are estimated based on equipment complements, land, and land-clearing costs. The 1984 surveys indicated that barley could be produced for a cash operating cost of $96.68 per acre. Repair, maintenance and insurance added another $15.38 per acre. Fixed costs were estimated at $36.40 per acre for a total of $148.46. All costs except those for drying grain remained approximately the same in 1985. The 1985 harvest season was exceptionally rainy, and drying cost increased from $4.00 to, in some cases, $16.00 per ton.

Best estimates made in 1985 show that an efficient cattle or hog producer or dairyman could pay up to $120 per ton for US #2 barley. This would be sufficient to cover cash operating cost for producing barley plus the $15.38 repair, maintenance, and insurance costs if yields were maintained at 1.0 ton per acre. There would be an excess of $7.94 per acre to apply to fixed costs, but this is not sufficient to cover the total. Thus for grain farmers to cover all costs at a production rate of 1.0 ton per acre, livestock owners must be willing to pay at least $149.00 per ton for #2 barley or grain yields must increase to 1.25 ton per acre. The latter is the most likely occurrence. This yield was obtained in 1984 and 1985 by farmers who followed best management practices for barley production. *C.E. Lewis.*

Modeling Production and Marketing Decisions For Alaska Reindeer Herds

In previous research, investment decisions for commercial reindeer production have been evaluated for specific small, medium, and large herd sizes. The cost of herd expansion was not included. In order to go beyond this approach of comparing static herd sizes, construction of a polyperiod linear programming model has begun. The model is constructed to allow a herd to grow, decline, or remain static depending on the impact of exogenous factors such as changing meat and antler prices, capital constraints, increases in grazing fees, and periodic losses to predators. The decision process endogenous to the model can be modified to represent high, medium, and low levels of management.

The economics of establishing a marketing cooperative for reindeer antlers is the second major aspect of the ongoing research. Increasing the competitive nature of the market is a key reason for adopting a uniform grading system and using a marketing pool. The price leadership characteristics of the present system of individual buyers are being analyzed in a separate economic model. When operational, the polyperiod linear programming model will be used to estimate

potential differences between the present system and the uniform grading approach. *W.C. Thomas.*

Economics of Institutions Governing Private Land Use in Alaska

Work on this project focused on two areas: (1) preparation of three manuscripts based on research completed in the previous year and (2) modeling work initiated for purposes of different time paths of land disposal by government entities in Alaska. Drawing on contributions to the economics literature on durable goods demand and exhaustible resources, a two-period dynamic optimization framework was developed to examine the comparative dynamics effects of changes in the discount rate, disposal costs, and demand growth. These exercises were performed, assuming linear demands, for two possible hypothesized objectives of land disposal programs: (a) maximization of discounted economic surplus and (b) maximization of discounted net revenues from land sales. The theoretical results specified the conditions under which the dynamic problem collapses to a static one, implying that all land inventories could optimally be disposed of in the earliest possible period.

Ongoing work concerns the generalization of the model to *n* periods, the consideration of nonlinear functional forms for demand, and the allowance for uncertainty. In addition other objectives for land disposal programs will be considered. While no empirical use of the model has yet been made, it is expected to have use for both prescriptive and descriptive purposes. *W.G. Workman.*

Survey of the Alaska Greenhouse Industry and Related Enterprises

A list of commercial greenhouses, nurseries, interiorscape businesses, landscape contractors, florist businesses, and variety stores that sell plant products was developed in order to determine the scope of the horticulture industry in Alaska. Presently, 155 greenhouse, nursery, and interiorscape businesses have been identified along with 304 landscape contractors, 80 florist businesses, and 41 variety stores that sell plants. A self-designed questionnaire was used to determine the current status of these enterprises, including information on location, square footage of facilities, source of heating and lighting for greenhouses, number and type of employees, products purchased and/or produced, and total gross sales. More than half of the greenhouse, nursery, and interiorscape businesses were started after 1976, and 40.4 percent of the businesses began as a hobby that was expanded into a commercial enterprise. Nearly all of the greenhouse operations had Quonset or even-span gable greenhouses that were covered with corrugated fiberglass or double-layer polyethylene. Most greenhouses were heated with natural gas or heating oil. Fifty-eight businesses had a total of 413,476 square feet of year-round heated greenhouse space, 266,900 square feet of seasonally heated space, and 18,369 square feet of nonheated space. The most commonly grown crops were flowering annual and vegetable bedding plants. The number of employees at the 58 businesses was 678: 152 year-round, full-time employees; 85 year-round, part-time employees; and 441 seasonal employees, 150 of which were hired only during the transplanting season. The estimated number of jobs available statewide in greenhouse, nursery, and interiorscape business totaled 1,559. Forty-four percent of the business reported gross sales of less than $25,000, while 5 businesses exceeded $1 million in gross sales. The estimated total gross sales for greenhouse, nursery, and interiorscape businesses in Alaska was $24,387,500. *P. Holloway and C. Kirts.*

Recreation Management Research

Two studies were completed this past year. The first focused on linking trail erosion to site characteristics in the Tanana Hills in interior Alaska. Erosion was measured by the change in the cross-section of the trail. The trail gradient and presence of permafrost significantly affected the amount of erosion, while vegetation had no significant effect. Much of the change in the cross-section of the trail was attributed to subsidence due to the disturbance of the surface vegetation during trail construction and subsequent melting of the permafrost.

Most dispersed recreation areas in Alaska lack access via trails, thus there is much interest in trail construction. In interior Alaska, much of the northerly slopes and low country have permafrost. Typical construction techniques were viewed in terms of their effect on these permafrost zones.

The second study compared management/environmental preferences between recreational and racing cross-country skiers. The responses from 284 skiers were used to identify divergences in perceived needs of the two skier groups. In general, both groups preferred low to rolling lands with spruce/hardwood forest. They desired similar types of services and facilities. Their differences were primarily in the perceived need for trail lighting, good trail grooming, and food concession. None of the differences was sufficient to warrant separately developed and maintained sites.

Specific recommendations were published by the experiment station and summarized in an article in the November 24, 1985, *Fairbanks Daily News Miner.* Work continued on the study entitled Recreation Management on the Kenai River.

There are significant differences in perceived needs between the major use groups. Interestingly, many of these users have naturally separated themselves along the river to minimize their conflict with one another. In other words, people have adjusted their behavioral patterns to maximize their own experiences. The results would in-

dicate that there is less need for overt management of user behavior and that simply adapting a policy that would recognize the natural segregation on the river would suffice. *A. Jubenville.*

Who's Planning Alaska: The Alaska Planning Directory

Since the 1970s the state of Alaska has been subdivided into dozens of management units, each with one or more land-use plans. The Alaska Native Claims Settlement Act, Alaska National Interest Lands Conservation Act, Federal Land Policy Management Act, National Forest Management Act, and Coastal Zone Management Act, among other Federal and state acts of the 1970s, required that Federal, state, and local agencies prepare land-use plans. Many Native corporations, although not obligated to do so, are also preparing plans.

Although there was tremendous activity in land planning in Alaska, no agency had taken responsibility for monitoring or evaluating the plans. The Cooperative Extension Service provided funds in 1984 to prepare the first summary of what was happening. A draft report, entitled *Who's Planning Alaska: The Alaska Planning Directory*, was published in May 1985. The draft identifies over 470 land-management units and lists over 220 existing plans or plans in progress. Over 500 copies were distributed to agencies for corrections before a final printing in May 1986. The directory will be updated periodically and will be available to the public through the author or through the Cooperative Extension Service, University of Alaska. *T.J. Gallagher.*

The Colorado Joint Review Process: Application in Alaska?

Alaska, like Colorado, has many large, proposed, development projects. Recent projects proposed for Alaska include the Susitna Hydropower Project, the U.S. Borax Molybdenum Project, and the Cominco/NANA Red Dog Project. These large projects may each require more than one hundred permits from Federal, state, and local agencies. To manage the permit process, the state of Colorado initiated a Joint Review Process (JRP) in 1979. The process has now been used for about a dozen major mining projects.

The process, or components of the process, may be useful to the state of Alaska. To determine the success of JRP, sixty people who have direct experience with the process have been contacted; these include: industry representatives, federal and state agency staff, local government officials, consultants, and special-interest groups. Early responses to a questionnaire indicate that the process saves time and money, increases coordination among agencies, increases public participation, helps identify missing data, and helps participants generate more creative alternatives. Final results will be presented to the governor's office in early 1986. *T.J. Gallagher.*

Establishment of Alaska Research Natural Areas for 1985

Data from site documentation visits to fourteen proposed BLM Research Natural Areas (RNAs) across central Alaska were analyzed and a series of RNA designation reports produced. Arrangements were made to publish these reports through the USDA Forest Service, Pacific Northwest Research Station.

The Steese National Conservation Area, (NCA) and White Mountains National Recreation Area (NRA) contain four RNAs, all of which

were approved in the final land-use plans for the management areas. The Limestone Jags RNA contains old karst features including caves, disappearing streams, cold springs, and limestone flora. Barren sites on the Serpentine Slide RNA are probably due to manganese toxicity, and local adaptation of the flora may have occurred. A new location for *Draba peysonii* and optimum habitat for the rock-nesting migratory bird, the wheatear, both occur in the Mount Prindle RNA. Local Dall sheep use of the Big Windy Creek Hot Springs RNA is heavy.

The draft land-use plan for the BLM Central Yukon Area proposed eight RNAs in the form they were initially recommended (in the largest size option) to the planning team. The group of eight areas includes two hot springs, two pingos, two lake and dune areas, and a treeline site. A new location for the rare legume *Oxytropis kokrinensis*; a range extension for the meadow jumping mouse; and parabola, transverse, and oblique dunes are some of the significant natural features included.

Land claims problems on the four proposed BLM RNAs of the Seward Peninsula required a reanalysis of features in relation to alternatives and boundary options. A special report to BLM documented the alternatives, pending a BLM decision in early 1986. After any adjustments, the Camp Haven Gap RNA would still contain the Walpole's poppy, proposed as *threatened* on the Federal government's endangered-species list, and range extensions for seven taiga forest species. A serpentine rock outcrop to the southeast of the Clear Creek Hot Springs RNA has been proposed as an addition because of the potential for rare plant occurrences; the lower portion of one of the three geothermal vents was significantly damaged by the unauthorized construction of a pool. Lands under selection and possible transfer from BLM ownership at the Mount Osborn RNA contain the summit, which is made up of a metamorphic rock (garnet peroditite) and which may be the deepest crustal rock now in surface exposure in North America. *G.P. Juday.*

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LEE D. ALLEN, Associate Professor of Agricultural Engineering; University of Idaho '57, B.S., '72, M.S. Mr. Allen's agricultural engineering research has included insulation and vapor barriers, cold-climate animal environment and waste disposal, soil cement and rammed earth structures, grain and hay drying, northern climatic measurements and phenology, irrigation and tillage, locally grown vegetable processing, and preservative treatment of Alaskan woods. Mr. Allen joined the AFES staff in 1957. He has been Alaska's representative on ten midwest and western Regional Research Committees. His current projects concentrate on climatological measurements and energy utilization.

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 cut roses and such investigations as the feasibility of small-scale meat production of ducks, geese, and rabbits in a village setting for sale in Alaska markets. 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 working on applying newly developed computer software to various farm management systems in Alaska.

LEROY BEN BRUCE, Instructor 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 unusual feedstuffs such as taro. In South Dakota, he was extension specialist in feedlot nutrition, providing service to cattle feeders statewide. His work with the University of Alaska-Fairbanks 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.

ARTHUR L. BRUNDAGE, Professor of Animal Science; Cornell University '50, B.S.; University of Minnesota '52, M.S., '55, Ph.D. Dr. Brundage was with the University of Alaska for 34 years and became senior project leader in animal science with primary responsibility for research in dairy cattle management, production, nutrition, and breeding. He also served as state extension dairyman, manager of the Matanuska Valley Breeders' Association (a nonprofit corporation of local dairymen operating in cooperation with the experiment station), and an instructor at the Matanuska-Susitna Community College. Dr. Brundage retired in 1985 and has subsequently been

awarded emeritus status. Dr. Brundage continues to maintain an informal relationship with the experiment station and the university.

VIVIAN L. BURTON, Laboratory Supervisor; University of Alaska 1971, B.S. Mrs. Burton was a cytology technician from 1958 to 1960 at Texas A. and M. where she worked in cancer research and stain technology. From 1960 to 1962 she worked in veterinary research at Montana State University. She began work as a soil science teachnician at the AFES Palmer Reserach Center in 1964, and in 1968 she became a technician in the Animal Science department there, leaving in 1969 for further study in Fairbanks. Mrs. Burton returned to the Animal Science Department in Palmer in 1973 where she assumed the role of head technician until July 1985 when she was promoted to supervisor of the new Matanuska laboratory facility.

DONALD E. CARLING, Assistant 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 includes variety testing and studies of herbicides, seed treatments, and general cultural practices. More basic research includes the study of Rhizoctonia disease of potatoes and vegetables.

VERLAN L. COCHRAN, Soil Scientist, 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.

WILLIAM B. COLLINS, Assistant Professor of Range Management; Brigham Young University '74, B.S.; Utah State University '77, M.S., '79, Ph.D. Dr. Collins's research interests are: behavior of grazing animals, grazing systems, and range management, with emphasis on reindeer production. Dr. Collins has also worked on problems associated with range use by mule deer, elk, pronghorn antelope, moose, musk ox, wild horses, and burros, cattle, and domestic goats.

JEFFERY S. CONN, Research Agronomist, USDA; 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 designing 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; 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.

JAMES V. DREW, Dean, School of Agriculture and Land Resources Management, and Director, Agricultural 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, 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.

ALAN C. EPPS, Professor of Natural Resources; Montana State University '66, B.S.; Montana State University '69, M.S. Mr. Epps's background is in natural resource allocation and management, with extensive experience in land-use planning. Before joining AFES he was with the Cooperative Extension Service, University of Alaska, where he worked extensively in public policy at the national, state, and local levels, receiving the USDA Distinguished Service Award in 1978 for his policy education work on the Alaska national interest lands issue. Mr. Epps is currently conducting research on natural resource policy and is coordinator of UAF's applied reindeer research and instruction program and teaches an upper division course on the Alaska Reindeer Industry.

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 the AFES, currently researching runoff relations of boreal forest watershed management, forest systems, forest management, resource measurements, simulation and modeling, and biometeorology.

THOMAS J. GALLAGHER, Assistant Professor of Regional and Land-Use Planning; University of Oregon '69, B.L.A.; University of Michigan '74, M.S., '77, Ph.D. His research interests are in the area of planning processes, participation methods, and rural land planning. He is presently conducting research on use of the Colorado Joint Review Process, a method of coordinating the permitting of large development projects, in Alaska. He teaches graduate courses in regional planning and undergraduate courses in land-use planning. Dr. Gallagher also serves with Cooperative Extension Service as a land resource specialist. He completed the draft of "Who's Planning Alaska: The Alaska Planning Directory" during the summer of 1985 and will complete the final report during the summer of 1986.

ANTHONY F. GASBARRO, Extension Forestry Specialist and Instructor of Forest Management; 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 2½ 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 Project and currently holds a joint appointment between SALRM and the Cooperative Extension Service.

JOSHUA A. GREENBERG, Research Associate; University of Connecticut '82, B.S.; University of Alaska '84, M.S. Mr. Greenberg's background is in resource and agricultural economics. He joined AES in 1984 where he has focused on economic research related to Alaska's reindeer industry.

MARILYN GRIFFITH, Assistant Professor of Plant Physiology; Mt. Holyoke College '75, B.A.; Yale School of Forestry '77, M.F.S.; University of Minnesota '81, Ph.D. Dr. Griffith was awarded a Killam Fellowship in 1981 to pursue independent research at the University of British Columbia and the University of Western Ontario in Canada. Her research interests are focused on growth and development of plants at low temperature using expertise in physiology, biochemistry, and anatomy. Since joining AFES in 1984,

Dr. Griffith has been involved in directing research programs in plant physiology and horticulture.

CHARLES W. HARTMAN, Executive Officer; Rutgers University '64, B.S.; University of Alaska '67, M.S. Mr. Hartman worked as a research engineer/hydrologist for the Institute of Water Resources from 1967 to 1974. In 1979, 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, Research Associate; University of Delaware '69, B.S.; University of Michigan '70, M.S.; Colorado State University '77, M.S., '81, Ph.D. Dr. Helm's background includes soil-vegetation relationships around alpine snowfields and vegetation inventory techniques in Colorado. She has been involved with the vegetation studies on the Susitna Hydroelectric Project since 1980, including studying vegetation succession along a 50-mile stretch of the river, mapping vegetation over several million acres, inventorying moose browse, and studying phenological development of plants near the potential impoundment area. She has assisted with data collection and analysis on range-related projects with Homer beef, Delta bison, Cantwell revegetation, and Beluga and Usibelli coal fields. She is also helping to streamline data collection and report generation techniques using available microcomputers and university mainframe computers. She has also taught a range management course at the Matanuska-Susitna Community College.

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 an 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, nutrition research has been conducted with swine and cattle to determine

the nutritional and feeding value of marine by-products. Recommendations have been made for feeding crab waste meal to livestock, and research is currently being conducted to determine chitin digestion by rumen microorganisms. Research to determine barley protein quality and the feeding value of a new hulless barley variety, 'Thual', are currently in progress. Courses in introductory animal science, livestock feeding, nutrition and graduate courses in nutrition and metabolism have been developed and offered through the Natural Resources Management degree program.

ALAN JUBENVILLE, Associate Professor of Natural Resources 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 two 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 has been an active member of W-133 Regional Hatch Project, linking economic theory with recreation management theory. Currently Dr. Jubenville is working on a textbook integrating theory into the management process.

GLENN P. JUDAY, Visiting Associate Professor of Plant Ecology; Purdue University '72, B.S.; Oregon State University '76, Ph.D. Dr. Juday's research background is in community ecology, especially composition, distribution, and structure of old-growth conifer forests. He was principal investigator, Indiana Natural Streams System in 1972. He was chairman of the Oregon Natural Areas Commission from 1973-76 and coordinator, Rosie Creek Fire Research Project, 1983-85. He was named coordinator of the Columbia Glacier Succession Study in 1985. Dr. Juday's major program responsibilities since joining AFES in 1982 have included coordination of multidiscipline research projects, especially the Alaska Ecological Reserves Program. This applied research has resulted in publications on climate change, forest fire effects, land-use planning, geomorphology, and wildlife-habitat relationships. He received a Meritorious Service Award for natural areas work from the governor of Oregon. He is now serving as president of the Natural Areas Association.

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 technical courses in natural resources management and agriculture. She also assists vocational agriculture teachers in Alaska with program planning and im-

plementation. Dr. Kirts received the Honorary State Farmer Degree in 1983 from the Alaska Association of the Future Farmers of America.

LESLIE J. KLEBESADEL, Professor of Agronomy; University of Wisconsin '54, B.S., '55, M.S., '57, Ph.D. Dr. Klebesadel joined the University of Alaska in 1957. He served as the first director of Matanuska-Susitna Community College, 1958. As a member of the Plant Science Team of US/USSR Agreement on Agricultural Cooperation, he traveled extensively in the Soviet Union in 1974. He served as research leader and location leader of the USDA Agricultural Research Service scientific staff in Alaska from 1968 to 1981. Dr. Klebesadel's research emphasis is in physiology and management of forage grasses and legumes; latitudinal, ecotypic, and photoperiodic aspects of adaptation, winterhardiness, and seed production; development of cold hardiness and dormancy; establishment techniques; nutrition and harvest management; evaluation and utilization of indigenous Alaskan grasses and legumes; and ecological physiology and genetics as concerned with germplasm modification within introduced populations during natural selection toward subarctic adaptation.

CHARLES W. KNIGHT, Instructor of Agronomy; Kansas State University '70, B.S., '71, M.S. 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.

WINSTON M. LAUGHLIN, Soil Scientist, Agricultural Research Service, USDA; University of Minnesota '41, B.S.; Michigan State University '47, M.S., '49, Ph.D. Dr. Laughlin's background is as a farm laborer and soil surveyor in Minnesota and as a geodetic computer with 30th Engineers, US Army. Since coming to Palmer in 1949, he has worked with the Agricultural Research Service in cooperation with the University of Alaska, dealing primarily with soil fertility problems and plant nutrient deficiencies.

GARY A. LAURSEN, Visiting Assistant Professor of Mycology; Western Washington State University, Bellingham '65, B.A., B.S.; University of Montana, Missoula '70, M.S.; Virginia Polytechnic Institute and State University, Blacksburg '75, Ph.D. Dr. Laursen's background includes teaching, research, and research administration in the Arctic, specifically at the Naval Arctic Reserach Laboratory in Barrow, and currently with a research appointment at AFES. His research interests include studies of fungi in Arctic, alpine and maritime tundra sites in Alaska, Norway, Sweden, Finland, and

Switzerland. Dr. Laursen's current interests emphasize continued Arctic Alaska fungal ecology and interior Alaska higher plant-fungi associations.

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, past 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, Assistant 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, as well as on tree rusts, wood decays, and mycorrhizal problems. 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.

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.

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, adaptation, 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 revegetative 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.

MAYO MURRAY, Publications Supervisor and Public Information Officer, SALRM, attended the University of Connecticut and the University of Alaska. Mrs. Murray has been with the University of Alaska since 1972, and with SALRM since 1976. As head of publications, she oversees the production of the station's journal, *Agroborealis,* as well as a variety of other publications on a variety of topics; as information officer for SALRM, Mrs. Murray provides information to a wide variety of agencies and publics.

BONITA J. NEILAND, Director of Instruction and Public Service, School of Agriculture and Land Resources Management. University of Oregon '49, B.S.; Oregon State University '51, M.A.; University of Wisconsin '54, Ph.D. Dr. Neiland's research background is in plant ecology with emphasis on soil-vegetation relations and forest regeneration. She has been head of the Department of Land Resources and Agricultural Sciences at UAF. In 1952, she was a Fulbright Fellow to the University of Wales.

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. He was senior silviculturist for 15 years with a forest products company in Canada. 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 technical advisor to the Governor's Timber Task Force.

BARBARA J. PIERSON, Research Associate in 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 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 background of research 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 and supervises the Plant Tissue and Soil Analysis Laboratory in Palmer.

SIGMUND H. RESTAD, Assistant Director of the Agricultural and Forestry Experiment Station, University of Minnesota '53, B.S.; University of Minnesota '54, M.S. Mr. Restad's background includes agricultural extension, research in dairy nutrition and management, administration of the Alaska Division of Agriculture, and executive officer AFES. His present position includes management of the Palmer Research Center.

ALLEN P. RICHMOND, IV, Research Associate, Forestry; Virginia Polytechnic Institute and State University '73, B.S. University of Alaska '83, M.S. After serving 4 years as an officer in the United States Army, Mr. Richmond left the service to attend the University of Alaska. He has worked since 1979 the Intensive Forest Management Project, demonstrating and evaluating various pieces of forestry equipment and silvicultural practices which may improve the productivity of interior Alaska's forest lands. Research has been directed toward determining forest management options available to forest managers.

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 experi-

ment 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.

STEPHEN D. SPARROW, JR., Assistant 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.

MAX STARK, Superintendent, AFES Farm, Fairbanks; Montana State University '42, B.S. Mr. Stark taught vocational agriculture for 35 years. He was also a part-time dairyman and a grower of certified potato and grain seed and spent fourteen summers with the Montana Potato Improvement Association at Montana State University. Mr. Stark retired from his position with AFES in the fall of 1985.

ROSCOE L. TAYLOR, Professor of Agronomy; South Dakota State University '48, B.S.; Iowa State University '50, M.S. Mr. Taylor has extensive experience in crop breeding and production research in Alaska, involving both grain and forage crops. He is responsible for the development of five barley, two oat, two wheat, and one rye varieties adapted to Alaska's growing conditions. Mr. Taylor assisted in the development and maintenance of one variety each of bluegrass, fescue, bromegrass, alfalfa, and red clover. Current research emphasis is on cereal breeding, involving the development of adapted barley varieties possessing urgently needed disease resistance, early-maturing oat varieties suitable for grain and forage, and early-maturing wheat varieties with improved grain yield and quality.

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.

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. Van Cleve 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.

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, ment, 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; 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 of white spruce forests to the environment and how this knowledge can be used to improve forest productivity in interior Alaska.

Financial Statement

Expenditures — July 1984-June 1985

Statement of expenditures of federal and state funds for the fiscal year beginning July 1, 1984, and ending June 30, 1985.

		% of total
Federal		
Hatch Regular Formula Funds	$ 723,904	11
Hatch Regional Formula Funds	154,305	2
USDA-Agricultural Research Service	518,778	8
McIntire-Stennis Formula Funds	205,680	3
Other Grants and Contracts	649,896	11
State Funds	4,170,637	65
Total	$6,423,200	100

1985 Annual Report

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