Agroborealis

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Agricultural and Forestry Experiment Station

School of Agriculture and Land Resources Management

University of Alaska-Fairbanks

Alaska and the Hatch Centennial

The year 1986 is a historic one for the Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks. It marks 80 years of service by the station to the citizens of Alaska.

Early in the history of Fairbanks the local people appealed to the U.S. Department of Agriculture to provide an agricultural experiment station nearby. In response, a federal station was established four and one-half miles northwest of Fairbanks in 1906. In addition, the Department of Agriculture established an experiment station near Palmer in 1915. In 1931, these facilities were transferred to Alaska's Land Grant institution, the Alaska Agricultural College and School of Mines, which opened in 1922 on a site adjacent to the agricultural experiment station near Fairbanks. In 1935, this institution became the University of Alaska.

Today the original federal experiment stations near Fairbanks and Palmer are research farms of the Agricultural and Forestry Experiment Station, School of Agriculture and Land Resources Management, University of Alaska-Fairbanks. This organization within Alaska's Land-Grant university stems from the Hatch Act of 1887 which authorized payments on a formula basis to each state that established an agricultural experiment station within its Land-Grant college. Each station was to engage in systematic scientific study of problems relating to agriculture within the state. In subsequent acts, Congress extended the Hatch Act to Alaska. Thus, along with its counterparts in other states, the Alaska Agricultural and Forestry Experiment Station is part of an integrated network of agricultural research in the United States. On page 4 of this issue of Agroborealis, *Dr. Alvin L. Young of the Office of Science and Technology Policy outlines the importance of the Agricultural Experiment Station System in meeting the challenges of the future.*

In 1987 the Agricultural and Forestry Experiment Station at the University of Alaska-Fairbanks will join with other state agricultural experiment stations in commemorating 100 years of agricultural research by the national system of state agricultural experiment stations. The Hatch Act Centennial itself will be initiated on March 2, 1987, in Washington, D.C. and will include an exhibition of agricultural research at the Smithsonian Institution. State agricultural experiment stations have an excellent record of helping American agriculture meet the food and fiber needs of our nation and many other parts of the world. Research at these stations has helped farmers, foresters, and other land managers solve problems related to pests, diseases, climate, weather, and shifting market conditions. In our complex society, such continuing challenges constitute a mandate for a strong state agricultural research system and demonstrate why this system is essential for our nation.

Nationally, the Experiment Station Committee on Organization and Policy has endorsed the design shown above as the official logo for the Hatch Centennial. The Alaska Agricultural and Forestry Experiment Station is proud to join in the centennial celebration of our nationwide system of agricultural research.

James V. Drew

James V. Drew
Dean, School of Agriculture and Land Resources Management
Director, Agricultural and Forestry Experiment Station

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Managing Editor . . . . Mayo Murray
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ABOUT THE COVER . . . *The Agricultural and Forestry Experiment Station's Fairbanks Research Farm is 80 years old! Established in 1906 by the U.S. Department of Agriculture, the facility continues to serve as a site for scientific studies that help Alaskans meet their food and fiber needs. Here, the farm's barley research fields play host to migrating Canada geese.*

Federal Support of Agricultural Research— A White House Perspective

By

Alvin L. Young, Ph.D.*

My grandfather was a wheat farmer in eastern Colorado. What God-forsaken land in which to raise a family of five girls and one boy. But grandfather was proud to be *not* just a wheat farmer but an innovative farmer. In 1909 he went on horseback to Duluth, Minnesota, (no easy trip in those days) just to purchase a newfangled "Automobile." In his 1909 Holsman he returned to Colorado. His automobile was a star attraction in his community—and with confidence in that new technology, he pursued design and construction of one of the first "Self-Powered" harvesting machines. By 1925, Grandfather ran harvest crews and machines that moved with the season from Texas to Canada. In his community, he was the first to employ new techniques and products. During his days as a farmer he forged crop rotation schemes for the neighbors and was the first to try rock fertilizers. He kept on his desk the current issues of the Sears and Wards catalogues, and it was a delight for him to see the changes that were occurring in his society.

Dr. Alvin L. Young

When my grandfather was 80 I was just a young boy, but I shall never forget that "Big Norweigen" teaching me about raising chickens and how to take care of the property on his remaining homestead. Prior to his death at age 93 in 1969, he shared with me some reflections on his life. He was proud to say that in his lifetime he saw the advent of the automobile, the airplane, the harnessing of the atom, and men walking on the moon. He was proud that I was an Agricultural Scientist, and that I would follow him and meet the challenges of a new day.

Now agricultural science is on the verge of a new step in harnessing and using our knowledge for the betterment of mankind. The methods and products of biotechnology will change the face of our lands and the very fibers of our society. We in agriculture do not follow—we lead. On us rest the responsibilities of using this new knowledge to help feed, clothe, and provide shelter for new generations of mankind.

How is it, you may ask, that we have advanced so far in our research programs while scientists in other countries still struggle to bring their nations to levels of self-sufficiency? The answers lie in our recognition of the value of innovation, competitiveness, and vision. Given tools and the opportunities to learn, from our minds will come innovative ideas.

Our American farmers account for less than three-tenths of one percent of all the farmers in the world. Yet today, each American farmworker produces enough food and fiber for himself and 75 others, more than one-third of whom live in some other part of the world. Clearly the U.S. farmer is the backbone of our agricultural industry, but much of the credit for making this industry the most productive in the world must go the the agricultural programs of our land-grant universities. These universities, through their research and education programs, provide the knowledge for progress.

Before the establishment of the land-grant system, there was nothing uniquely American about higher education on this continent, even though we have had higher education institutions since the 1630s. The University of Georgia was the first state-chartered institution of higher learning, and the University of Virginia was the first tax-supported collegiate institution in America. But when the doors of the University of Virginia opened under the leadership of Presi-

***Senior Policy Analyst for Life Sciences, Office of Science and Technology Policy, Executive Office of the President, Washington, D.C. 20506.**

dent Thomas Jefferson in 1824, there was nothing special about the curricula nor the structure of the university that made it any different from most of the universities of Europe. However, things were soon to change.

It was in 1862 that Justin Morrill's "Land-Grant Act" was signed into law (the same year the U.S. Department of Agriculture was established). Twenty-five years later, an ingenious approach to research was established, specifically, our State Agricultural Experiment Station System with stations in every state and territory, characterized by decentralized management, shared funding, and the practical application of scientific principles. It is refreshing to see that the concepts upon which this system was established nearly a century ago seem to be even more appropriate as we approach the second century.

A quarter of a century after the establishment of the Experiment Station System, a parallel program was established for Cooperative Extension, a system dedicated to assembling and disseminating the newest knowledge in a usable form to the farmers and ranchers of America. My own family as well as our contemporaries have benefited over the decades. The research community has had numerous other programs, including the McIntire-Stennis program for forestry research, the Evans-Allen program for the Colleges of 1890 and Tuskegee Institute, animal health research, marketing research, and research on environmental concerns. All of these were coupled through the land-grant system to the teaching programs of those institutions.

In 1898 an Agricultural Experiment Station was established at Sitka in the Territory of Alaska with the responsibilities of supporting resource management activities. In 1985, the Alaska Agricultural Experiment Station became one of only three in the nation to include the responsibilities for forestry, thus becoming the Agricultural and Forestry Experiment Station.

During 1984 and 1985, in meeting my responsibility as the Agricultural Research Advisor to Dr. Jay Keyworth, the President's Science Advisor, I have visited many of our Land-Grant Institutions and our Federal Agricultural Laboratories. Doom and gloom have not been what I have seen. Indeed, what I have seen is the intense interest and enthusiasm of young men and women learning to use the tools of biotechnology. Clearly, technological changes are occurring at incredible speed. I have noticed how quickly the new generation has become computer oriented. Indeed, computerized information systems are creating a revolution in the dissemination of research results and the marketing of farm products. Yet, the most critical challenge at these institutions must be the development of our nation's human resources—our young men and women. Their shoulders will carry the burdens of our mistakes and the glories of our successes.

There is no doubt that the agricultural scientific community must attract and train the men and women whose skills will be needed in such areas as molecular genetics, systems analysis, engineering, plant sciences, international marketing, animal health, and human nutrition. For our farms to improve their efficiency and for our nation to compete successfully in the global marketplace, we will depend on the laboratory, the research stations, and the classrooms to develop and disseminate the most valuable of all tools—knowledge.

For these changes to occur, however, the transition that the scientific community must undergo will take more than ability and hard work. It will take a heavy financial commitment and a proper environment to encourage innovation, competitiveness, and vision. This means a recommitment of Federal and State funding for research. This is especially true for the situation now facing plant and animal sciences. Two decades of minimal Federal, State, and industrial support for these sciences has left this nation an infrastructure inadequately prepared to capitalize on the recent advances made in modern biology. The fact is that minimal Federal support for research has contributed to:

- An economic plight of agricultural enterprises dependent upon such natural resources as our rangelands and forests.
- Environmental concerns arising from real and perceived perturbations to rangelands and forests.
- A decline in size and quality of our professional scientific cadre.
- A decline in student enrollment.

As with other areas agricultural research, we are, as the economist would say, "spending the principal at a faster pace than the interest is accruing."

New knowledge has to be discovered. New technologies need to be developed and perfected. New generations of scientists, engineers, technicians, and managers have to be educated. For decades now, the nation's research and educational establishments have been pressured to create a constantly increasing base of scientific knowledge, technological innovations, and well-qualified manpower. Pressures have been strong, and successes have been notable. But the wellspring of fundamental knowledge from which new management systems must be derived is no longer adequate to assure continuing success. If the quality of natural resource management is to continue to improve, the present state of theory and understanding of complex systems must be advanced.

I could go on with numerous examples which would illustrate that we are in the midst of a scientific and technological revolution which is unmatched in history. We are now collecting dividends on the investments we made in basic research after World War II. The encouraging conclusion is that this revolution is one that we created and it is one we ought to be able to sustain.

Some people seem to see only the danger in technological change and allow this fear to play into the hands of people who have other motives. They then use the fear to slow or stop progress. We of course would not advocate pushing the frontiers blindly or throwing caution to the wind. In fact, this is one of the reasons to make sure that groups of researchers are interdisciplinary; that they consider the ethi-

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Notice of Release of 'Nortran' Tufted Hairgrass

By

William W. Mitchell*

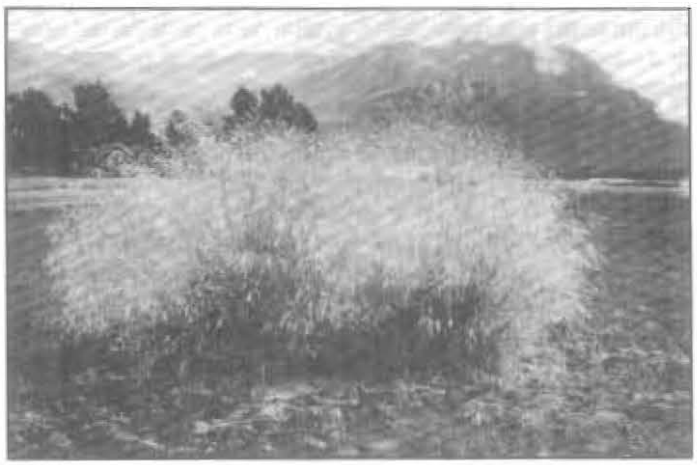
The Agricultural and Forestry Experiment Station, University of Alaska-Fairbanks, announces the release of 'Nortran', a cultivar of tufted hairgrass [*Deschampsia caespitosa* (L.) Beauv.]. The new variety is recommended for revegetation use, for low-maintenance ground cover, and, under some circumstances, for forage or pasture use at northern latitudes. Nortran is believed to be the first cultivar developed of this species of grass; however, 'Norcoast', a cultivar of the closely related species Bering hairgrass (*D. beringensis* Hultén), was previously released by this experiment station.

Nortran is tufted grass with most of its leaves produced in a basal clump. Flowering culms are numerous and have relatively long, diffuse inflorescences. Nortran tufted hairgrass tends to have shorter, narrower leaves that are darker green than those of Norcoast Bering hairgrass. Inflorescences of Norcoast are straw colored, whereas those of Nortran are more variable but often are bronze to gunmetal in color and generally are shorter, as are the spikelet parts. Inflorescences of Nortran are produced erect above the leaves, thus seed harvest is readily accomplished with a combine. Seed production of 150 to over 200 lbs per acre (170 to over 225 kg/ha) can be expected.

Tufted hairgrass is distributed widely through circumpolar regions; it occurs from the north coast of Alaska southward through the Rocky Mountains of the western states. In Alaska, tufted hairgrass is mostly an inland grass while Bering hairgrass is restricted to the coastal areas and islands of the western to southeastern portions.

Nortran tufted hairgrass is based on indigenous plant collections made in Alaska and Iceland. Breeding material for Nortran is a composite of four components: IAS 239 derived from a collection at Galena on the Yukon River, IAS 458 derived from a collection in the Talkeetna mountain range north of Palmer, and IAS 371 and IAS 284 derived from collections made in Iceland. Each component is seed-propagated in isolation, and the breeder material composited of amounts of pure, live seed equalling 30 percent of IAS 371, 20 percent of IAS 284, and 25 percent of each of the other two components.

The components have been tested in revegetation trials on coal spoil materials at stripmine locations in central interior and southcentral Alaska and in forage trials at various locations in southcentral Alaska and interior Alaska. One of the components has been tested in turf grass trials at the Palmer Research Center.



The tufted nature and abundant heading characteristic of plants of 'Nortran' tufted hairgrass are evident here. The two plants pictured above are parents to one of the components in the breeding material of Nortran. Trials with the components of Nortran have shown adaptations for revegetation and ground cover uses and possibly for forage purposes in some situations.

These tests demonstrate possible revegetation uses for Nortran from low elevation to alpine situations through the southcentral to central interior portions of Alaska. Its applications in the more northern to Arctic regions of Alaska are not well defined and may be marginal, particularly in the Arctic. The cultivar can tolerate strongly acidic soils and appears resistant to rusts and snow molds that may affect cultivars of Kentucky bluegrass and red fescue. Nortran has the ability to reseed itself on disturbed sites. Its short, but persistent, growth under a low-fertility regime suggests a possible use for Nortran as a low-maintenance ground cover.

In forage trials under a two-harvest system on acidic soils, Nortran components generally have not equalled the first-harvest yields of timothy but have provided better regrowth and sometimes more total production. The single component entered in turf trials has shown excellent persistence under frequent mowing. These trials suggest an adaptablilty to grazing use. Trials have not been conducted, however, on its acceptance by animals. The species is grazed in the Rocky Mountains and in Iceland, where it also is cut for forage; it may be utilized elsewhere, as well.

***Professor of Agronomy, University of Alaska-Fairbanks.**

A small amount of breeder seed currently is available for increase. Seed classes of Nortran are limited to: breeders, foundation, and certified. Breeder seed is maintained under the supervision of the Alaska Agricultural and Forestry Experiment Station. Increase of breeder and foundation seed is administered through the Alaska Seed Growers, Inc., 533 E. Fireweed, Palmer, AK 99645.

Acknowledgments

I extend my thanks to the U.S. Department of Energy for its substantial monetary support for revegetation research and to the Alaska Division of Mines and Mining for its support in the continuation of that research, also to the Usibelli Coal Mine, Inc., and to Placer Amex, Inc., for their support and cooperation in providing access to and use of stripmine locations on which to conduct the research. The cooperation of the Agricultural Research Institute of Iceland and in particular of Dr. Thorsteinn Tomasson and Dr. Bjorn Sigurbjornsson made possible the inclusion of Icelandic germplasm in this cultivar, for which I am grateful. Special thanks go to my valuable assistants in the field, laboratory, and office, without whom the work necessary to produce this cultivar could not have been accomplished. □

A White House Perspective, continued . . .

cal and environmental consequences of research as they proceed and produce outcomes which have built-in safety nets. What we fear is that the adversary system of recent years will otherwise rear its head, and that we as a nation will be forced to make decisions based upon oratory and legal maneuvers rather than upon logic. Many of us believe that such use of fear, for whatever purpose, could cause our nation not to take advantage of the tremendous technological strength we have.

Our aim, in the office of Science and Technology Policy, then, is to support initiatives which manage change well, which catalyze opportunity so that it in turn has maximum likelihood to contribute long-term economic growth.

In state governments we are witnessing an investment in economic growth that is coupled with a re-emergence of interest in quality education. Nearly every time a legislator talks, he points to Route 128 in Boston, or to Silicon Valley in California, or to the Research Triangle in North Carolina as proof of how economic development is tightly coupled to quality higher education.

And students are beginning once again to return to the fields of science and technology. They can see the future and, since the media are no longer referring to them as the "me" generation, it can't be simply for selfish reasons.

We are also seeing industry support for the concept of research in universities even with some of their precious operating dollars. Almost all business is recognizing the need to have long-range research of the highest quality going on in universities, not for the *trained* students (and I use that word carefully), but for the *educated* students they produce and for the free environment which allows research to proceed where it will. And finally industry has understood that it cannot gain for long if it simply hires away the faculty for its own (usually short-range) programs. Industry recognizes how important the university technical base is to its future and how it is trying strengthen the research capability on campuses and to share its perspectives on important areas of research.

The challenges confronting us in Agricultural Research are great. But challenges to us are opportunities! Rather than painting a negative picture, I chose to paint for you a positive view. I'm positive because I see among you leaders who meet challenges. Alaska is a land of challenges and most of you would not be here today if you were not prepared to face those challenges. You folks are bridge builders—individuals who respond not to the needs of the scientific community but to the needs of your state and our nation.

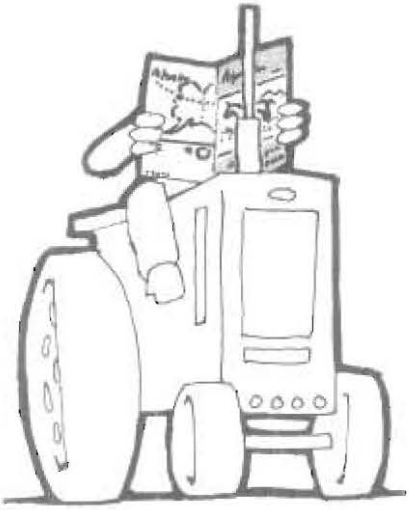
Let me end by telling you what Mr. Will Dromgoole describes as "The Bridge Builder."

An old man going a lone highway
Came at evening cold and gray
To a chasm vast and deep and wide
The old man crossed in the twilight dim,
The sullen stream had no fears for him
But he turned when safe on the other side
And built a bridge to span the tide.

"Old man," said a fellow pilgrim near.
"You are wasting your time with building here
You never again will pass this way —
Your journey will end with the closing day.
You have crossed the chasm deep and wide
Why build you this bridge at eventide?"

The builder lifted his old gray head.
"Good friend, in the way that I've come," he said,
"There followeth after me today
A youth whose feet must pass this way
This stream that has been naught to me,
To the fair-haired youth might a pitfall be.
He, too, must cross in the twilight dim;
Good friend, I'm building the bridge for him."

Editor's note: The foregoing is the text of an address delivered on November 22, 1985, at the Eighth Annual Alaska Agricultural Symposium, held at Fairbanks, Alaska.



AFES Notes

A new $2.2 million research laboratory has been completed and is operating at the Matanuska Research Farm near Palmer. The 12,800-square-foot facility was completed in July 1985 and replaces the obsolete lab facilities at the Palmer Research Center.

The lab analyzes soil, plant tissue, milk, animal feed, water, waste oil, and wildlife fecal samples. The lab provides analytical services to over fifty university research projects and state, Federal, and private consulting and mining companies as well as out-of-state interests. In addition, services are provided for Cooperative Extension Service soil- and feed-testing programs. There were 17,000 soil and plant tissue samples analyzed in FY 1986, with more than 75,000 total determinations. AFES cooperates with the Northcentral Lab Committee and Western Regional Soil Survey Committee to calibrate and modify procedures and to ensure quality. The facility provides for horticultural and plant pathology lab work as well. The operation provides for the consolidation of the station's expensive laboratory analytical work in one area in order to help mitigate the cost and operation of expensive, up-to-date procedures.

Lee Allen, associate professor of agricultural engineering, retired from the Agricultural and Forestry Experiment Station, Palmer Research Center, on January 31, 1986, after thirty years of service. Professor Allen has an agricultural engineering degree from Montana State University. He was active in gathering Alaska weather data and relating observed weather parameters to plant development and quality; evaluating energy-efficient structures and investigating renewable energy sources and their application to Alaska's high latitude agriculture through the use of plastics, solar ventilators and heat sinks; and handling agricultural engineering problems including low-cost grain drying, wood treatment, building ventilation, and land-clearing methods.

Two long-time employees from the Palmer Research Center support staff have retired since the last publication of *Agroborealis*. **Bud Patton,** agricultural supervisor for plant breeder **Roscoe Taylor,** began working for AFES at Palmer in 1959 and retired October 1985. Mr. Patton built up a remote homestead across the Little Susitna River while working at the station. His support to agricultural research provided a significant contribution to the many varieties of grains and grasses that have been developed at the Palmer Research Center during his twenty-six years of employment.

Glenn Smith, laboratory technician, retired September 1985 after 18 years of service to the Palmer Research Center. He provided a substantial contribution to agricultural research and service to agriculture by operating the old lab in downtown Palmer. Most of his service was working with **Winston Laughlin,** soil scientist with the Agricultural Research Service, who retired recently after thirty-five years of service.

. . . **Continued on page 30**

Use of a Plant Growth Regulator On Barley to Prevent Lodging

By

Ann J. Rippy* and Frank J. Wooding**

Introduction

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. Yields may also be lowered by the loss of grain in the field due to failure of harvesting machines to pick up low-lying grain heads. Lodged grain dries more slowly in the field, which in turn, delays harvest operations, increases after-harvest drying costs, and, in some cases, may result in lower-quality grain (Pinthus 1973).

Very early-maturing varieties are essential for successful barley production in 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 trade name Cerone®, is a plant growth regulator which can effectively reduce plant height and increase stem diameter.[1] Reduced plant height and increased diameter can increase straw strength and prevent lodging in barley (Wooley 1980). Cerone shortens the last internodes of the stem, particularly the one just below the grain head (Squires et al. 1980). The chemical breaks down inside plant tissue to form the natural plant hormone ethylene, which reduces cell division and cell elongation (Warner and Leopold 1968). Cerone is applied between the time the flag leaf is first visible and the swollen boot stage.

[1]This product is manufactured by Union Carbide and has been used in Europe for several years.

*Graduate research assistant, Agricultural and Forestry Experiment Station, Fairbanks. Currently with the USDA Soil Conservation Service, Fairbanks.

**Professor of Agronomy, Agricultural and Forestry Experiment Station, Fairbanks.

Preliminary investigations with Cerone were conducted at the Fairbanks Research Center of the Alaska Agricultural and Forestry Experiment Station during the summer of 1984. In these studies, the effectiveness of this chemical as an antilodging agent for barley was tested when applied at different rates and at different stages of growth. The studies were conducted on a Tanana soil under dryland conditions. 'Otra' barley was selected as the test variety as it is prone to lodging. All treatments received uniform, high applications of fertilizer.

Rate of Cerone Application

Barley was subjected to spray applications of Cerone during the early boot stage of growth. At this stage of growth, the flag leaf is emerging and the immature grain head is located in the lower portion of the stem and is not visible unless the stem is torn apart. The chemical was applied at rates of 0.0, 0.5, 1.0, 1.5, 2.0, and 4.0 pints per acre. The manufacturer recommends 1.0 pint per acre.

Grain yields, lodging estimates, and plant heights for the Cerone treatments are presented in Table 1. The control treatment, receiving no Cerone, lodged severely. For this study, Cerone rates of 1.5 pints per acre or higher effectively controlled lodging. Lower rates of application reduced,

Table 1. The effect of Cerone rate on grain yield, lodging, and plant height of 'Otra' barley.

Cerone Rate (pints/acre)	Grain Yield[1] (bu/acre)	Lodging[1] (%)	Plant Height[1] (inches)
0	102.1	70.1	41.3
0.5	121.8[2]	38.8[2]	38.5[2]
1.0	115.3[2]	30.1[2]	35.3[2]
1.5	105.5	5.0[2]	33.5[2]
2.0	100.0	5.0[2]	33.3[2]
4.0	99.5	3.8[2]	31.8[2]

[1]Each number is the mean of four replications of that treatment.
[2]Indicates significant difference from the control at $\alpha = .10$.

Cerone

no Cerone

Figure 1. Barley plants which received a foliar application of Cerone remain upright from the beginning of ripening (upper left) to fully ripe (upper right). Barley plants which received no Cerone are starting to lean during the early ripening growth stage (lower left) and are severely lodged by the time ripening is complete (lower right).

but did not prevent, lodging. However, it was the two lower rates of Cerone that resulted in higher grain yields. The 0.5- and 1.0-pint rates produced grain yields that were 19.3 and 12.9 percent greater than the control treatment, respectively. Cerone rates of 1.5 pints per acre or greater had no noticeable effect on yield.

The reduced lodging resulting from use of this chemical is primarily due to increased stem diameter and decreased stem height (Wooley 1980). Figure 1 illustrates the relative plant height reduction and control of lodging which can result from Cerone application. Application rates of 0.5, 1.0, and 1.5 pints per acre resulted in height reductions of 6.7, 14.5, and 18.8 percent, respectively. Cerone rates greater than 1.5 pints per acre had little additional effect on plant height.

Time of Cerone Application

Cerone was foliar applied at growth stages 5, 7, 9, 10, and 10.1 of the Large-Feekes scale illustrated in Figure 2. The manufacturer recommends application of Cerone between growth stages 8 and 10. Cerone was applied at the manufacturer's recommended rate of 1 pint per acre. The control treatment received no Cerone. Grain yields, percent lodging, and plant heights for each stage are listed in Table 2.

Cerone applied at the two earliest growth stages (stages 5 and 7) resulted in the highest grain yields, even though

Table 2. The effect of Cerone applied at different growth stages on grain yield, lodging, and plant height of 'Otra' barley.

Growth Stage (Large-Feekes scale)	Grain Yield[1] (bu/acre)	Lodging[1] (%)	Plant Height[1] (inches)
Control	103.9	60.0	40.8
5	111.2	70.0	40.5
7	112.0	55.0	38.0[2]
9	109.5	40.0	36.5[2]
10	105.4	35.0	38.5[2]
10.1	108.8	32.5[2]	37.5[2]

[1]Each number is the mean of four replications for that treatment.
[2]Indicates significant difference from the control at α = .10.

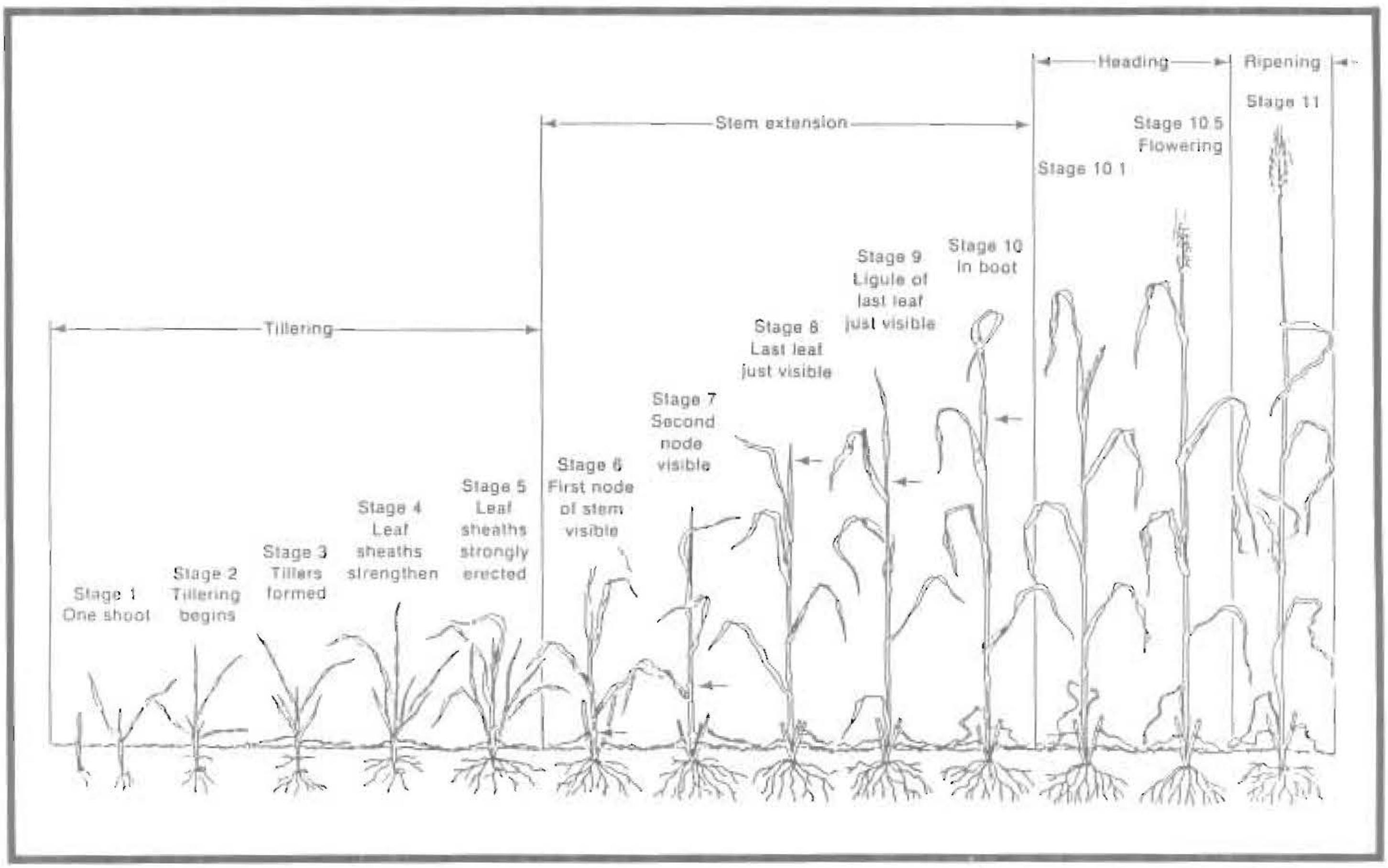


Figure 2. Growth Stages of barley from seedling emergence to maturation (referred to as the Large-Feekes scale). The arrows show the location of the growing point of inflorescence in stages 6 to 10. [From Growth Stages in Cereals by E.C. Large. 1954. IN: Plant Pathology *3:128-129. Redrawn with permission of Her Britannic Majesty's Stationery Office and the publishers of* Plant Pathology*].*

application at that time had only a slight effect on lodging and plant height. It should be noted that test plots were harvested by hand. In field situations, it is probable that the increased yields at stages 5 and 7 would be lost due to problems in harvesting lodged grain.

Lodging was effectively reduced when Cerone was applied at growth stage 9 or later. Application at stages 9, 10, and 10.1 resulted in lodging reductions of 20, 25, and 27.5 percent, respectively.

Results are Promising but More Research is Needed

Results from this investigation indicate that Cerone may provide substantial benefits for barley growers in Alaska. However, additional information is needed to more clearly define 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. Results for 1985 field trials indicated that weather may influence the effectiveness of Cerone. Specifically, cool, wet weather at the time of application may drastically reduce the response of barley to Cerone.

Additional studies should be conducted to determine the effects of Cerone on different types and varieties of barley recommended for Alaska. There is also a need to determine the effects of irrigation and increasing levels of fertilization on the amount of Cerone needed to control lodging. The economics of using this product should also be examined. If Cerone can increase yields by allowing higher levels of irrigation and fertilization without increasing the risk of lodging, will the financial returns outweigh the additional expense? These questions are currently under investigation at the Agricultural and Forestry Experiment Station. □

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Natural Selection May Modify Introduced White Clover Toward Superior Winterhardiness

By

Leslie J. Klebesadel*

The valuable contribution of legume forages to livestock production has been recognized since ancient times; this recognition and the widespread use of legumes continues throughout the world today. Forage legumes are valued for their good palatability and high nutritional value. The nutritional excellence of legumes derives in part from their ability to capture atmospheric nitrogen with the assistance of beneficial symbiotic bacteria (Klebesadel 1978). The nitrogen thus incorporated into legume plant tissues contributes to the high protein concentrations in legume herbage. Not only do legumes benefit directly from this vital capture of nitrogen, but roots of grasses growing in association with nitrogen-fixing species are able to draw upon and benefit from the fixed nitrogen as well.

Herbaceous legumes are valued also for purposes other than pasture and forage. The low-growing white clover (*Trifolium repens* L.) often is included in lawn seed mixtures, and white clover and several other legume species are included in seed mixtures planted for revegetation, control of soil erosion, and ornamental purposes. The flowers of legumes provide bees with nectar and pollen, and many types of wildlife feed on legume herbage and seeds (Graham 1941).

Native Alaskan Legumes

Alaska's native flora includes a wealth of herbaceous legumes (Klebesadel 1971a). About fifty species occur in the state, and they vary in growth form from tiny, tufted types to some that are tall and leafy. Most are classified within the two genera *Astragalus* and *Oxytropis*, but a few species occur within certain other genera (*Lathyrus*, *Hedysarum*, *Lupinus*, and *Vicia*).

The many native legumes are a valuable element in the total flora. They occur in numerous habitat types from shorelines to interior forests, and from low-lying tundra to alpine sites. Some serve as "pioneer" species on river gravels left by glacier retreat, and all contribute fixed nitrogen to their respective ecosystems (Allen et al. 1964, Alexander et al. 1978). All possess ideal physiologic adaptation to Alaska's subarctic climatic patterns and most are very winterhardy here (Klebesadel 1971a, b; 1980).

None of Alaska's native legumes, however, are species valued for cropland forage production. Numerous native species judged initially to have potential for forage production potential have been evaluated in experimental studies, but all possess from minor to major agronomic defects that affect their usefulness (Klebesadel 1971a). Attention therefore has been directed toward identifying the best adapted and most winterhardy strains within other legume species that have been used traditionally for forage purposes elsewhere.

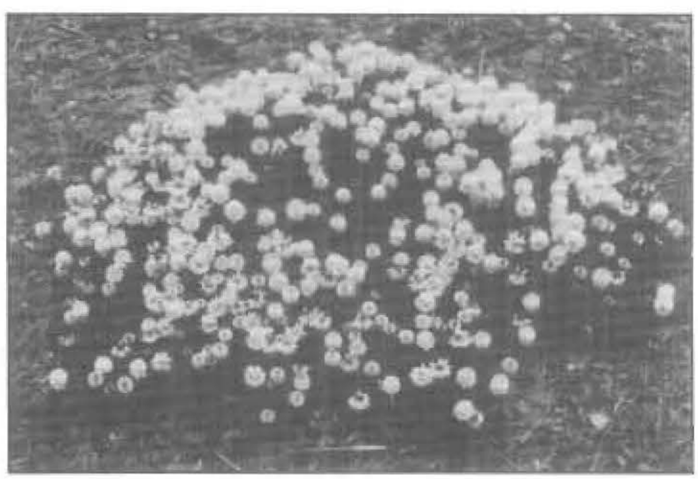

Figure 1. An individual plant of white clover. Photo taken 29 June when plant was in full bloom. Pen provides size comparison.

* **Professor, Agronomy, Agricultural and Forestry Experiment Station, Palmer.**

Winterhardiness Problems

In contrast to Alaska's native legumes, introduced legumes that are useful and valued as livestock forage in other areas of the world generally are not adequately winterhardy when grown in field culture in Alaska (Irwin 1945; Klebesadel 1971b, 1980, 1985).

A number of species of forage legumes have been introduced into Alaska and have "escaped" from field culture to become naturalized, well established, and persistent populations, especially along Alaskan roadsides. However, there are significant and critical differences between the winter stresses imposed on plants that grow in roadside habitats and those that grow in adjacent fields. Therefore, simply because a plant thrives along Alaska's roadsides or in other unharvested situations does not ensure that it will perform equally well in cropland use.

The differences in stresses between roadsides and fields are due to both artificial and natural effects. Harvesting of field-grown plants once or twice per growing season can impose considerable stresses on food reserves and physiologic processes within the plants, stresses not experienced by unharvested roadside plants. Furthermore, field-grown plants usually are left with only a short stubble at the end of the growing season, and strong winter winds can remove virtually all of the protective mantle of snow. In roadsides or other undisturbed habitats, tall plant growth holds the protective snow in place, and plants there are subjected to much less winter stress. A few to several inches of insulating snow cover over plants protects their overwintering organs from dehydration, from injuriously low air temperatures, and from harmful warm temperatures during freeze-thaw fluctuations that often occur locally. Warm temperatures during winter can break the dormancy of plants. If a warm period is prolonged, the protective snow cover can melt and refreeze as a layer of ice. Ice is greatly inferior to snow as insulation over plants; moreover, ponded ice can cause smothering of plants.

Even within a single lawn the protective influence of snow can be seen. White clover will survive in Matanuska Valley lawns where wind patterns leave drifts of snow in place all winter. In immediately adjacent lawn areas swept bare of snow, however, white clover commonly winterkills completely.

Throughout Alaska, numerous roadside populations of introduced legumes have persisted successfully for many years. White clover is one of the species frequently seen. Despite being subjected to somewhat lesser winter stresses, these roadside legumes have nonetheless been exposed during a long term of residence to Alaska's uniquely north-latitude climatic conditions. It is quite possible that the effects of natural selection pressures over many plant generations could alter their genetic makeup toward heightened physiologic compatibility with the specific seasonal photoperiodic patterns and temperature stresses in this northern area. Such increased harmony between plant and environment could lead to genotypes of white clover that possess winter survival characteristics superior to that in strains or varieties brought to Alaska directly from various other world sources.

White Clover Characteristics

White clover is one of about 250 species in the legume genus called *Trifolium* (Carlson et al. 1985). It is a long-lived perennial under favorable growing conditions. Plants spread both vegetatively by extension and branching of the prostrate stems, called stolons (fig. 2), and by the production of seeds.

The only aerial or elevated portions of the plant are the white, ball-shaped flowers on slender stalks and the profusion of leaves, each of which consists of a petiole stalk topped by three leaflets (fig. 2). Discovery of an occasional "four-leaf clover" is considered to confer good luck upon the finder.

White clover is acknowledged to be one of the most nutritious of the world's forage legumes (Gibson and Hollowell 1966). Because the plant's prostrate stems are rooted and held fast to the soil, only leaves and flowers are removed by harvest equipment or grazing livestock. This herbage is very palatable, low in fiber, and highly digestible. It is also high in protein and generally higher in nutritionally important minerals than grasses. Other benefits attributed to white clover in pastures are improved animal health, milk flow, calf weaning weights, daily gains, and conception rates (Carlson et al. 1985). Beyond the dominant use by cattle, white clover also is valued as a high-protein forage for swine and poultry.

White Clover Types

Authorities generally recognize three main types of white clover, based on size of plant parts; these are referred to as *small, intermediate,* and *large,* or *giant,* types (Carlson et al. 1985, Duke 1981, Gibson and Hollowell 1966). All are interfertile, and some intergradation is apparent between the major types.

The small type often is referred to as "wild" white clover. It is common in pastures subjected to heavy grazing pressure, and it withstands close defoliation. Its size restricts its forage yields, and so it is rarely seeded, but is found as a volunteer plant in agricultural areas. It is especially common in pastures in Great Britain.

The intermediate type is intermediate in size of plant parts between the small and large types, and includes most of the regional or common strains and many selected and named cultivars used principally in pasture seed mixtures.

The large, or giant, type of white clover is also called ladino clover. All plant parts are larger than intermediate white clover except the seeds, which are the same size. First records of ladino clover's existence date to 1848 when it was identified in the Po River valley of Italy near 45 degrees north latitude. Records indicate ladino clover was first introduced into the United States in 1848 (Gibson and

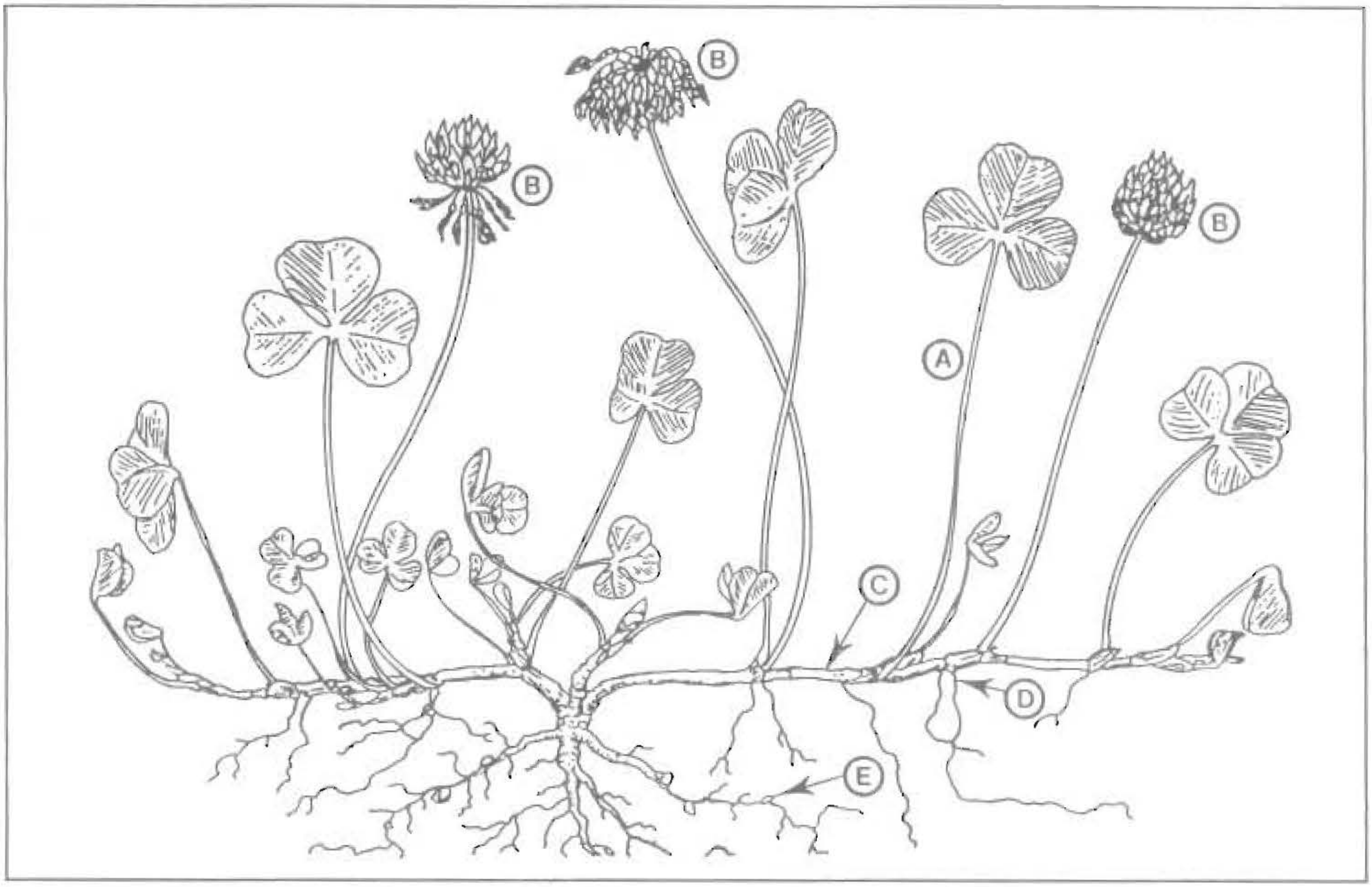

Figure 2. Drawing of white clover plant showing plant parts. A = leaf, consisting of petiole stalk and 3 leaflets; B = flowers in different stages of development; C = Prostrate stem or stolon; D = Root from node on stolon; E = Root nodule containing beneficial bacteria able to capture atmospheric nitrogen for plant.

Hollowell 1966). Owing to its Mediterranean-area origins, ladino clover generally is less winterhardy than the intermediate and small white clovers. Because its growth is sufficiently tall for recovery with harvest equipment, ladino is more often included in forage mixtures intended for mechanical harvest than are the two smaller types. Several named cultivars of ladino clover have been developed and released in North America and abroad (Carlson et al. 1985, Duke 1981, Gibson and Hollowell 1966).

White Clover Distribution

White clover is one of the most widely distributed of all the forage legumes. The species is believed to have originated in the eastern Mediterranean region or Asia Minor (Carlson et al. 1985, Duke 1981, Gibson and Hollowell 1966). Animal caravans spread white clover throughout Europe and western Asia. It is believed the species was cultivated in the Netherlands in the late 1600s, and it was introduced into England during the 1700s (Carlson et al. 1985).

Its distribution throughout the world has followed human migration, and the evolution and spread of white clover is closely associated with the domestication of cattle (Carlson et al. 1985). Not that the only consumption of white clover has been by livestock—Lightfoot (1792) states "In Ireland the poor people, in a scarcity of corn, make a kind of bread of the dry'd flowers of [white clover] reduced to a powder. They call the plant *Chambrock*, and esteem the bread made of it to be very wholesome and nutritive."

Early colonists brought white clover to America. The range of the species in the Western Hemisphere now extends from Alaska to southern South America. It is estimated that half of the 111 million acres of humid or irrigated pastureland in the U.S. contains varying amounts of white clover (Carlson et al. 1985, Duke 1981).

Earlier White Clover Evaluations in Alaska

The introduction of white clover into Alaska is recorded as a planting at the Sitka Experiment Station in 1902 (Irwin 1945). Other early plantings followed at territorial experiment stations at Copper Center and Kenai in 1903, Rampart in 1906 and 1908, Fairbanks in 1912, and the Matanuska Station in 1919. From these early plantings, and undoubtedly numerous other introductions, white clover has become a familiar species in many areas of Alaska. From field and turf plantings, it has spread to many sites of past and present settlements and to many trails, roadsides, and other disturbed areas.

Irwin (1945) summarized early results of trials at the Matanuska Station between 1919 and 1942 when a total of twenty-six varieties and strains of white clover were evaluated. Excellent stands and growth were obtained in the seeding years, but large-leaved varieties died the first winter. Small-leaved, low-growing strains were found to be the most winterhardy, and they were also more palatable to grazing sheep and cattle than the larger-leaved white clover.

In early trials at Rampart, Alaska's northernmost territorial experiment station, white clover invariably winterkilled the first winter. Similar results occurred at the Copper Center and Matanuska Stations when it was seeded alone; winter survival was improved at those stations and at Fairbanks when the clover was seeded with a grass.

Recent Alaska Collections

Alaskan agronomists have collected seed from a great number of native and introduced legumes and grasses throughout the state during the last 20 years. Plants grown from these seed collections have been evaluated for numerous purposes in field nurseries at the Matanuska Research Farm. Some seed lots of white clover were included among these, and certain recent collections have been of special interest.

White clover *Collection AK-3* was made in 1980 from a large roadside population in southcentral Alaska's Matanuska Valley. This area is less subject to the extremely low midwinter temperatures common in Alaska's Interior, but is more subject to other stresses such as (a) winter winds that sweep away insulating snow cover and (b) winter temperature fluctuations that often include midwinter thaws followed by refreezing.

Two other collections of white clover seed were made in 1982 at roadhouses along the Richardson Highway in Alaska's Interior. The Richardson Trail was an early transportation artery from Valdez, a shipping point on Alaska's south coast, to Fairbanks, a mining center in the territory's Interior. Along its 380-mile length, a series of roadhouses was established for trade, lodging, and the pasturing and stabling of draft horses used for drawing wagons and sleds along the trail.

Collection AK-4 was made at Bennett's Roadhouse (fig. 3), built near the Tanana River in 1904 about 10 miles north of the present community of Delta Junction. *Collection AK-5* was harvested in the vicinity of Old Richardson Roadhouse which was moved to its present location in the 1920s. No known records exist to indicate when white clover first became established at those roadhouses. However, it is likely that seed was included in imported hays or seed lots, and it is possible that white clover may have persisted at those locations for over half a century. Emphasis on draft-horse use along the Richardson Trail diminished gradually with the advent of motor vehicles in the 1920s and 1930s. These three white clover collections were included in a field experiment at the Matanuska Research Farm during 1984-85.

Figure 3. Bennett's Roadhouse (once called Rika's Roadhouse) on the Richardson Trail near the banks of the Tanana River. Horses were pastured and stabled here near the beginning of this century. Collection AK-4 was made near here from a white clover plant population that probably has persisted for many years.

Experimental Procedure

Fertilizer disked into a plowed Knik silt loam seedbed supplied N, P_2O_5, and K_2O at 32, 128, and 64 pounds per acre, respectively. On 18 June 1984, several strains of legumes within four species, and from various world sources (table 1), were seeded in rows 28 feet long and 18 inches apart. A randomized complete block experimental design was used with four replications. When seedlings were 1 to 3 inches tall, they were thinned by hand pulling to leave individual seedlings 6 to 8 inches apart. In spring of 1985, when surviving plants had started to grow, living and dead plants were counted in all rows and percent winter survival was calculated for each strain.

Results and Discussion

Very striking differences were noted in spring 1985 in winter survival among legume species, cultivars, and strains (table 1). An Alaskan strain of siberian alfalfa (*Medicago falcata* L.) and Denali, an Alaskan cultivar of variegated alfalfa (*M. sativa* L.), survived the winter with virtually no stand loss. In sharp contrast, all four cultivars of

Table 1. Comparative winter survival of strains of white clover and other legumes from various world sources grown as individual plants in rows at the Matanuska Research Farm. Planted 18 June 1984.

Species	Selection, strain, or cultivar	Origin	Percent winter survival
White clover:	AK-3	Alaska	87
	AK-5	"	69
	AK-4	"	49
	Tammisto	Finland	23
	Hja-364	"	5
	Sonja	Norway	0
	"White Dutch"	USA	0
Red clover:	Alaskland	Alaska	0
	Pradi	Norway	0
	Tripo	"	0
	Kenland	Kentucky	0
Alsike clover:	Alpo	Norway	0
	Tammisto	Finland	0
	Tetra	Sweden	0
	Aurora	Canada	0
Alfalfa:	*M. falcata*	Alaska	99
	Denali	"	98

red clover and four of alsike clover winterkilled 100 percent, regardless of origin.

Only with white clover were there wide differences in winter survival of strains within a species. Of the seven strains evaluated, survival ranged from none (Norwegian Sonja and commercial "White Dutch" from the USA) to very good (87 percent in AK-3). Alaska collections AK-5 and AK-4 displayed somewhat poorer survival at 69 percent and 49 percent, respectively. However, all three Alaska collections surpassed by a wide margin the 23 percent and 5 percent survival of Tammisto and Hja-364, respectively, both from Finland.

The differences in winter survival noted in the present test between red clovers and white clovers parallel findings of Ruelke and Smith (1956) in Wisconsin. They found (using common Wisconsin strains) that medium red clover developed cold tolerance in overwintering tissues later in autumn, and developed a lesser level of cold tolerance, than white clover. Such differential patterns of cold-tolerance development, if similar in Alaska to trends in Wisconsin, could account for the 100 percent winterkill of all red clovers in this test, as contrasted to the much better survival in several of the white clover strains.

Of substantially greater interest, however, are the wide differences found in winter survival among the seven white clover strains (table 1, fig. 4). Not surprising was the 100 percent winterkill of the "White Dutch" strain from an unknown origin within the conterminous 48 states far to the south of Alaska. Poor winter survival in Alaska of forage legumes adapted to midtemperate latitudes is well known (Klebesadel 1971a, b; 1980; 1985).

The origins of the other three non-Alaskan white clovers, however, are from latitudes much more similar to those of Alaska. The cultivar Sonja from Norway winterkilled totally, and survival of Tammisto and Hja-364 from Finland was very poor as compared to the three Alaska collections (table 1, fig. 4).

The origins of the white clover genetic stocks that gave rise to the naturalized populations at the three locations in Alaska from which seed lots AK-3, AK-4, and AK-5 were collected are unknown. However, it is known that the three white clover stands from which seed was collected had probably persisted in Alaska for a considerable number of years. Moreover, virtually all commerce (such as introduction of seed lots or imports of hays containing seeds) with the territory during the nineteenth century and the first half of the twentieth century was from the west coast of the U.S. This suggests strongly that the white clover stands originated from seed brought to Alaska from areas considerably farther to the south. In all probability their original winterhardiness levels in Alaska would have been somewhat similar to that found in the "White Dutch" strain used in the test reported here. However, since those early white clover introductions were not grown in the very stressful habitat of an open field, as in the experiment reported here, some plants apparently were able to survive initially to give rise to the persistent populations that are present now at those locations.

Natural Selection for Winterhardiness

Evidence strongly suggests, then, that during the long-term residence in Alaska of those three white clover populations, natural selection pressures have caused genetic modification toward better adaptation to Alaskan climatic conditions and, hence, toward the better winter survival displayed in this field test.

The hypothesis drawn from this evidence agrees with conclusions by Gibson and Hollowell (1966) concerning white clover: "The variability in the species plus the high degree of cross-pollination favor shifts in response to natural or artificial selection pressures. Strains of white clover have been naturally and artificially made and maintained under specific environmental conditions. Many ecotypes exist."

If natural selection for winterhardiness is to be effective in a plant population growing in a new environment, there must be seed produced and a turnover of plant generations. During this genetic mixing of surviving plants, and the sorting and elimination (by winterkill) of inadequately winterhardy plants by environmental pressures, a "survival-of-the-fittest" scenario gradually selects for plants with a better-adapted "genetic constitution" for that specific environment (Cooper 1965, Wilsie 1962). That desirable genetic constitution possessed by winterhardy plants controls physiologic processes within the plant that are thus in heightened harmony with environmental forces that determine plant behavior, such as the interacting seasonal patterns of photoperiod and temperature (Klebesadel 1985).

Natural selection for winterhardiness cannot proceed very effectively in the span of a few decades on plant populations that are mostly winterhardy and are long-lived.

Figure 4. Comparative winter survival of white clover cultivars, strains, and collections from various world origins when grown at the Matanuska Research Farm. Planted 18 June 1984; photo 30 July 1985. Rows are identified at right.

Label	*Identity*	*Origin*
HJA	*HJA-364*	*Finland*
SON	*Sonja*	*Norway*
WD	*Commercial "White Dutch"*	*USA*
TAM	*Tammisto*	*Finland*
AK-3, AK-4, AK-5	*Collections*	*Alaska*

However, in a plant population that is marginally winterhardy, where only a few plants survive winters to flower and interpollinate (and thereby "intermix" their superior genetic characteristics), natural selection can effectively shift away from the original genetic make-up of the population. Moreover, such a shift will be much more rapid if the plants are relatively short-lived, for that characteristic accelerates the cycling of generations and more rapid sorting within the available gene pool. Although white clover is a long-lived perennial under ideal growing conditions, Gibson and Hollowell (1966) state: "White clover is classified as a perennial, but plants may behave mostly . . . as biennials or short-lived perennials in the North." Sylven (1937) reports enhanced performance of German white clover in Sweden following natural selection in the more northern environment.

Natural selection toward improved winterhardiness in alfalfa has been documented many years ago by workers in the Midwest US (Brand 1908, Waldron 1912). A similar pattern of enhanced winterhardiness has been noted also in alfalfa grown through many generations in Alaska (Klebesadel 1971b, 1985, Klebesadel and Taylor 1973).

Superficially, it might seem somewhat unusual that Alaska white clover collections AK-4 and AK-5 from Alaska's Interior did not survive as well in the field test as collection AK-3 from the Matanuska Valley. This may seem especially odd since the white clover populations at the old roadhouses very likely have persisted for longer terms in Alaska and in somewhat more northern areas that experience much colder winters than occur where AK-3 evolved. I believe, however, that the difference derives from the fact that AK-3 evolved in the Matanuska Valley, an area where winter stresses are *different* than simply the occurrence of extremely low temperatures where AK-4 and AK-5 evolved. Based on studies of other plant species, I believe that collection AK-3 may be found in future studies to be able to achieve a more dormant status that protects against freeze-thaw temperature oscillations that typically occur during Matanuska Valley winters (Klebesadel 1974, 1985). This is a different kind of winter stress than that experienced in Alaska's Interior where protective snow cover usually persists throughout the winter. In the Interior, winter air temperatures may be extremely low but seldom fluctuate sufficiently to cause midwinter thaws followed by refreezing as occurs commonly in the Matanuska Valley (Klebesadel 1974, 1985).

The 1984-85 winter at the Matanuska Research Farm had numerous thaw intervals that affected the experiment with clovers reported here. In January alone there were three separate thaw periods. On a total of 26 days during January the daily maximum exceeded 32 degrees Fahrenheit, and on 19 days it exceeded 40 degrees Fahrenheit. After a late-January/early-February thaw period of 20 consecutive days with maximums exceeding 32 degrees Fahrenheit, there occurred a very cold period during which 16 of 17 consecutive days had minimums below 0 degree Fahrenheit, and the lowest temperature reached 16 degrees below zero Fahrenheit. Inasmuch as the Matanuska Valley collection AK-3 evolved over what is believed a long period of time under this type of winter-stress conditions, it is quite understandable that it survived well in this test.

Conclusions

Results reported here of differences in winter survival among several white clover strains are relatively limited in scope and should be verified in more extensive comparisons involving more strains from various origins and over several years. Nonetheless, the wide differences in winter survival rates between the Alaska white clover collections and the cultivars from other northern countries suggest strongly that adaptive modification toward superior winter hardiness has occurred in the long-resident, naturalized white clover populations from which the Alaska collections were drawn. □

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Effect of Phosphorus and Potassium On Alsike Clover

By

Winston M. Laughlin*, Glenn R. Smith**, and Mary Ann Peters***

Soils in the Kenney Lake area of the Copper River Basin of Alaska have a neutral to alkaline pH. Thus one would expect these soils to support the growth of legumes more satisfactorily than the more acidic soils common to many areas of Alaska. Several unsuccessful attempts were made between 1979 and 1982 to establish a uniform stand of alsike clover in the Kenney Lake area. Plantings were made on spring rototilled soil and the area compacted immediately after planting. Uniform stands of young plants were obtained, but extreme drought caused so many plants to die that the stands were very uneven.

Experimental Procedure

In August 1981 a relatively uniform area of the lacustrine substratum phase of Klawasi silt loam was selected and rototilled. The experimental site was located at Mile 5 on the Old Edgerton Highway about 23 miles southeast of Copper Center. In 1976, this area had been cleared of trees, plowed and disced, and left uncropped. On September 30 the Canadian variety 'Aurora' alsike clover was broadcast on about four inches of snow with a Cyclone hand seeder. The soil beneath the snow was frozen to a .25-inch depth. Again on April 23, 1982, another broadcast seeding of alsike clover was made on 15 inches of snow. On May 18 a 4 × 4 factorial experiment replicated six times was established. We used four rates of phosphorus (P) as treblesuperphosphate 50, 100, and 150 pounds P_2O_5 per acre, equal to 0, 22, 44, and 66 pounds P per acre, per year and four of potassium (K) as sulfate of potash (0, 50, 100, and 150 pounds K_2O per acre, equal to 0, 41.5, 83, and 124.5 pounds K per acre, per year). These fertilizers were broadcast by hand on 18 May 1982, 19 May 1983, and 22 May 1984. Growth in 1982 was slow, and plants were very short so no harvest was made although weeds were mowed the latter part of June and early in August.

On 28 June and 20 September 1983 and 26 June and 10 September 1984, clippings were made with a small power mower equipped with a sickle, leaving a 2-inch stubble. The harvested area consisted of a strip 30 inches wide and 12 feet long cut from the center of each 6- by 15-foot plot. Fresh and dry weights were recorded from each harvest. Representative herbage samples from each plot

*Research Soil Scientist, Agricultural Research Service, USDA.

**Laboratory Technician, Agricultural and Forestry Experiment Sation, University of Alaska-Fairbanks.

***Biological Technician, Agricultural Research Service, USDA, Palmer, Alaska 99645.

were ground to pass a 20-mesh stainless steel laboratory mill screen. Chemical analyses were made as follows: total nitrogen (N) and P were determined colorimetrically using a Technicon autoanalyzer (Technical Industrial Systems 1976); K, calcium (Ca), and magnesium (Mg) were measured using an atomic absorption spectrophotometer following sulfuric-selenous acid digestion and using lanthanum to control interferences (Perkin-Elmer Corp. 1973); and total sulfur (S) was determined with an automatic S analyzer (Smith 1980). The soil samples, taken at a 6-inch depth after the 1984 harvest, were analyzed for pH and available N, P, and K using the following methods: pH was measured with a pH electrode (one part soil to two parts water); NH_4-N and NO_3-N were extracted with 2N NaCl measured colorimetrically with a Technicon autoanalyzer (Technican Industrial Systems 1973); P was extracted with Bray No. 1 extractant and analyzed with a spectrophotometer (Gaines and Mitchell 1979); and K was extracted with 1 N ammonium acetate at pH 7 and analyzed using an atomic absorption spectrophotometer (Perkin-Elmer Corp. 1973).

These data were analyzed statistically with conventional statistical techniques. The significant P × year interactions with N, P, S, and Mg concentrations are presented in Table 3, and the significant P × K interaction with first-cutting Mg concentrations are presented in Table 4.

Results and Discussion

Application of P increased the first-cutting forage yield above that of the control (which received no P), but there was no significant difference in yield for the different P rates. For the second cutting, yields increased with each increase in P rate (table 1). Only the highest K rate (124.5 pounds per acre) increased the yield of both cuttings (table 2).

We do not understand the poor growth in 1982 nor do we understand the extremely low first-cutting yields in 1983 and 1984. Aurora alsike clover is well adapted for southern Canada. Perhaps the longer day length in Alaska as well as the lack of moisture in the early season adversely affected growth. We found very poor nodulation even though a fresh, viable, commercial culture was used to treat the seed just prior to each seeding. This may indicate present commercial cultures do not have rhizobium adapted to this area. We have noted in this area considerable responses of alsike clover to N applied the season the crop was planted.

Nitrogen Concentration and Uptake

First-cutting N concentration was increased by P only in 1984 (table 3). The N uptake was increased by P application (table 1).

The N concentration was not influenced significantly by varying K rates in either alsike clover cutting. The N uptake was increased only by the highest K rate (124.5 lb per acre) (table 2).

Phosphorus Concentration and Uptake

Concentration of P in the first cutting was increased by each increasing P rate, although the increase from 44 to 66 pounds P per acre was not large enough to be significant (table 1). Second-cutting P concentration increased with each increasing P rate in both years (table 3). The seasonal P uptake also increased with increasing P rate; however, the increase between 22 and 44 pounds P per acre was not large enough to be significant (table 1).

Applications of K had no significant effect on first-cutting P concentration. However, each increasing K rate increased the P concentration in the second cutting. Only the highest K rate (124.5 pounds per acre) resulted in increased P uptake (table 2).

Potassium Concentration and Uptake

The K concentration in neither cutting was influenced by P, but the K uptake was increased by P application (table 1). Each increasing K rate increased the K concentration in both cuttings as well as the total seasonal K uptake; however the increase in K uptake from 41.5 to 83 pounds K per acre was not large enough to be significant (table 2).

Sulfur Concentration and Uptake

First-cutting S concentration was depressed by P application in 1983 and increased in 1984 (table 3). We know of no reason for such a reversal. Second-cutting S concentration was increased by P rates exceeding 22 pounds per acre while P application increased the S uptake (table 1).

First-cutting S concentration tended to be increased by increasing K rates, but the S concentration in the second cutting was not influenced significantly by K; S uptake was increased only by the 124.5 pounds K per acre rate (table 2).

Calcium Concentration and Uptake

First-cutting Ca concentration tended to be increased by P application and each increasing P rate tended to increase the Ca concentration in the second cutting; Ca uptake was increased by P application (table 1).

The Ca concentration in the first cutting was erratic as related to K rate and that in the second cutting tended to decrease with increasing K; Ca uptake was not influenced significantly by K rate (table 2).

Magnesium Concentration and Uptake

The Mg concentration in the first-cutting was increased by P application only in 1984 (table 3). Second-cutting Mg concentration was not influenced significantly by P rate but the seasonal Mg uptake was increased by P application (table 1).

The effect of the K rate on first-cutting Mg concentration varied with each of the four P rates being erratic when no P was applied. Concentration of Mg tended to decrease

Table 1. Two-year means (1983 and 1984) of effects of P rates on alsike clover forage yield (dry weight) on N, P, K, S, Ca, and Mg uptake, and on N, P, K, S, Ca, and Mg concentration in herbage. (Means of 48 measurements)

	Yield			Uptake					
P rate	1st cut	2nd cut	Total	N	P	K	S	Ca	Mg
(lb/A)	(T/A)			(lb/A)					
0	0.28b[1]	1.21c	1.49b	76b	6.3c	70b	5.34b	46b	13.6b
22	0.48a	1.67b	2.15a	110a	10.9b	107a	8.05a	68a	20.0a
44	0.43a	1.68ab	2.11a	108a	12.2b	108a	8.15a	67a	20.5a
66	0.47a	1.84a	2.31a	119a	14.9a	111a	8.94a	77a	22.6a

	Concentration							
	N	P	K		S	Ca		Mg
P rate	2nd cut	1st cut	1st cut	2nd cut	2nd cut	1st cut	2nd cut	2nd cut
	(%)							
0	2.54a	.233c	2.34a	2.15a	.169b	1.50b	1.53c	.468a
22	2.44a	.279b	2.61a	2.33a	.173b	1.64a	1.56bc	.460a
44	2.48a	.308a	2.55a	2.28a	.181a	1.52ab	1.62ab	.488a
66	2.48a	.326a	2.47a	2.27a	.181a	1.63a	1.67a	.488a

[1]Letters in the tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 2. Two-year means (1984 and 1985) of effects of K rates on alsike clover forage yield (dry weight), on N, P, K, S, Ca, and Mg; and on N, P, K, S, Ca, and Mg concentration in herbage. (Means of 48 measurements)

	Yield			Uptake					
K rate	1st cut	2nd cut	Total	N	P	K	S	Ca	Mg
(lb/A)	(T/A)			(lb/A)					
0	0.36b[1]	1.43b	1.79b	92b	10.2b	68c	6.55b	60a	20.1a
41.5	0.38b	1.57b	1.95b	100b	10.6b	87b	7.30b	64a	19.6a
83	0.39b	1.59b	1.98b	101b	10.6b	103b	7.51b	62a	17.6a
124.5	0.52a	1.82a	2.34a	120a	12.8a	132a	9.09a	70a	19.5a

	Concentration										
	N		P		K		S		Ca		Mg
K rate	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	2nd cut
	(%)										
0	2.81a	2.51a	.279a	.199d	2.03d	1.77d	.216b	.172a	1.67a	1.67a	.551a
41.5	2.77a	2.48a	.287a	.242c	2.39c	2.12c	.233ab	.177a	1.58ab	1.65ab	.503b
83	2.72a	2.49a	.285a	.280b	2.63b	2.45b	.236ab	.177a	1.48b	1.57b	.440c
124.5	2.89a	2.46a	.295a	.312a	2.93a	2.70a	.246a	.178a	1.55ab	1.49c	.408d

[1]Letters in the tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 3. Effect of P on the N, P, S, and Mg concentration in alsike clover herbage, 1983-1984. (Means of 24 measurements)

	N		P		S		Mg	
	1st cut		2nd cut		1st cut		1st cut	
P rate	1983	1984	1983	1984	1983	1984	1983	1984
(lb/A)	(%)							
0	2.70a[1]	2.64b	.189d	.209d	.250a	.224b	.522a	.435b
22	2.70a	3.00a	.215c	.269c	.220b	.251a	.515a	.531a
44	2.71a	2.87a	.247b	.312b	.226b	.250a	.514a	.509a
66	2.84a	2.93a	.276a	.347a	.217b	.248a	.518a	.533a

[1]Letters in the tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Table 4. Effect of P and K on first-cutting Mg concentration in alsike clover, 1983-1984. (Means of 12 measurements)

K rate	P rate (lb/A)			
	0	22	44	66
(lb/A)	(%)			
0	.483ab[1]	.607a	.655a	.594a
41.5	.535a	.500b	.503b	.561a
83	.406b	.510b	.473bc	.468b
124.5	.490a	.476b	.415c	.479b

[1]Letters in the tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

with increasing K rate when P was applied (table 4). Second-cutting Mg concentration decreased with each increasing K rate while the total seasonal Mg uptake was not influenced significantly by the K rate (table 2).

Soil Test values

Available P in the soil in September of 1984 increased with each increasing P rate. Apparently P application increased the September values for NO_3-N (table 5). This increase probably results from the added P increasing the rate of organic matter decay and the release of N.

Each increasing K rate increased the available K in the soil in September 1984. The heaviest K application (124.5 pounds per acre) apparently increased the NO_3-N in the soil (table 5) probably resulting from the added K increasing the rate of breakdown of the soil organic matter.

The lower N values in September 1984 compared to those in May 1982 suggest more N was being removed with the clover than is released through organic matter decay. Over the 3-year period, P and K fertilizers increased both the P and K available in the soil. It is interesting that the value for available K was greater in 1984 than in May 1982 when no K had been applied. Other data, not shown, indicate spring K values were higher than the fall values indicating the release of exchangeable K during the time the crop was not removing K.

Table 5. Effect of P and K on soil pH and on inorganic N, extractable P, and exchangeable K September 1984. (Means of 24 measurements)[1]

	pH	Inorganic N		Extractable	Exchangeable
		NH_4-N	NO_3-N	P	K
P rate	Effect of P Applications				
(lb/A)		(lb/A)			
0	7.53a[2]	4.35a	0.85b	38d	335a
22	7.54a	3.98a	1.31a	87c	316a
44	7.46a	4.83a	1.50a	132b	338a
66	7.40a	4.72a	1.31a	187a	338a
K rate	Effect of K Applications				
(lb/A)		(lb/A)			
0	7.57a	4.29a	1.03b	108a	165d
41.5	7.55ab	4.03a	1.09b	110a	238c
83	7.42bc	4.51a	1.32b	112a	394b
124.5	7.38c	5.05s	1.52a	115a	531a

[1]Baseline values (May 1982) for pH, NH_4-N, NO_3-N, P, and K were 7.54, 10.8, 27.8, 35, and 114, respectively.
[2]Letters in the tables are used in accordance with Duncan's multiple range test. Any two values within a column not followed by the same letter are significantly different at the 5% level of probability.

Interpretive Summary

Soils in the Kenney Lake area of interior Alaska have a neutral to alkaline pH and should be more adapted for legume growth than the more acid soils in other areas. After several attempts to secure a uniform clover stand, a replicated experiment with four rates of P (0, 22, 44, and 66 lb P/A) and K (0, 41.5, 83, 124.5 lb K/A) was established on an Aurora alsike clover stand in 1982. Two annual harvests were made in 1983 and 1984 and forage samples analyzed for N, P, K, S, Ca, and Mg. Yields were increased by both P and K. Available P and K in the soil were increased during this period by annual applications of P and K. The very poor growth in 1982 and very low first-cutting yields, suggest this variety of alsike clover may not be adapted to this area. The very poor nodulation further suggests a strain of rhizobium is needed which is adapted to both the legume and to the area.

Conclusion

This 2-year study shows a yield response by alsike clover to both P and K fertilization in the Kenney Lake area. It further suggests that a variety of alsike clover better adapted to the area is needed. The poor nodulation suggests a more effective strain of rhizobium is needed for more efficient N fixation. More study is needed to evaluate nodulation and dinitrogen fixation by alsike clover in this region of Alaska. □

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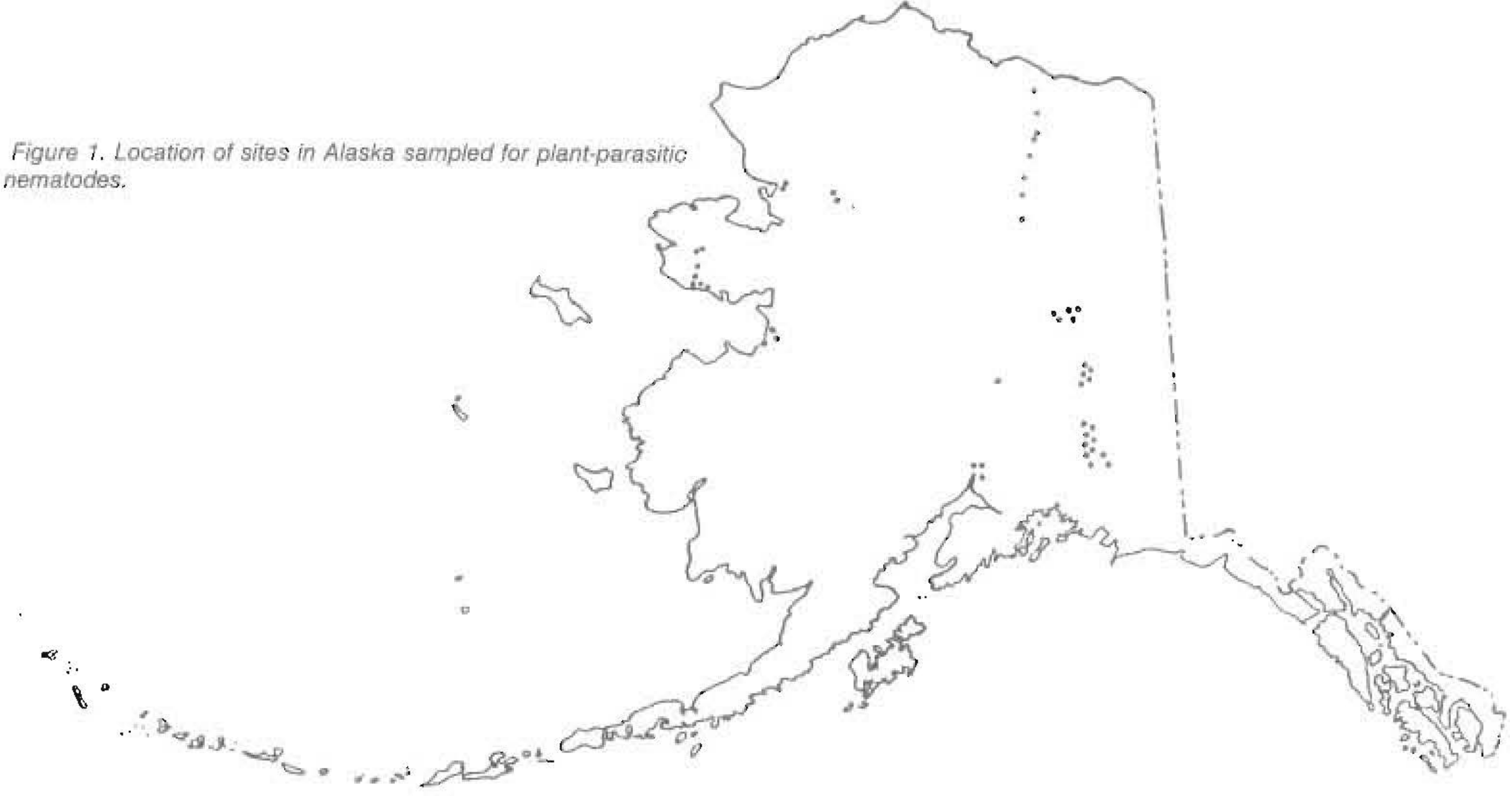

Figure 1. Location of sites in Alaska sampled for plant-parasitic nematodes.

Plant-Parasitic Nematodes in Alaskan Soils

By

Ernest C. Bernard* and Donald E. Carling**

Introduction

Nematodes constitute an extraordinarily diverse and widespread phylum of animals. They have adapted to nearly every conceivable habitat, and several major ecological groups, each of which contains many hundreds or thousands of species, can be recognized. These groups include marine nematodes, which feed primarily on microorganisms; free-living terrestrial nematodes, which subsist on bacteria, fungi, algae, or such small soil fauna as other nematodes; vertebrate parasites; arthropod parasites; and plant parasites. Annual losses in agronomic and horticultural crops in the United States due to plant-parasitic nematodes have been estimated at about 10 percent (Society of Nematologists 1970). Crops in warm temperate and tropical regions are usually considered more vulnerable to damage, but many crops such as potato, sugar beet, carrot, and cabbage may be affected in the northern U.S., southern Canada, and northern Europe. Root-knot nematodes (*Meloidogyne* spp.), cyst nematodes (*Globodera* and *Heterodera* spp.), and lesion nematodes (*Pratylenchus* spp.) are the most significant genera in northern crop production regions and have been extensively studied. Because of recent efforts to expand Alaska's agriculture on a large scale, the potential impact of indigenous nematode species on crops should be investigated.

Current knowledge of Alaskan nematodes is quite limited and probably consists of no more than a dozen reports. Cobb (1921) and Mulvey (1963) reported briefly on a collection of nematodes made by the 1915-16 Stefansson Expedition in the Canadian Arctic and Alaska, but did not give localities for the listed genera. In 1949, Thorne (1949) described *Tetylenchus joctus* from Wrangell. We have examined numerous soil samples from the Aleutian Islands, primarily Adak Island, and described a number of species (Bernard 1979, 1981, 1982, 1984). Freckman et al. (1977), in a brief report on nematode communities at three sites along the Trans-Alaska pipeline, found only twenty-two genera of all types of free-living and plant-parasitic nematodes. Several species of *Nagelus*, *Pararotylenchus*, and *Pratylenchoides* have been described or noted from Alaska by Baldwin and coworkers (Baldwin and Bell 1981, Baldwin et al. 1983, Powers et al. 1983).

*Professor, Department of Entomology and Plant Pathology, University of Tennessee, Knoxville, TN 37901.
**Associate Professor, Horticulture, Agricultural and Forestry Experiment Station, Palmer, AK 99645.

In 1983 and 1984, soil samples from various parts of Alaska (fig. 1) were collected for nematode extraction and identification. It is evident from study of these samples that plant-parasitic nematodes are an abundant and diverse fraction in Alaskan soils (fig. 2) and that several species may pose a potential risk to the agricultural goals of the state. We are continuing cooperative studies of the plant-parasitic nematode fauna in order to reach the following objectives: 1) to identify and describe the plant-parasitic nematodes of Alaska; 2) to assess the potential impact of nematodes on Alaskan agriculture; and 3) to develop hypotheses which explain the current distribution of nematodes in Alaska; and 4) to predict future distributions in new crop-growing areas.

Relationships of Nematodes to Plants

Nearly all plant-parasitic nematodes are less than .08 inch long. Most species remain vermiform (wormlike) their entire lives (figs. 3-7), but in some of the most destructive forms, the females are greatly swollen compared to the infective juvenile stage (figs. 8-10).

All plant-parasitic nematodes possess a stylet, or spear, with which they puncture plant cells (figs. 11-16). In the more generalized species, the stylet is used to penetrate cell walls, after which digestive enzymes are injected into the cell cytoplasm to liquefy it. The nematode then ingests the liquefied, predigested contents from the cell. This entire process may take only a few seconds. The stylet, which closely resembles a hypodermic needle, has a very narrow lumen that allows only liquids or extremely minute particles to pass. Bacteria and most cell organelles are too large to enter the stylet. Trichodorid nematodes have a solid stylet (fig. 16).

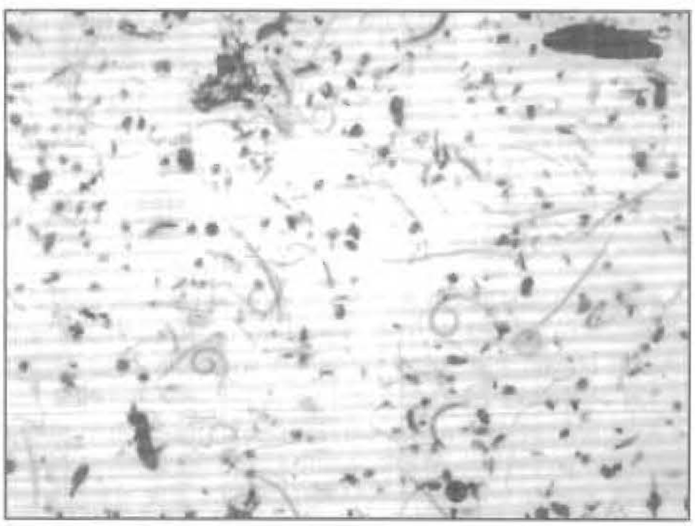

Figure 2. Typical abundance of nematodes in a 200-cubic-centimeter soil sample.

In more specialized plant parasites, such as root-knot and cyst nematodes, the nematode injects substances which induce the plant to produce enlarged, multinucleate cells called giant cells or syncytia (fig. 17). The developing nematode feeds on these cells without killing them. The death of the nematode results in degeneration of the syncytium.

Most plant-parasitic nematodes live in soil and feed upon root cells. A few forms are parasites of leaves or plant reproductive organs, and at least two species are significant parasites in the trunks of some pine trees and coconut palms. Species which parasitize roots are usually grouped by nematologists into the three following feeding types. *Ectoparasitic* nematodes are species which live their lives in the soil, rather than in roots, and feed upon the cortical or epidermal tissue of the root. *Migratory endoparasites* travel through the cortex while feeding and may spend their entire lives within the root. *Sedentary endoparasites* are those species which enter roots, establish giant cells (syncytia) or other specialized feeding sites, often in the vascular tissue, then begin to enlarge while at the same time losing their power of movement.

Symptoms on Alaskan Plants

Symptoms of nematode damage are usually very general and not identifiable as nematode-induced without further investigation. Affected plants are often stunted and slightly chlorotic. In times of moisture stress they may wilt before unaffected plants and recover more slowly. On roots, symptoms can be classified as galls, stubby roots, root lesions, or root necrosis. In Alaska, two species of nematodes have been identified which induce root galls (figs. 18, 19). *Meloidogyne subarctica* Bernard, a root-knot nematode described from Adak Island, produces large and abundant galls on the beachgrass *Elymus arenarius* (fig. 19). These galls are caused by formation of giant cells and proliferation of cortical and vascular parenchyma. Unlike most other *Meloidogyna* spp., the nuclei in giant cells of *M. subarctica* apparently remain clumped together, rather than dividing and moving apart following chromosomal replication (fig. 17).

Another type of galling observed on *E. arenarius* from Adak Island and parts of the mainland is that caused by *Anguina radicicola* (Greeff) Teploukhova. These galls form near the root tip and curl as they enlarge due to proliferation of cortex (fig. 18). The nematodes apparently feed on the cortical cells, causing the formation of large cavities within the gall (fig. 20). *A. radicicola* is an important pest of grasses in parts of northern Europe.

It is very probable that the distributions of these two nematodes are much more extensive in Alaska than is now known. Some effort should be devoted to determining whether their parasitic activities on *E. arenarius* can destabilize dunes and beaches by reducing the root-binding capacity of this species.

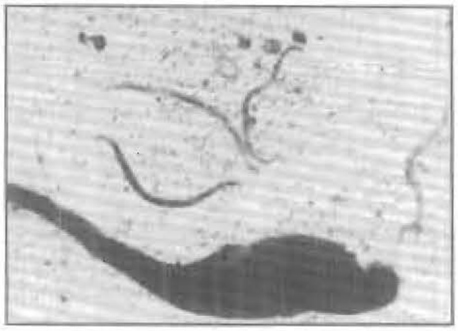

Figure 3. Adults and eggs of Anguina radicicola *removed from a galled* Elymus arenarius *root.*

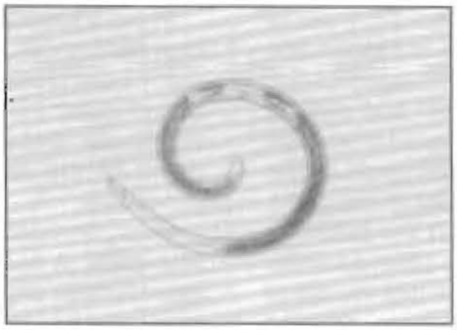

Figure 4. Female Helicotylenchus *sp.*

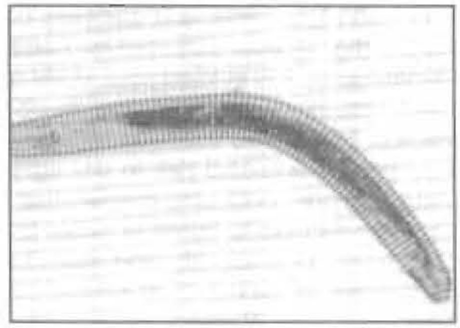

Figure 5. Female Criconemella *sp.*

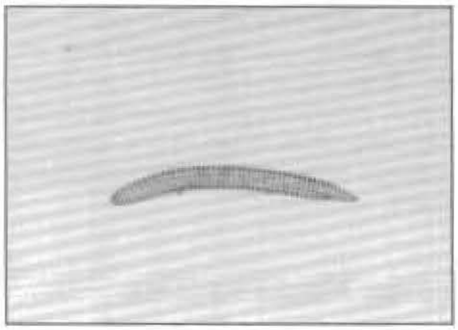

Figure 6. Female Seriespinula seymouri.

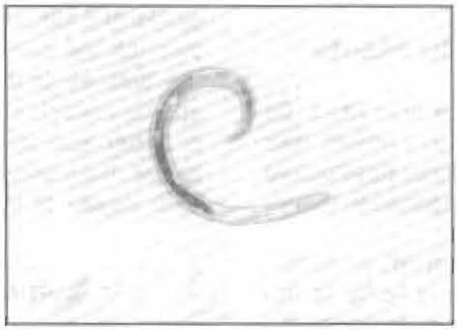

Figure 7. Female Paratylenchus *sp.*

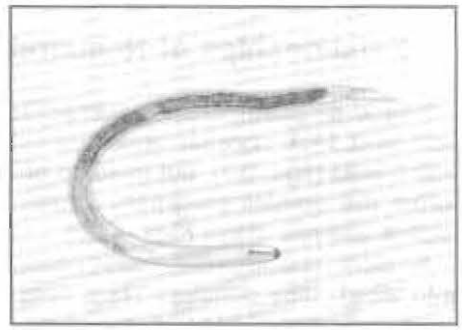

Figure 8. Infective juvenile of Heterodera trifolii, *a cyst nematode.*

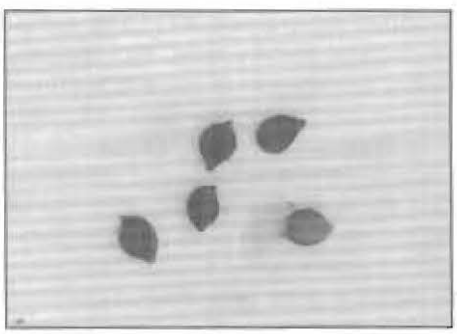

Figure 9. Heterodera trifolii *cysts.*

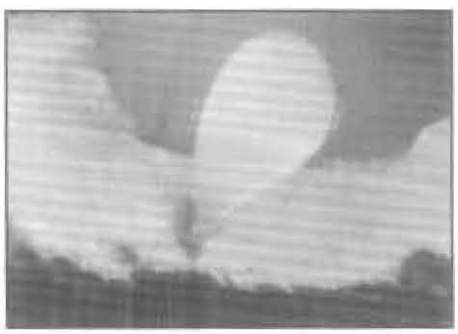

Figure 10. Female Thecavermiculatus crassicrustata *on* Elymus arenarius *root.*

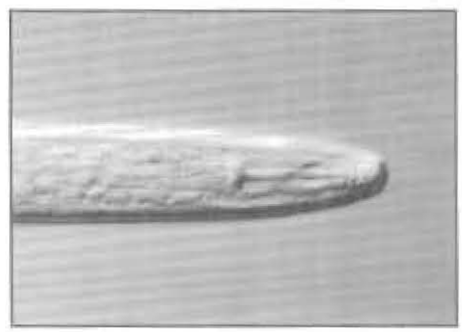

Figure 11. Head end of Nagelus *sp.*

Diversity of Alaskan Nematodes

Alaska has an abundance of plant-parasitic nematode species (fig. 2), and it is probable that many more species will be identified with more extensive soil collections. At present, twenty-four genera with fifty-four species, most of them apparently undescribed, have been collected (table 1). A more detailed discussion of the species by family is given below.

Class Secernentea

Tylenchidae: Numerous species of this family occur in all Alaskan samples. The members of Tylenchidae are usually considered fungal feeders or weak parasites of root hairs, thus they have not been enumerated in Table 1.

Anguinidae (Anguina, Ditylenchus spp.): Most of the damaging members of this family are endoparasites of the leaves, stems, and ovules of many plants. The wheat stem nematode, *A. tritici* (Steinbuch) Chitwood, and the stem and bulb nematode, *D. dipsaci* (Kuhn) Filipjev, are the best-known temperate species. In Alaska, *A. radicicola*

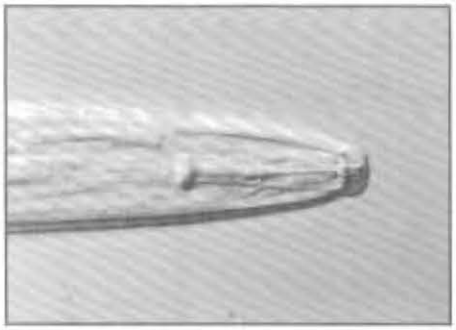

Figure 12. Head end of Merlinius *sp.*

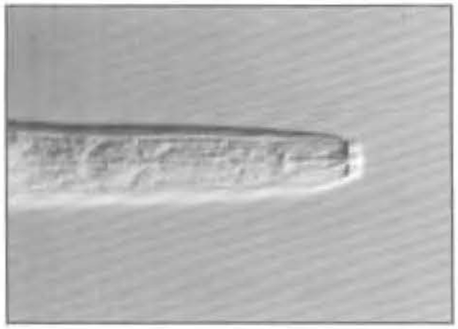

Figure 13. Head end of Pratylenchus *sp.*

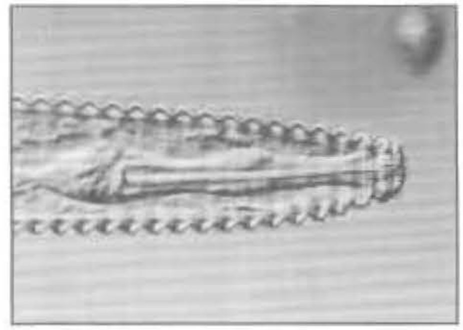

Figure 14. Head end of Criconemella *sp.*

Figure 15. Head end of Paratylenchus *sp.*

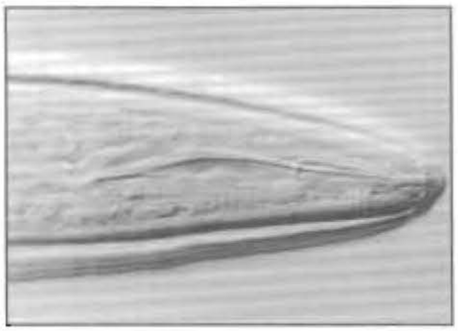

Figure 16. Head end of Trichodorus *sp.*

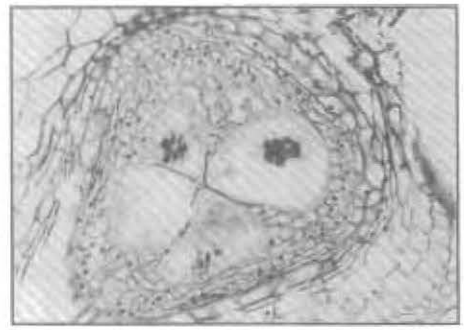

Figure 17. Cross-section of M. subarctica *gall, showing giant cells with clustered nuclei amid disoriented xylem.*

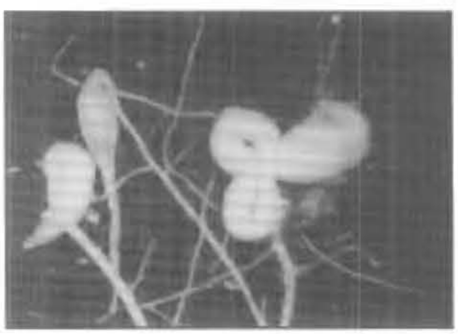

Figure 18. Galls of Anguina radicicola *on* Elymus arenarius.

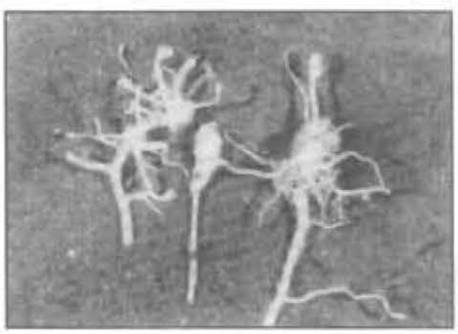

Figure 19. Galls of Meloidogyne subarctica *on* Elymus arenarius.

Figure 20. Cross-section of A. radicicola *gall, showing nematode-filled cavities in cortex.*

parasitizes the roots of *E. arenarius.* (figs. 18, 20). Many *Ditylenchus* spp. occur in the soil, but their role as plant parasites is questionable since many species in this genus are believed to be fungal feeders.

Tylenchorhynchidae (Geocenamus, Merlinius, Nagelus, Scutylenchus, Tylenchorhynchus spp.): This family is numerous and widely distributed throughout the mainland, with representatives as far out as Adak Island. They all probably parasitize epidermal and cortical tissues. *Merlinius, Nagelus,* and *Tylenchorhynchus* spp. are particularly diverse and may be useful in understanding how plant parasites become dispersed after severe climatic changes. *Nagelus* spp. (fig. 11) are known from southcentral Alaska to Fairbanks and thence along the Dalton Highway up to Point Barrow (Powers et al. 1983), in addition to other points in North America, Asia, and Europe. However, none were found in the Aleutian Islands or on the Seward Peninsula. Conversely, *Merlinius* spp. (fig 12) were found to be abundant on the Seward Peninsula, with one species on Adak Island, but none were collected in southcentral Alaska. The distribution of *Tylenchorhynchus* spp. was similar to *Merlinius*. Climatic changes may have eliminated most species from the region, but, as the climate moderated, members of each genus may have dispersed

Table 1. Plant-parasitic nematodes known from Alaska.

Species	Mode of Parasitism[1]			Reference[2]
	Sed. Endo.	Migr. Endo.	Ecto.	
Anguina radicicola (Greeff) Teploukhova		X		Bernard 1979
Cerchnotocriconema psephinum Bernard			X	Bernard 1982
Cerchnotocriconema sp.			X	—
Criconemella hemisphaericaudata (Wu) Luc & Raski			X	—
Criconemella xenoplax (Raski) Luc & Raski			X	Bernard 1982
Criconemella sp.			X	—
Dolichodera sp.	X		—	
Geocenamus sp.			X	—
Helicotylenchus amplius Anderson & Eveleigh			X	Bernard 1984
Helicotylenchus spitsbergensis Loof			X	Bernard 1984
Helicotylenchus sp.			X	Bernard 1979
Hemicycliophora amchitkaensis Bernard			X	Bernard 1982
Heterodera trifolii Goffart	X		—	
Heterodera sp.	X		—	
Hoplolaimus sp.		X or	X	Bernard 1979
Meloidodera eurytyla Bernard	X			Bernard 1981
Meloidogyne subarctica Bernard	X			Bernard 1981
Merlinius adakensis Bernard			X	Bernard 1984
Merlinius joctus Thorne (Sher)			X	Thorne 1949
Merlinius sp. A			X	—
Merlinius sp. B			X	—
Nagelus borealis Powers, Baldwin & Bell			X	Powers et al. 1983
Nagelus leptus (Allen) Siddiqi			X	Powers et al. 1983
Nagelus obscurus (Allen) Powers, Baldwin & Bell			X	Powers et al. 1983
Nagelus sp. A			X	—
Nagelus sp. B			X	—
Nothocriconema longulum (Gunhold) DeGrisse & Loof			X	Bernard 1982
Pararotylenchus megastylus Baldwin & Bell			X	Baldwin & Bell 1981
Pararotylenchus sp.			X	—
Paratylenchus amundseni Bernard			X	Bernard 1982
Paratylenchus sp. A			X	—
Paratylenchus sp. B			X	—
Paratylenchus sp. C			X	—
Pratylenchoides magnicauda Baldwin, Luc & Bell		X		Baldwin et al. 1983
Pratylenchoides megalobatus Bernard		X		Bernard 1984
Pratylenchoides variabilis Sher		X		Bernard 1984
Pratylenchoides sp. A		X		—
Pratylenchoides sp. B		X		—
Pratylenchus pratensisobrinus Bernard		X		Bernard 1984
Pratylenchus ventroprojectus Bernard		X		Bernard 1984
Pratylenchus sp. A		X		—
Pratylenchus sp. B		X		—
Scutylenchus sp.			X	—
Seriespinula seymouri (Wu) Khan, Chawla & Saha			X	Bernard 1979
Thecavermiculatus crassicrustata Bernard	X			Bernard 1981
Thecavermiculatus sp.	X			—
Trichodorus sp. A			X	—
Trichodorus sp. B			X	—
Tylenchorhynchus sp. A			X	Bernard 1979
Tylenchorhynchus sp. B			X	—
Tylenchorhynchus sp. C			X	—
Tylenchorhynchus sp. D			X	—
Tylenchorhynchus sp. E			X	—
Xiphinema sp.			X	Bernard 1979

[1]Modes of parasitism are based primarily on those of related temperate species or genera: Sed. Endo. = Sedentary Endoparasite; Migr. Endo. = Migratory Endoparasite; Ecto. = Ectoparasite.

[2]Dashes in the reference column indicate unpublished records of occurrence in Alaska.

from different points: *Nagelus* from the southeast, *Merlinius* and *Tylenchorhynchus* from the west. Of course, much more thorough collecting, identification, and analyses must be undertaken to substantiate this hypothesis.

Heteroderidae (Dolichodera, Heterodera, Meloidodera, Meloidogyne, Thecavermiculatus spp.): Worldwide, this family contains the most important nematode pathogens of crop plants, the root-knot and cyst nematodes. All are sedentary endoparasites in which the females become enlarged and produce several hundred eggs each. *Dolichodera* (Adak Island) and *Heterodera* spp. (Adak Island, Seward Peninsula) females become converted into brown cysts (fig. 9) which protect the eggs within the body. *Meloidogyne subarctica,* previously mentioned, is known only from Adak Island, as is *Meloidodera eurytyla.* The genus *Thecavermiculatus* is very interesting because of its extremely wide distribution in the western hemisphere. One species lives on grass roots in California, while another is a potato parasite in the Andes region of South America. There are two known Alaskan species. *T. crassicrustata* (fig. 10) occurs on grasses in the Aleutian Islands (Adak, Amchitka Island) and has been collected from the Seward Peninsula. An undescribed fourth species was found in abundance in a potato garden near Noorvik. The potential roles of Heteroderidae in reducing crop yields should be studied as agriculture intensifies in Alaska. Much more collecting is needed to assess accurately the distribution of these nematodes in the state.

Hoplolaimidae (Helicotylenchus, Pararotylenchus, Pratylenchoides spp.): This family consists mostly of ectoparasites and migratory endoparasites (fig. 4). Species of this family appear to be widely distributed in Alaska.

Pratylenchidae (Pratylenchus spp.): All lesion nematodes (fig. 13) are migratory endoparasites. Some species are significant potato root and tuber parasites in North American and European production areas, while others parasitize cereal crops.

Paratylenchidae (Paratylenchus spp.): These are the smallest plant parasites (figs. 7, 15). Females have long, slender, often flexible, stylets, while males usually do not have stylets. All species are probably ectoparasites; they are rarely considered to cause crop damage.

Criconematidae (Cerchnotocriconema, Criconemella, Nothocriconema, Seriespinula spp.): All of these nematodes are stout, robust ectoparasites (figs. 5, 6). They are easily recognized by their prominent, often ornamented, body annulation and their heavy, stout stylets (fig. 14). A few species have roles in complex diseases of orchards in more temperate regions, but are probably insignificant in Alaska.

Class Adenophorea

Longidoridae (Xiphinema spp.): These nematodes have long, slender stylets formed differently from those of all the families previously listed. Thus they are considered unrelated to the Secernentea. Only a single specimen of *Xiphinema* has been collected from Alaskan soil (Adak Island).

Trichodoridae (Trichodorus spp.): The stubby-root nematodes possess a third type of stylet, a slender, solid tooth used to puncture root cells (fig. 16). One of the two species collected in Alaska seems to be widely distributed on the mainland, occurring in cultivated fields in southern Alaska and in tundra.

Summary

Plant-parasitic nematdoes are well represented in every sampled area in Alaska. With expansion of Alaskan agriculture, the role of these nematodes in plant disease needs to be understood. However, our current knowledge of host-parasite interactions on Alaskan crop plants is still very limited. A continuing survey of nematodes in potential and actual agricultural regions of the state should be continued. At the same time, the environmental requirements of potential pathogens should be investigated. In some cases, soil temperatures may normally be too low to permit maximum nematode activity. However, adaptation among endemic species should be expected, and there is some evidence that *M. subarctica* cannot survive at soil temperatures much above 48 degrees Fahrenheit (Bernard 1981). Further study will determine the potential part plant-parasitic nematodes may play in reduction of Alaskan agricultural yields.□

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AFES Notes continued . . .

Wayne C. Thomas, professor of economics, will temporarily assume the post of director of graduate studies in September. His appointment will extend through June of 1987. In this position, Dr. Thomas will have responsibility for administering the graduate programs at the University of Alaska-Fairbanks. This will include oversight of graduate research fellowships and selection of outside examiners for theses defense and oral examinations. This responsibility constitutes a half-time appointment for Dr. Thomas; he will also continue his regular research duties at the Agricultural and Forestry Experiment Station. **Edward C. Arobio,** agricultural economist with the Division of Agriculture, Department of Natural Resources, will take over one-half of Dr. Thomas' normal research duties during this time period. Mr. Arobio is a former research associate in economics at AFES.

The Honors Program at the University of Alaska-Fairbanks offers several interdisciplinary courses each year. This year, the School of Agriculture and Land Resources Management is offering "Design with Nature" (ALR 393). The course will be taught by **Tom Gallagher,** assistant professor of land planning. Students taking this comprehensive integrated course include those majoring in virtually every area offered at the University of Alaska-Fairbanks.

The course is concerned with ways in which people work with natural forces and processes in designing art works, landscapes, building, cities, and regions. While there is no specific textbook for the course, there is an extensive reading list comprised of books and articles which address such topics as environmental psychology, ecology, economics, architecture, and land planning. In addition, guest speakers will address a variety of related topics including art history, mathematics, and wildlife management.

Dr. Gallagher's interest in offering this course stems from his academic background in landscape architecture in which he holds a bachelor's degree, natural sciences in which he holds a master's degree with emphasis on wildlife management, and natural resources planning in which he was awarded the Ph.D. after extensive research in environmental psychology.

The Agricultural and Forestry Experiment Station, Standard Alaska Production Company, and the U.S. Fish and Wildlife Service are collaborating on a five-year research project. The study focuses on investigating the basic biological and ecologial aspects of *Arctophila fulva*, a grass that grows in certain wetland habitats of Alaska. Specialists in migratory waterfowl have noted a correlation between the occurrence of this grass species and preferred habitat for some species of waterfowl on Alaska's North Slope. Because the breeding grounds for several waterfowl species lie in that area, the region and its habitats are of national and even international importance. Consequently, activities in the Arctic affecting such wetlands are being given special consideration—hence, the need for information on this grass.

Even though the grass is relatively common throughout the Arctic, it is one of only two vascular plant species that can grow on terrestrial sites and is an emergent in aquatic habitats as well. Furthermore, it appears to be the only vascular emergent in the arctic tundra that can live in both fresh and salt water. Relatively little research has been directed toward the species. Increased knowledge of how the plant grows and how it functions and adapts to a wide range of environmental conditions is not only of practical significance to the petroleum industry working in arctic

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Helping Your Greenhouse Help You

By

Lee Allen* and Patrick Mayer**

Home Greenhouse Production

The operation of a family greenhouse in Alaska can be a rewarding and even profitable hobby. Rewards can take many forms, whereas profitability depends not only on successful crop production, but also on cost of production.

Greenhouses that work can cost from hundreds to several thousands of dollars. Making any small greenhouse "pay" requires use of a low-cost design. Consider, for example, the additional production required to return costs from a greenhouse costing $2000 compared to one costing $200. Certainly, there are indirect benefits derived from owning a more expensive greenhouse: pride of ownership, increased value of the property, and resale value. However, such negative aspects as increased taxes, interest on investment, and insurance must also be considered.

The basic greenhouse proposed here is based on USDA Plan No. 5946. It is a semiportable, bowed plywood rib design that costs about $200 to construct (fig. 1). There are many modifications that can be made to this basic greenhouse to improve its performance. It is important to consider the cost of each improvement, and any improvement should show a proportionate increase in yield.

Greenhouse Modifications

The overall layout for our 1982 greenhouse study is shown in Figure 2. The free-standing greenhouses pictured are 8.5 by 16 feet, which provides 136 square feet of interior space, enough room for about twenty-four tomato plants. The low-cost modifications added to the basic greenhouses were designed to control excessively high daytime temperature and humidity, store excess daytime heat for nighttime use, and prevent the escape of heat at night. The desired result is warmer night temperatures, resulting in less temperature variation, higher average temperature, and increased production.

All greenhouses were unheated, but each had some form of automatic ventilation. Standard fans were electrically powered and provided one or two air changes per minute, a level at which the fans cycled even on clear days. All the greenhouses had an open, slotted air inlet on the end of the greenhouse opposite the exhaust fan. Automatic ventilation allows the homeowner to leave the greenhouse unattended for periods of up to a few days. The less desirable alternative is to leave the greenhouse vents open whenever overheating might occur.

The first heat-saving feature studied was the use of fiberglass insulation on the north side of an east-west

Figure 1. Infrastructure of greenhouses used from 1980-83.

* **Associate Professor Agricultural Engineering, Agricultural and Forestry Experiment Station, Palmer.**

** **Agricultural Supervisor, Agricultural and Forestry Experiment Station, Palmer.**

Figure 2. Greenhouses at the Palmer Research Center where heat conservation and storage experiments were performed.

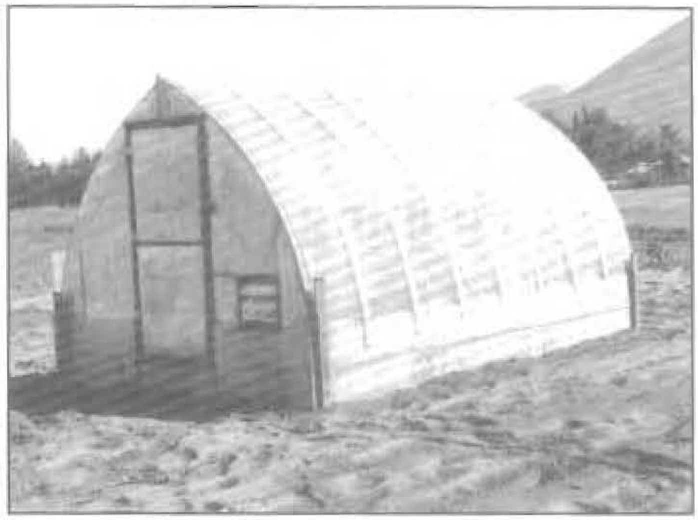

Figure 3. Greenhouse with a standard fan insulated on north side and ends.

oriented house (fig. 3). For the curved-bow design, we insulated the north wall and north roof slope of a gable-roofed house. Insulation was 3.5 inches thick and rated at R-11 with the reflective surface on the inside of the greenhouse.

Another heat-saving modification was the use of 25 percent of the greenhouse floor for storage of water barrels. Eighteen 18-gallon brown cans were filled with water and stacked along the north wall (fig. 4).

A third modification was designed to avoid the reduction in floor space required for the water barrels by using the greenhouse soil for heat storage. The method used solar chimneys designed to convect air through a container partially buried in the soil, thereby increasing heat transfer from the greenhouse air to the greenhouse soil (fig. 5).

A fourth modification used the soil for heat storage by mechanically circulating the warm greenhouse air into the

Figure 4. A row of 18-gallon containers collected excess daytime heat and released it during the night, but replaced one row of tomatoes.

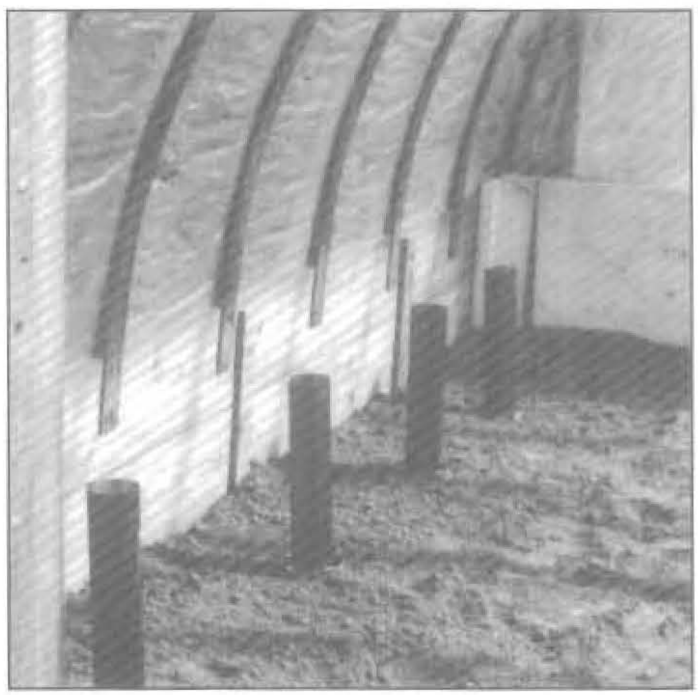

Figure 5. Soil-warming treatment using solar chimneys.

Figure 6a. Basic layout for mechanically venting exhaust air through pipes buried in greenhouse soil.

Figure 6b. A box built around a standard exhaust fan served as a manifold to accept cooled air from the soil pipes. Insulation around the perimenter retained some heat with no loss of light.

cooler greenhouse soil via a single-wall stove pipe 4 inches in diameter buried to a 4-inch depth (fig. 6).

The final modification that indirectly increased the heat within the greenhouses was the use of solar-powered fans (fig. 7). These fans ventilated at a considerably lower rate than did the electric fans. The solar fans provided only about 0.3 air changes per minute and did not cycle on and off like the electrically powered fans. Rather, they ran continuously whenever the sun struck the solar modules.

Experimental Procedure

During the four field seasons in which this study was conducted, every greenhouse, except for those using water barrels, contained twenty-four tomato plants (variety 'Fantastic'). Those with water barrels had room for only eighteen plants. Plants at first bloom stage were transplanted directly into the greenhouse soil at a 9-inch depth with 20-inch spacing. Individual tomato plants were staked at planting time and supported throughout the growing season (approximately June 1 to October 15) using string suspended from the greenhouse ceiling (Wittwer and Homna 1979). A 16- to 20-inch buffer was left between the greenhouse perimeter and the plants. All plants within each greenhouse received equal applications of water and fertilizer. Each house was covered with a single layer of 4-mm polyethylene regardless of the other heat-saving measures used. Tomatoes were harvested weekly in the early part of the season, biweekly during the peak harvest season, and weekly during the last portion of the growing season. Tomatoes were considered ripe and harvested just as they began to turn red. Soil temperatures were measured periodically to determine the relative success of the soil-warming treatments.

This study was initiated in 1980 with four greenhouses. Treatments included a control greenhouse and one just like it which was insulated on the north side and on each end. One greenhouse of each type (insulated and uninsulated), was equipped with a bank of water barrels for solar heat storage along the north wall.

In 1981, the experiment was expanded to six greenhouses. Four houses employed the same treatments as in 1980, and two additional houses were added. The standard and insulated greenhouses added were ventilated

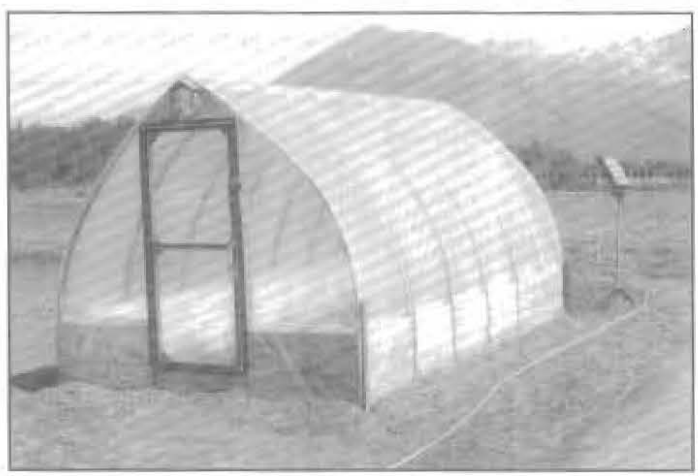

Figure 7. The solar fans required no outside source of power. Because of their low output they were placed at the peak where they would be more effective at removing excess heat.

with solar-powered fans. In full sunshine, the fans were rated at 250 cubic feet per minute (cfm), or 0.3 air changes per minute.

In 1982, the experiment was again expanded, this time to include a treatment utilizing solar chimneys for warming the soil in standard and insulated greenhouses. The premise was that, if solar energy could be stored in the soil rather than in water barrels, additional plant space could be obtained. Presumably there would also be a direct benefit to the plants from the warmer soil environment. For this treatment ten solar chimneys per greenhouse were installed consisting of 3-pound coffee cans buried in the soil with two sections of black 4-inch stovepipe raised 2 inches from the can bottom. We hoped this would move air along the can sides as it convected upward through the stovepipe.

In 1983, the solar chimneys were replaced by an underground exhaust system. With this arrangement, warm air from near the greenhouse peak was passed through underground tubes to warm the soil prior to its being exhausted outside.

Results

Throughout the course of this study, success of a particular treatment or combination of treatments was determined using total tomato production as the primary indicator. Soil temperatures were taken periodically to determine if the soil-warming treatments were performing as expected. Table 1 shows the total production and percentage of ripe fruit for each year.

Both of the original treatments initiated during 1980, insulation and heat storage, entailed a compromise with another desirable feature. The insulation reduced incoming solar radiation throughout the day, especially in the morning and evening. Tomato plants in the insulated houses grew 10 percent taller and appeared to have more total foliage. This phenomenon was observed in the insulated houses during succeeding years of study. Plants in the insulated houses maintained a dark green color and were quite vigorous. Mold on the fruit became a slight problem later in the growing season (fig. 8).

Figure 8. Gray mold (Botrytis cinerea) most likely resulting from excess humidity.

For 1980, the standard house with the water barrels outproduced other treatments by 35 to 50 percent. This is impressive, considering the reduction in growing space. The insulated house with water barrels, however, had the lowest total tomato production for that year. All of the modified houses were able to provide an extended growing season with a higher percentage of ripe fruit than the unmodified houses.

Table 1. Tomato yields and percentage of ripe fruit for treatments in uninsulated and insulated greenhouses at Palmer Research Center for 1980 through 1983.

	Standard Fan		Solar Fan		Water Barrels		Soil Exhaust Pipe		Solar Chimney	
Year	Uninsulated	Insulated	Uninsulated	Insulated	Uninsulated	Insulated	Uninsulated	Insulated	Uninsulated	Insulated
1980:										
Total fruit (lb)	13.6	88.2			174.5	86.7				
Ripe (%)	24.3	65.0			56.0	58.3				
1981:										
Total fruit (lb)	116.7	92.5	141.9	91.3	107.7	94.9				
Ripe (%)	72.5	75.5	76.7	75.3	65.6	82.9				
1982:										
Total fruit (lb)	52.8	63.5	99.1	84.4	70.1	68.2			76.4	71.7
Ripe (%)	68.4	61.0	77.3	46.7	69.8	42.0			71.2	56.0
1983:										
Total fruit (lb)	147.5	131.5	187.5	140.0	146.4	145.1	181.2	128.7		
Ripe (%)	55.8	60.4	85.9	84.5	60.5	77.6	80.6	80.9		
Average										
Fruit (lb)	107.5	93.9	142.8	105.3	124.7	98.7				

In 1981, insulation again was of no benefit and seemed to be detrimental. Insulated houses were more humid, no doubt due to reduced condensation on the north wall and decreased avenues for moist air to escape. As a result, mold became a negative factor in fruit set and production.

Houses with water barrels again showed the highest average yields per plant, thereby compensating for the 25 percent reduction in number of plants.

The solar fans performed well in their first year. Yields for the houses without the barrels were 18 to 24 percent higher for the one with a solar fan compared to those with the other treatments. Solar fans were smaller and did not cycle as frequently as their electrical counterparts. In 1981, there was no thermostatic control of the solar fans, therefore they turned on earlier in the day, even though greenhouse temperatures were cool. Since excess humidity may have been a major factor limiting yields with other treatments, the operating characteristics of the solar fans may have helped prevent water condensation on plant leaves and fruit. These small fans allowed higher daytime temperatures which may have carried over into the evening hours and ultimately improved production. The treatments again lengthened the growing season 40 days over the control.

In 1982, insulation was not particularly effective for most treatments although a slight increase in yield was noted for the insulated house with the standard fan. Yields were reduced when insulation was combined with any other treatment, especially solar fans. Water barrels resulted in reasonable yields, especially in the uninsulated house. Solar fans increased yields significantly over other treatments in both the insulated (16 to 25 percent) and uninsulated (23 to 47 percent) houses. Solar chimneys were second in production figures indicating they provided some benefit. This is particularly interesting since no increases in soil temperatures were observed. The temperature inside the black chimneys ranged from 95 to 100 degrees Fahrenheit during the warmest part of the day, indicating they were not drafting air flow through the buried container. No condensation was ever noticed in the underground portions of the device, and occasional smoke tests indicated they were not functioning as expected.

Since the solar chimneys produced no measurable increase in soil temperatures during 1982, this treatment was replaced in 1983 when exhaust air was vented mechanically through soil pipes. These treatments (insulated and uninsulated) each resulted in an average of 10 degrees Fahrenheit increase in soil temperature at plant root depth. Increased soil temperatures were most apparent in the afternoon and evening. Since routing the exhaust air through the soil pipes required some air pressure loss, the soil pipe treatment exhausted less air and resulted in somewhat warmer daytime temperatures.

In 1983, all greenhouses had good yields. Weather conditions were favorable, and mold was not a serious problem. Under these conditions the insulated north bows were detrimental. There was more yield reduction resulting from reduced light than there were yield increases from warmer nighttime temperatures. The highest yields were obtained from the solar fans or soil pipe exhaust system in the unmodified plastic-covered greenhouse.

Conclusions

There are several heat-conserving practices or greenhouse features that can generally be expected to increase yields in unheated greenhouses (Ross et al. 1978). Of those tested, warming greenhouse soil with exhaust air was most effective, and use of insulation was least effective. Exhausting overhead air through soil tubes involved extra cost both for the tubes and for the additional electric power to operate the fans against increased resistance. Cost of this option will vary with greenhouse size and configuration. We did not detect any significant or potential problems that might reduce yields. Heat storage in the soil probably improves plant growth and makes the otherwise lost heat available for warming the greenhouse air at night.

The solar-powered fans worked well during 1981, 1982, and 1983. Their most apparent disadvantage is the relatively high cost for the solar cell. The 250 cfm solar fans we used were rated at one air change every 3 to 4 minutes in full sunlight and cost about $250. For comparable ventilation capacities, solar fans cost about twenty times as much as conventional fans. However, we did find that with solar-powered fans we could get by with lower than commonly recommended ventilation rates. Solar fans would probably not be an economically sound investment if electricity were available, although the one-time investment for a solar module and fan may be worthy of consideration in remote areas of Alaska where electricity is unavailable or very expensive. (Another, lower-cost, option for automatic greenhouse ventilation that may have potential is the solar-powered door opener.)

Practices that stored heat above ground, such as water barrels, were beneficial in terms of yield per plant. Although floor space was reduced due to placement of the water barrels, there would also be reduced labor in caring for eighteen plants as opposed to twenty-four. Our greatest success with the water barrels was achieved in the uninsulated houses.

Solar chimneys were abandoned after 1 year and replaced with the soil exhaust system. Since we did not record higher soil temperatures with solar chimneys, we do not recommend this treatment for home greenhouse use.

The practice of insulating the north wall and roof of unheated greenhouses for the purpose of heat retention must be evaluated thoroughly. Reduced light levels may result in increased vegetative growth and reduced fruit production. Tomato plants became more spindly near the growing point. This effect is probably more pronounced in northern latitudes due to the greater arc the sun travels around the earth and, hence, the greenhouses. It is possible that greenhouses with gable roof designs, rather than the curved bow design we used, could benefit from north wall but not north roof insulation, depending on their height-width ratio. The use of benches for starting bedding plants would reduce the need for light through the north wall compared to roof lighting. Heat conservation achieved by insulation of foundations and any other opaque surfaces will always be beneficial. Likewise, perimeter insulation to keep the greenhouse soil from losing heat to the outside soil would be helpful without any negative influence except cost.

Common sense and understanding of the principles involved will be the gardener's best guide when deciding whether or not to spend money on the heat-saving devices discussed here. Plain, clear greenhouses work, yet they can be improved. If improvements are costly, then yield increases should be in proportion to the costs incurred. Each greenhouse is different, and the operator's ability to improve and build the improvements himself from low-cost materials may well determine if the required investment is sound. Improved knowledge of how a crop reacts to the local environment will enable us to develop our greenhouse management skills. □

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Wintering Beef Cows on Alaskan Barley And Subsequent Selenium Status

By

Leroy Ben Bruce*

Introduction

Feed is the single largest cost to the beef producer. This is an even heavier burden in Alaska with a shorter grazing season and expensive feed. Hay or silage has long been considered the primary feed for wintering cows. In an effort to give beef producers another option, research was conducted to test the possibility of using barley as a primary source of feed for wintering cows in place of hay. This research was conducted using Alaskan feeds, which are low in selenium (Brundage 1985), and selenium status was constantly monitored. Addition of selenium by intramuscular injection was compared to nontreated animals to establish base-line information for developing recommendations for selenium supplementation.

Experimental Procedures

Crossbred beef cows at the Matanuska Research Farm were used in two groups of five animals each for this study. They were weighed on 28 November 1984 and placed on rations of brome hay or hulled barley as major components. All feeds with the exception of limestone, trace mineral salt, and soybean meal were produced at the research farm. Nutritive values of feeds and ration compositions are listed in Tables 1 and 2, respectively. Animals were allowed a 3-week adjustment period to their pens and rations. Each group was housed in a three-sided barn with open access to a paddock of about .5 acre. All cows were weighed and blood samples taken via jugular venipuncture on 20 December 1984. Three animals out of each group received intramuscular selenium injections (10 milliliters of BO-SE, a trademark of Burns-Biotec Laboratories, Inc.). The cattle were then weighed, bled, and, for the selenium-supplemented animals, injected every 28 days until 10 April 1985. Feed samples and monthly blood samples were analyzed for selenium content, and feed samples analyzed for dry matter, crude protein, neutral detergent fiber, acid detergent fiber, in vitro dry matter digestibility, calcium, and phosphorus. Total digestible nutrients (TDN) for the feeds were estimated by regression equations using acid detergent fiber values.

Rations were formulated to be similar in nutrient content and to meet suggested miniumum nutrient levels (NRC 1984); ration formulations are presented in Table 2. To avoid feed sorting by the animals, ration components were ground daily and mixed completely before feeding. Rations were limit fed, with only enough feed placed in the feed bunks to allow each animal 19.6 pounds (hay/straw ration, dry-matter basis) or 14.3 pounds (barley ration, dry-matter basis) daily. Enough feed bunk space (about 30 inches per head) was provided to allow all animals to feed simultaneously, and feed was spaced in even amounts through the bunks, ensuring that all animals had equal opportunity to feed.

Results and Discussion

The nutritive needs of beef cows are commonly expressed in terms of TDN, crude protein, calcium, and

*Assistant Professor, Animal Science, Agricultural and Forestry Experiment Station, Palmer.

Table 1. Nutritive values of individual feeds fed to wintering cows.

	DM[1]	TDN[2]	CP[3]	Ca[4]	P[5]	Se[6]
	(% dry matter)					(ppb)
Brome hay	81	65	16	.46	.30	16
Barley straw	85	44	3	.31	.09	36
Barley grain	82	80	10	.17	.43	15
Soybean meal	89	84	58	.59	.73	1109
Limestone	100	0	0	20.70	0	0

[1] dry matter, [2] total digestible nutrients, [3] crude protein, [4] calcium, [5] phosphorus, [6] selenium

phosphorus. There are many sources of feedstuffs that can be used to meet these nutrient needs. This allows use of rations of different feedstuff combinations, but not without some limitations. Rations formulated with grains normally carry more energy per pound than do rations with mostly roughage. This could result in higher energy intakes than those desired if animals are allowed to eat their fill. The desired energy intake on a high-energy diet may be attained by limiting feed consumption. This must be done with some care, since the grain ration should be at least 15 percent roughage and both grain and roughage must be ground and mixed to prevent sorting by animals. When group feeding this type of ration, there must be enough bunk space to allow all animals in one pen to feed at the same time and feed must be spread evenly across the bunks.

Table 2 shows the nutritive value and amounts fed to the beef cows during the winter of 1984-1985. Table 3 shows weight gain of hay and barley groups. Both performed equally well and within desired performance expectations, showing the viability of using barley as a base feed for wintering beef cows. This study was not intended for economic analysis, but feed costs per day can be estimated. Using average values reported by the Alaska Crop and Livestock Reporting Service (1985), barley grain was worth $3 per bushel, brome hay $160 per ton, and barley straw about $140 per ton. Soybean meal was estimated at $400 per ton. Limestone and salt were not included in price estimates because of the small amounts used. Using these values, the hay/straw ration cost $1.55 per head per day to feed and the barley grain rations $1.14.

Table 2. Nutritional requirements of and dietary nutritive values and amounts fed to wintering cows.

Ingredients	Amount provided in dry matter					
	Weight	TDN	CP	Ca	P	Se
Hay ration	(lbs)					(ppb)
Brome hay	8.8	5.7	1.4	.040	.026	16
Barley straw	10.7	4.7	.3	.033	.009	36
Limestone	.1	0	0	.020	0	0
total	19.6	10.4	1.7	.093	.035	27
Grain ration						
Barley straw	2.1	.9	.1	.007	.002	36
Barley grain	11.3	9.1	1.1	.020	.049	15
Soybean meal	.5	.4	.3	.002	.004	1109
Limestone	.3	0	0	.055	0	0
total	14.2	10.4	1.5	.084	.055	56
Nutrient requirements						
1000-lb cow	19.6	10.4	1.6	.050	.040	100

Selenium has been shown to be a necessary element for beef cattle, but one that can also be toxic (NRC 1984). The minimum desired level in feedstuffs for beef cows is about 100 parts per billion (ppb), and the toxic level is around 200 ppb for cattle (NRC 1984). Alaskan feeds are low in selenium content and pose potential deficiency problems (Brundage 1985). Selenium is easily supplemented by intramuscular injection of liquid selenium or by using feeds with a high selenium content. Table 4 shows the amount of selenium in the blood of the beef cows at the start and end of this trial. The normal level is about 80 ppb in blood, and blood values are considered a good indicator of selenium status.

Table 3. Beginning and ending weights for beef cows fed hay or grain and selenium supplemented or unsupplemented.

	Cow weight		
	Selenium	No selenium	Averages
	(lbs)		
Brome hay ration			
December 20, 1984	1031	1131	1071
April 10, 1985	1093	1128	1107
Gain or loss	+62	−3	+36
Barley ration			
December 20, 1984	1125	1093	1112
April 10, 1985	1172	1178	1174
Gain or loss	+47	+85	+62
Averages			
December 20, 1984	1078	1112	
April 10, 1985	1132	1153	
Gain or loss	+54	+41	

Table 4. Beginning and ending blood selenium content for beef cows fed hay or grain and selenium supplemented or unsupplemented.

	Amount of selenium in cow blood		
	Selenium	No selenium	Averages
	(ppb)		
Brome hay ration			
December 20, 1984	18	23	20
April 10, 1985	67	23	49
Gain or loss	+49	0	+29
Barley ration			
December 20, 1984	20	25	22
April 10, 1985	80	48	67
Gain or loss	+60	+23	+45
Averages			
December 20, 1984	19	24	
April 10, 1985	74	35	
Gain or loss	+55	+11	

These cows, which had been maintained prior to the trial solely on Alaskan feeds, were selenium deficient when the trial started. While no overt physical symptoms of selenium deficiency could be seen, their conception rate was only 30 percent. This cannot be linked positively to selenium deficiency, but is normally considered a symptom. Table 2 shows the selenium content of the rations. Both rations were below the accepted 100-ppb requirement for beef cattle diets. Selenium-injected cows showed a marked increase in blood selenium content, but were still below the desired level. The monthly injections of 10 milliliters per head of BO-SE was not enough to restore acceptable selenium status. The cattle wintered on the barley diet had substantial increases in blood selenium content over the hay group (table 4). Apparently, the soybean meal, which was added to the barley diet as a protein supplement, contained enough selenium to raise the blood values. The soybean meal component in the diet was small, and this indicates that only small amounts of feed with normal selenium content are needed to raise blood levels.

Future research will establish correct supplementation levels with selenium injections for Alaskan cattle as well as investigate supplementing with feed components.□

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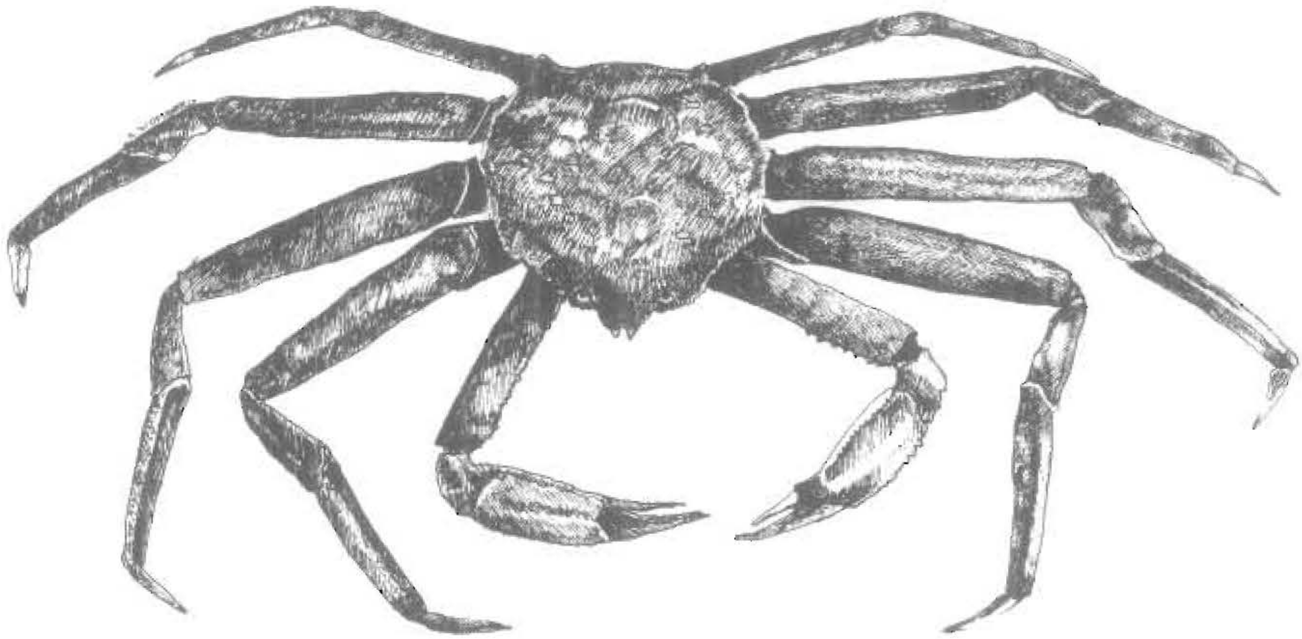

Feeding Tanner Crab Meal to Holstein Dairy Calves

By

Arthur L. Brundage*

Feeding experiments at the Palmer Research Center have shown that both king crab meal and tanner crab meal can be substituted for soybean meal in concentrates fed to lactating dairy cows (Brundage et al. 1981, 1984). However, we have recommended that crab meals be limited to 15 percent in concentrates because higher levels reduced total feed intake and animal performance.

I have also studied the use of tanner crab meal to replace soybean meal in concentrates fed to growing Holstein heifers and steers. In this experiment, thirty-two heifers and thirty-two steers were fed one of four different concentrates in groups of four from 8 weeks to 1 year of age. The experiment was conducted for 2 years; four pens of four heifers and four pens of four steers were fed each year. Concentrates were mixed to contain 20 to 21 percent protein. The control concentrate contained 19 percent soybean meal and no tanner crab meal. The other three concentrates were formulated so that protein in tanner crab meal replaced 25, 75, or 100 percent of soybean meal protein. These three concentrates were 14, 5, and 0 percent soybean meal and 7.5, 22.5, or 30 percent tanner crab meal, respectively. Table 1 lists the composition of the four concentrates fed, and Table 2 lists the chemical analyses of tanner crab meal, the four concentrates, and the hay and silages used in the experiment.

All calves were placed in outside hutches at birth and fed 8 pounds of milk daily, plus calf starter and hay. Calves were weaned at 6 weeks of age and fed the same concentrates until 8 weeks when they were fed 4 pounds of the experimental concentrates daily, plus roughage free choice. Grass hay was fed until calves were 6 months old, and grass or barley/oat silage was fed thereafter. Male calves were castrated at 2 weeks of age and moved to groups of four in larger, outside hutches when they were 8 weeks old. Heifer calves were moved from hutches to free-stall pens of four animals each in our warm, controlled-environment barn when they were 8 weeks old.

Calves were weighed and measured for wither height, heart girth, and paunch girth at 8 weeks of age and every 4 weeks thereafter. Linear regression coefficients for liveweight and body measurements on time were calculated and found to be highly significant; increases in weight and

*Professor of Animal Science, Emeritus, Agricultural and Forestry Experiment Station, Palmer.

Table 1. Ingredient composition of concentrates.

Ingredients	Concentrates			
	0% TCM[1]	7.5% TCM	22.5% TCM	30% TCM
	(%)			
Corn	4.9	4.9	4.9	4.7
Barley	45.0	45.0	45.0	45.0
Mixed feed oats	10.0	8.3	2.3	.0
Alfalfa meal	10.0	10.0	10.0	10.0
Linseed meal	7.5	7.5	7.5	7.5
Soybean meal	19.0	14.0	5.0	.0
Crab meal[1]	.0	7.5	22.5	30.0
Molasses	2.0	2.0	2.0	2.0
Monocalcium phosphate	.4	.0	.0	.0
Dicalcium phosphate	.4	.0	.0	.0
Trace mineral salt	.8	.8	.8	.8
Vitamin A	(2000 IU)			
Vitamin D_2	(6000 IU)			

[1]Tanner crab meal.

Table 3. Weight, wither height, heart girth, and paunch girth of 1-year-old Holstein steers and heifers fed four different concentrates.

	0% TCM[1]	7.5% TCM	22.5% TCM	30% TCM
	Steers			
Weight (lb)	759	699	700	674
Wither height (in)	49.5	47.8	47.3	47.2
Heart girth (in)	66.1	63.9	64.8	63.4
Paunch girth (in)	82.1	80.2	80.0	80.8
	Heifers			
Weight (lb)	714	699	700	700
Wither height (in)	48.7	47.9	47.9	48.7
Heart girth (in)	63.1	63.2	62.9	63.8
Paunch girth (in)	77.7	78.0	77.2	76.8

[1]Tanner crab meal.

body measurements between 8 weeks and 1 year of age were best expressed by straight lines. Linear regression coefficients calculated for each animal were used in the statistical analysis of weight and measurement data, defining the 2 years and the four concentrates as main effects influencing calf growth, in addition to the interaction of year of experiment with concentrates fed. Data from the heifer and steer groups were analyzed independently because calf sex was completely confounded with degree of environmental stress: heifers were raised inside the barn; steers were raised outside in small, open shelters. It was impossible to measure individual feed consumption because calves were maintained and fed in groups of four, but routine observations were made on the apparent acceptability of the four different concentrates to groups of calves.

Adding up to 30 percent tanner crab meal to concentrates did not appear to affect adversely their acceptability to either steers or heifers. When the same concentrates were fed to lactating Holstein cows in greater quantities, 22.5 and 30 percent tanner crab meal reduced acceptability (Brundage et al. 1984).

Regression coefficients calculated for weight and body measurements relative to time were used to estimate weight and body measurements for heifers and steers when 1 year old. These estimates are shown in Table 3. Heifers fed concentrates containing tanner crab meal weighed less at 1 year than those fed concentrates with no crab meal, but differences were not significant. Regressions of wither height on time were significantly different for heifers fed different concentrates, but the magnitude of wither height differences at 1 year appeared to be of little biological consequence.

Differences between regression coefficients for weight gain in steers were statistically significant. Steers fed concentrates containing either 7.5 or 22.5 percent tanner crab meal weighed 60 pounds less at 1 year than those fed no crab meal. Those fed 30 percent crab meal weighed 80 pounds less than those fed none. With the exception of weight gains, steers were not significantly affected by diets fed.

Steer heart girth was significantly greater the second year; otherwise, year of experiment had no effect on steer growth. Heifer weight, wither height, heart girth, and paunch

Table 2. Chemical analyses of ration components.

Analysis	0% TCM[1]	7.5% TCM	22.5% TCM	30% TCM	TCM	Hay	Silage
Dry matter (%)	87.6	88.0	89.1	89.2	91.5	83.8	35.2
	(dry basis)						
Cell wall (%)	28.7	25.6	25.6	27.2	23.3	67.0	67.3
Acid detergent fiber (%)	11.5	12.8	12.9	14.8	20.2	33.6	38.9
Lignin (%)	2.3	2.3	1.7	2.0	1.7	3.6	6.0
Cellulose (%)	8.8	9.9	10.2	11.3	18.9	28.2	30.2
In vitro dry matter disappearance (%)	81.9	80.5	80.5	79.8	75.5	67.7	58.0
Crude protein (%)	20.0	20.9	21.1	21.3	30.6	12.4	11.4
Calcium (%)	0.76	1.65	3.42	4.11	14.02	0.24	0.23
Phosphorus (%)	0.55	0.54	0.75	0.75	1.71	0.53	0.66
Metabolizable energy (Mcal/lb)	1.43	1.40	1.40	1.39	1.30	1.13	0.93

[1]Tanner crab meal.

girth were all significantly greater the second year of the experiment. There were no significant interactions between year of experiment and concentrate diets fed to either steers or heifers.

Results from this study suggest that tanner crab meal can be fed to Holstein heifers as 30 percent of the concentrate portion of the diet without adversely affecting growth when animals are housed in a warm barn. Results also suggest possible reduction in rate of gain when tanner crab meal is included in diets fed to Holstein steers housed outside with minimal shelter throughout the year. Because steers and heifers were maintained under different housing systems throughout this study, results do not define possible interactions between sex and concentrates fed that are not completely confounded by conditions of the experiment. Adding tanner crab meal up to 30 percent of the concentrates fed did not appear to affect adversely palatability of diets to either steers or heifers. In Alaska, where tanner crab meal is produced and more traditional protein supplements, such as soybean meal, must be imported, there is an economic incentive to use tanner crab meal to replace soybean meal if the unit price for protein is less in the former than in the latter.☐

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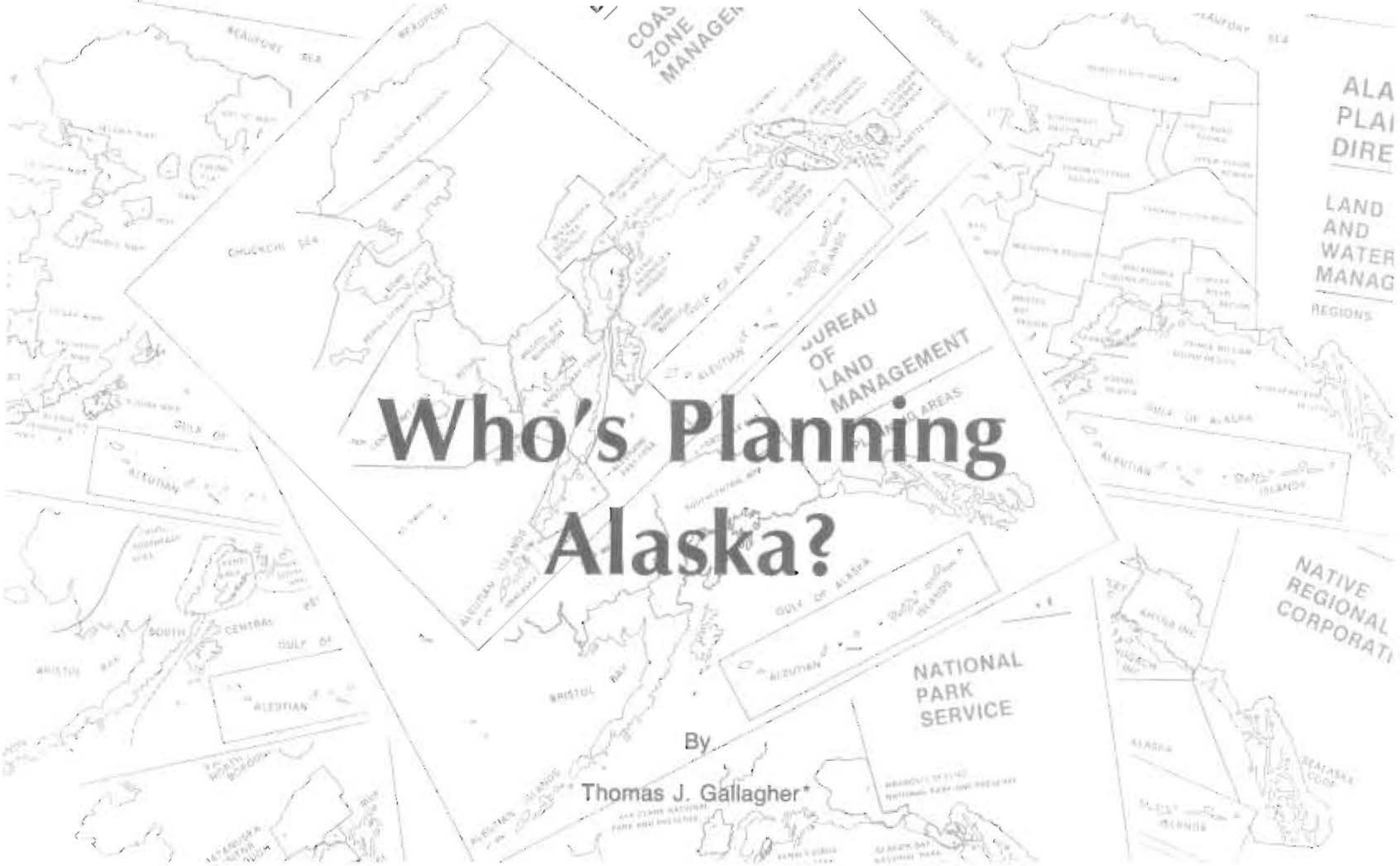

Who's Planning Alaska?

By

Thomas J. Gallagher*

Introduction

Who's planning Alaska? The Cooperative Extension Service (CES) at the University of Alaska recently published a handbook to answer this question. Called *Who's Planning Alaska: The Alaska Planning Directory*, the document summarizes land plans prepared by federal and state agencies, boroughs and cities, and Native corporations in Alaska.

The need for the directory first became evident in 1984. At that time, CES recognized that a great number of land plans had been completed since 1980 and that many more plans were in progress or anticipated in the near future. CES recognized that although these plans influenced the people and land throughout rural Alaska, there was very little documentation on them. Each agency kept its own records; there was no central source that planners or the public could turn to for information. Only a few professional planners employed by large agencies knew what was happening.

The lack of documentation was causing two problems that interested CES. First, it complicated coordination among planning groups and their plans. Coordination requires time, money, and personnel. Large agencies are usually better able to hire professionals specifically to oversee coordination, but small entities, like village corporations, can face an unacceptable burden. As a result, plans are not always compatible. Given the complex land ownership pattern in Alaska, incompatible plans may seriously hamper future land management and resource development efforts in Alaska.

Second, the large number of plans were overwhelming the public. Without adequate documentation it had been nearly impossible for people to keep up with the plans as they were being initiated, prepared, reviewed, and put into action. Not only were there many plans, but each agency was using a different planning process and different terms. Even for professional planners, the procedures and jargon of other agencies often posed a barrier to communication. The variety of plans, each with its own outline and language, easily confused the public. Given the number and character of the plans, and the great distances and bad weather separating people from planners, participation was often less than ideal.

Both problems fit within the scope of CES responsibility: to provide information to people that will help them make better decisions in their personal life and in their community. In the summer of 1984, CES authorized preparation of the directory.

Background

A series of laws passed over the last 26 years created the recent surge in land planning. These laws established

***Assistant Professor, Land Resources Planning, School of Agriculture and Land Resources Management, Fairbanks.**

planning units and either required or encouraged land plans for these units. The major laws and their effect on planning are:

- The Federal Housing Act of 1954 required that a community prepare a comprehensive or master plan as a prerequisite to receiving federal urban renewal and housing funds. Boroughs and cities were affected. The first plans were completed in the mid-1960s with other communities completing plans at a relatively uniform pace ever since.
- The Alaska Statehood Act of 1958 gave the state the right to select 104 million acres from the public domain—the 370 million acres (99 percent of the state) then managed by the Bureau of Land Management (BLM). This act, unique among the fifty states, contained a special title on natural resources that required the Department of Natural Resoures (DNR) to classify and plan state lands once they were received. Several DNR divisions are now actively involved in land planning.
- The Alaska Native Claims Settlement Act (ANCSA) of 1971 established 12 in-state, land-holding Native corporations (and one out-of-state, nonland-holding corporation) and more than 210 village corporations. It authorized these private, "for-profit" corporations to select 44 million acres from identified public domain. Each of the regional corporations and many of the village corporations are now involved in land planning.
- The federal Coastal Zone Management Act of 1972, supplemented by the Alaska Coastal Management Act of 1977, encouraged local governments to include federal coastal goals in their comprehensive plans. The program involves twenty-eight boroughs and cities and five special "coastal resource service areas" that represent parts of the unorganized borough. Each of thirty-three coastal districts has been actively planning.
- The Resource Planning Act (RPA) of 1974, augmented by the national Forest Management Act of 1976, required the US Forest Service to prepare national, regional, and forest level plans. In Alaska, the Forest Service manages 24 million acres in two national forests, the Chugach and Tongass of southcentral and southeast Alaska, respectively. Both forests have well developed planning programs.
- The Federal Land Policy Management Act (FLPMA) of 1976 changed the Bureau of Land Management's operating goals from land disposal to land management. The act required BLM to prepare comprehensive plans for the land it will retain following the Alaska National Interest Lands Conservation Act and selection by the state and natives. The BLM is in the process of preparing the required plans.
- The Alaska National Interest Lands Conservation Act (ANILCA) of 1980 established thirteen national parks and preserves; sixteen national wildlife refuges; two recreation and conservation areas; and numerous wild and scenic rivers, wilderness areas, and other special areas. The act required that the managing agency prepare a comprehensive plan for each unit. The National Park Service is near completion of its plans; the US Fish and Wildlife Service expects to complete all plans by 1988.

With each act the number of land units and the pressure to prepare land plans increased. Although some municipalities began planning in the mid-1960s, uncertainty about which agency or corporation was to receive what land effectively prevented planning until this decade. The primary source of delay was ANCSA which established the Joint Federal-State Land Use Planning Commission to study lands in Alaska that have national interest. The commission's task focused federal, state, and Native attention on the selection process during the 1970s. Only after ANILCA clarified which lands the federal government would retain in 1980 could planning for most of Alaska's land begin in earnest.

Thus, although the legislative mandate for planning extends over three decades, planning for most of Alaska lands has just started. And although this surge is less than five years old, it has already transformed the majority of Alaska's land from "unplanned" to "planned." In the haste to get plans completed, no one, until now, has taken responsibility for documenting all of the many planning efforts.

The Collection Process

The first CES action was to define the scope of the directory in three areas: subject matter, planning scale, and entity (agency or corporation) involved. Concerning subject matter, the directory focuses on land plans, often called land use, general, comprehensive, or master plans. In compiling the directory, CES's intent was to identify management units and their associated plans. This focus excluded a variety of narrower plans and studies, such as transportation plans, capital improvement plans, business plans, resource inventories, and management plans for specific plant or animal species.

Land plans can range in scale from nationwide to site. The directory focuses on larger plans, including those on a national, statewide, regional, or area scale. An exception is made for small municipalities and village corporations for which a primary land plan may cover a few hundred to a few thousand acres.

The directory looks at four major groups of planning entities: federal agencies, state agencies, municipalitites, and Native corporations. Subgroups for federal and state agencies include only those with direct, substantial, land-planning responsibility. Agencies with minor holdings, such as the University of Alaska, with about 130,000 acres, were not included. The directory includes all muncipalities and Native corporations even though second-class cities and private corporations have no legal mandate to prepare land plans. Some of both groups have prepared or are preparing plans. They were included to help further the directory's goals of improved coordination and participation.

Data for the directory come from several sources. First, other summaries of plans and studies provided a beginning. Of particular value were reports by the Arctic Environmental Information and Data Center (AEIDC 1984), the state Department of Community and Regional Affairs (CRA 1982), the state Office of Managmenet and Budget (OMB 1984), and professionals (Jaeger 1984).

Second, libraries of the University of Alaska-Fairbanks, the Alaska Resources Library in Anchorage, and the Department of Community and Regional Affairs (which assists local communities with land plans) added to the list. The library search substantiated the need for better documentation: no more than 50 percent of listed plans were available in any single library.

Third, the agencies or entities themselves provided data. Federal and state agencies corrected a draft list sent to them; boroughs and regional Native corporations corrected a draft list over the phone; and, the first- and second-class cities and Native village corporations responded to a mailed questionnaire.

The present list of plans is still considered a draft. CES policy requires that the first publication of such summaries encourage corrections and revisions. Comments and corrections received will be combined with more accurate and detailed maps and superior printing to produce a "final" document in 1986. After that, CES will update the directory on a periodic basis.

Summary of Plans

Who's Planning Alaska: The Alaska Planning Directory is divided into four sections: federal agencies, state agencies, municipalities, and Native corporations. Each section is further subdivided into major planning entities. For each entity there is a brief description of their reason for planning (including the applicable legislation) and the types of plans they prepare. For agencies and municipalities there is a list of plans completed or in progress and a contact person. For Native corporations, the presence of a plan is simply noted with an asterisk with a contact provided. Maps showing planning units and management units, if different, are provided where available.

The directory includes both *primary* and *secondary* land plans. A primary plan meets one or more of three criteria: (1) it is of national, state, or regional interest; (2) it is the central, comprehensive plan for a community or corporation of any size; or (3) it involves public particiption as a legal requirement. Thus, primary plans may include the entire state or they may represent a small community.

Secondary plans may not meet one or more of the criteria, but they are still, clearly, major land plans and often have substantial public interest. Most secondary plans in the directory are either subplans of a primary plan or are plans prepared under special legislation or administrative action. The summary that follows concerns only primary plans.

Federal Agencies

Four federal agencies, the Bureau of Land Management, Forest Service, National Park Service, and Fish and Wildlife Service, prepare plans for almost 220 million acres (59 percent of the land in Alaska). Other listings in this section include the Department of Defense (DOD), Coastal Zone Management (CZM), and Alaska Land Use Council (ALUC). DOD manages several million acres on five military bases and one flood-control/recreation project. CZM and ALUC are included here because they originated with federal acts. Although CZM goals are implemented through community plans, they are considered "primary" and are included in the summary because of their high level of public participation. The ALUC conducts a wide range of studies and plans. Only the Bristol Bay Regional Plan, however, is considered a true land plan and is included.

Table 1 lists these agencies, the acreage they manage, the number of planning units or plans involved, and the number of plans complete or in progress. In some cases the number of planning units or plans is not the same; when this occurs the larger number is used. The acreage figure for CZM is an estimate of the amount of land actually influenced by CZM goals. Acreage for ALUC is for the Bristol Bay Management Plan. CZM and ALUC figures are in parenthesis because they overlay other planning units and are not used when determining total acres.

Table 1. Summary of federal agency primary plans.

Federal agency	Acres (millions)	Plans/ units	Plans complete	Plans in progress
Bureau of Land Management	65	10	6	4
Forest Service	24	5	5	0
National Park Service	52	13	13	0
Fish and Wildlife Service	77	16	5	8
Department of Defense	2	6	6	0
Coastal Zone Management	(100)	33	16	16
Alaska Land Use Council	(31)	1	1	0
Total	220	84	52	28

The Bureau of Land Management has several older complete plans that must be redone to meet FLPMA requirements. The anticipated revisions are not included in the column labeled "Plans Complete." Of the National Park Service plans, four are complete and approved and nine are presently out for public review. All Park Service plans are listed as complete, however.

State Agencies

Three divisions of the Department of Natural Resources prepare land plans. The Division of Land and Water Management is responsible for the vast majority of the state's 104 million acres (28 percent of the state). The division prepares the statewide natural resource policy plan, the state's regional river basin plans, and special area plans. The Division of Parks and Outdoor Recreation prepares two types of statewide plans and has prepared or is preparing several regional plans. It manages 110 parks of which 10, totaling 4 million acres, have master plans that meet the "primary" criteria. The Division of Forestry prepares a statewide forest plan and general plans for its two forests.

The state is also involved in planning through the Department of Community and Regional Affairs, Division of Municipal and Regional Assistance. This division helps groups of communitities prepare regional plans. (It also helps individual communities prepare comprehensive plans, which is discussed in the next section.) Table 2 summarizes the primary plans prepared by state agencies. The Community and Regional Affairs acreage figure is an estimate. The figure is in parenthesis because it overlays other planning units and is not included in the total.

Table 2. Summary of state agency primary plans.

State agency	Acres (millions)	Plans/ units	Plans complete	Plans in progress
Land and Water Division	98	20	8	5
Parks Division	4	15	12	0
Forestry Division	2	3	2	1
Community/Regional Affairs	(80)	5	1	4
Total	104	43	23	10

Municipalities

In Alaska, the term "municipality" includes boroughs and cities and combined boroughs and cities called unified home-rule governments. This section is presented in five parts: (1) unified home-rule governments, (2) boroughs, (3) home-rule cities, (4) first-class cities, and (5) second-class cities. Of this group all have the obligation to prepare land-use plans except the single third-class borough (Haines) and second-class cities. Boroughs are responsible to plan for cities within their boundaries.

Boroughs and cities, unlike federal and state agencies, are primarily involved in planning of private land. Although the boroughs encompass 93 million acres (25 percent of the state) over 95 percent of this acreage is managed by the federal or state government or by Native corporations. Hence, acreage figures shown in Table 3, in parenthesis, are not included in the final tabulation. Acreage figures for cities are not available, but the total is considered minor. The number of "plans in progress" is an estimate based on questionnaire responses.

Table 3. Summary of municipal primary plans.

Municipality	Acreage (millions)	Plans/ units	Plans complete	Plans in progress
Unified home rule	(16)	3	3	0
Boroughs	(78)	7	7	0
Home-rule cities	n.a.	9	7	0
First-class cities	n.a.	21	16	3
Second-class cities	n.a.	116	29	20
Total	(94)	156	62	23

Native Corporations

ANCSA permitted Native regional and village corporations to select 44 million acres (12 percent of the state). The corporations, as private businesses, have no obligation to prepare land plans or to make them public. All twelve land-holding regional corporations are involved in land planning, but only two are thought to have completed the equivalent of a comprehensive plan for their land.

Although ANILCA established 210 village corporations, mergers with regional or other village corporations have reduced this number to 177. (A recent merger not included in the draft summary further reduces this number to 168.) Most village corporations are still involved in the conveyance process even though they have received the bulk of their entitlement. Less than twenty villages have completed land plans but many more are in progress, or are anticipated (table 4).

Table 4. Summary of Native corporation primary plans.

Native corporation	Acres (millions)	Plans/ units	Plans complete	Plans in progress
Regional corporations	16	12	2	10
Village corporations	28	177	19	30
Total	44	189	21	40

Table 5 summarizes tables 1 through 4. Alaska is now divided into 472 primary planning units. Each unit, at least potentially, involves a land plan. Of this number, 436 are autonomous units and 39 (including CZM, ALUC, and CRA plans) overlay other units. Boroughs are considered autonomous in this count as each borough plans for one or more autonomous city(ies). A total of 158 plans are complete, and 101 are in progress. Assuming all planning units eventually complete plans, there are 213 additional plans yet to be initiated. Not all entities must plan, however. One borough, 116 second-class cities, and all 189 Native corporations have no legal obligation to prepare land plans.

Table 5. Summary of primary plans by section.

Summary	Acres (millions)	Plans/ units	Plans complete	Plans in progress
Federal agencies	220	84	52	28
State agencies	104	43	23	10
Municipalities		156	62	23
Native corporations	44	189	21	40
Total all plans	368	472	158	101
Not required	44	306	50	50
Total required plans	324	166	108	51

Discussion

Although the directory was prepared as a tool for coordination and participation and not as a research study, it provides several insights into Alaska's land planning. First, it is apparent that Alaska is midway in preparation of plans, at least in terms of gross numbers. Of the 472 total plans, 46 percent have not been started. Assuming all entities with land units prepare plans, there is still substantial work to be done. This assumption is supported by the large number of "not-required" plans already complete or anticipated. Most required plans, however, are either complete (65 percent) or in progress (31 percent), leaving only 4 percent yet to be started. The large number of planning units without plans should support a high level of planning well into the 1990s.

Second, the large entitites are far ahead of the small entities in number of plans complete or in progress. Federal agencies have completed or have in-progress 95 percent of their plans, state agencies 75 percent, municipalities 54 percent, and Native corporations 32 percent. Second-class cities and village corporations have the advantage of using data collected by larger entitities, but they may also have the disadvantage of having to work with, or around, established plans.

Third, most of Alaska's land has already been planned by federal and state agencies. Although almost half of all plans have not been started, the existing plans represent about 300 million acres, or 80 percent of the state. Most of Alaska can now be considered "planned."

Fourth, the number of plans and the acres planned has jumped dramatically in this decade. Prior to 1980 there were probably no more than 50 primary plans, mostly borough and city comprehensive plans. An additional 100 plans, including the major federal and state plans, have been completed in the past 5 years,. The change from "unplanned" to "planned" has been very rapid.

Fifth, land-use planning efforts are not likely to diminish in Alaska in the forseeable future. There are many primary plans yet to complete; there are numerous primary plans that require specific subplans as part of their implementation; and all plans need periodic updates, often as frequently as every other year.

Sixth, Alaska's lands are publicly owned. With the exception of that land owned by Native corporations, less than 2 million acres (.5 percent) is privately owned. The large number of plans and the acreage involved express the fact that Alaska is, and will be, a state planned and managed through government agencies—and agencies use plans to make and justify decisions.

Conclusion

Alaska, in a single decade, has gone from a state with almost no planning, i.e., the "Last Frontier," to a state dominated by plans. Alaska has experienced more planning in 5 years than most other states have seen in the past 50 years. The reasons are many. Alaska has far more public land than other states, and public land is managed through plans. Also, Alaska has special legislation, particularly ANCSA and ANILCA, which created management units and required plans.

Since 1980, Alaska has been caught up in a flood of plans. *Who's Planning Alaska: The Alaska Planning Directory* has caught the first stream of plans midflow. Once the surge is past, however, there will be a steady flow of plans for an indefinite period. CES will update the directory periodically to keep the document current and accurate. With this publication, both agencies and public alike will be able to answer the question, "Who's Planning Alaska?" □

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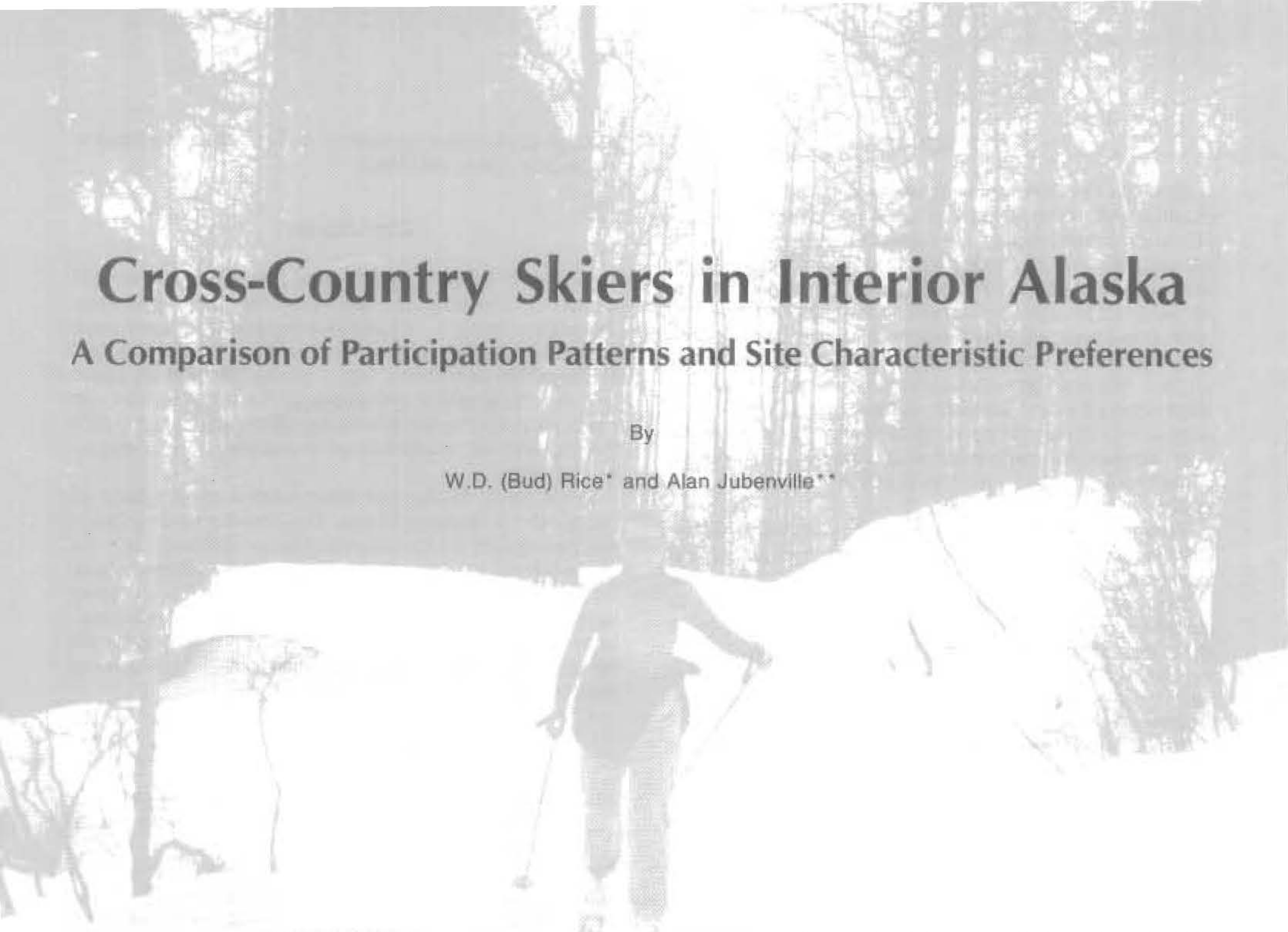
Editors Note: For a copy of the latest edition of Who's Planning Alaska: The Alaska Planning Directory, *contact the author or the Cooperative Extension Service, University of Alaska, 219 Eielson Building, Fairbanks, Ak 99775-5200.*



Cross-Country Skiers in Interior Alaska

A Comparison of Participation Patterns and Site Characteristic Preferences

By

W.D. (Bud) Rice* and Alan Jubenville**

Introduction

Winter recreation has increased dramatically in the United States in recent years. Cross-country skiing has become one of the most rapidly growing winter recreational activities. Prior to 1960, almost anything written about cross-country skiing had to be prefaced with explanatory remarks. More recently, the activity has become very popular, particularly in the snowbelt regions, and most people know what "cross-country" or "Nordic" skiing implies. Winter recreation management has focused on this activity out of necessity, but unfortunately recreation management research has not kept pace. The study reported here is a response to the need to better understand skier behavior and preferences.

Cross-country skiing first began in the Scandinavian countries approximately 4,500 years ago. Laplanders used skis for hunting and herding of reindeer. Skis provided an efficient means of transportation for survival and work in snow country. Norwegian miners introduced skis to the U.S. in California in 1840, and in 1850 they organized the first races in the Sierra Nevada (Brady and Skjemstad 1974). Hardy Scandinavian homesteaders and miners brought skiing to other locations in the U.S., including Alaska.

Popularity of cross-country skiing grew slowly in the U.S. until the late 1960s and early 1970s. A running and health craze swept through the country in the 1970s, and Nordic skiing logically extended the running season through winter months in the snow belt regions. Exercise physiologists now know that Nordic ski racing is one of the best overall physical conditioning activities. Participants also discovered that cross-country skiing can be a peaceful and satisfying way to enjoy the out-of-doors during the winter.

Consequently, cross-country ski sales increased exponentially during the 1970s. In 1966, an estimated 8,500 pair of Nordic skis were sold in the U.S., but in 1971 about 170,000 pair were sold. Over 350,000 pair were sold during the next year (Brady and Skjemstad 1974), and sales have continued to increase.

A similar pattern has emerged in Alaska. The authors of the 1981-85 Alaska Recreation Plan state that about 25 percent of the 60,000 residents of the Interior participate in cross-country skiing (Alaska Division of Parks 1985). The total number of skiers should continue to increase since

***Graduate Research Assistant, School of Agricultural and Land Resources Management, University of Alaska-Fairbanks.**
****Associate Professor, Resource Management, Agricultural and Forestry Experiment Station, Fairbanks.**

Table 1. Summary of participation variables for recreational and racing skiers.[1]

Participation variable	Variable category	Recreational Numbers	Recreational Percent	Racing Numbers	Racing Percent
Total years skiing	First Year	31	15.3	4	4.9
	2 or more years	171	84.7	78	95.1
Frequency participated/month[2]	2 times or less	56	28.0	1	1.2
	more than 2 times	144	72.0	81	98.8
Miles per day[2]	1-5 miles	153	75.7	18	22.0
	6 or more miles	49	24.3	64	78.0
Type of group[2]	Alone	70	34.7	32	39.0
	Small Group	93	46.0	41	50.0
	Family	29	14.4	0	0.0
	Other	10	5.0	9	11.0
Primary activites	Skiing only	176	87.1	74	91.4
	Ski and camp	16	7.9	5	6.2
	Ski and other	10	5.0	2	2.5

[1]N = 284, but "no-response" cases have been omitted. Percentage calculations are based only on active responses.
[2]Significant difference at the 0.05 level of chi-square.

the population in the Fairbanks vicinity has been projected to increase to 90,000 by 1990. In addition, improved facilities, easier access, and better equipment continue to attract more and more participants.

The early Nordic skiers in the Fairbanks community integrated the activity into their lifestyles by commuting to work places and schools on skis. The Skarland Ski Trails, for example, were developed between the University of Alaska and outlying residential areas. In 1965 Lathrop High School initiated the Skiathon, a citizen race which follows portions of the Skarland Ski Trails. The Nordic Ski Club of Fairbanks sponsors an increasing number of Nordic ski events each winter including ski clinics, ski tours, the "Turkey Day Relays," the "Breakup Triathlon," and the 55-kilometer "Chena Hot Springs Hiihto." During March of 1984 Fairbanks hosted the final World Cup Race at Birch Hill—a race in which many of the world's finest Nordic skiers competed. In addition to trail skiing and racing, many cross-country skiers travel to nearby open slopes to practice such Nordic downhill techniques as the celebrated Telemark turn. But most of all, interior Alaskans cross-country ski purely for recreational enjoyment of the great outdoors during the winter.

The Study

A "self-administered" questionnaire was developed to sample cross-country skier preferences for landscape features, facilities, services, and management policies. Using the questionnaire, a survey of cross-country skiers in the vicinity of Fairbanks was conducted at nine cross-country skier locations during the winters of 1983-1984 and 1984-1985. Three primary classifications of cross-country skiers were identified for sampling: recreational, racing, and mountaineering. Skiers were asked to classify themselves according to their normal patterns of participation and respond to the questionnaire based on their chosen mode of participation. Too few of the survey respondents identified themselves as mountaineering skiers for statistical purposes, and consequently this group was deleted from further analysis. A statistical comparison of the preferences of recreational (n = 202) and racing (n = 82) skiers was made. The general behavior patterns and landscape and management preferences of the two classes were compared using Chi-square analysis to determine whether the differences were sufficient to warrant separate management programs. These data, presented in the following sec-

Table 2. Summary of environmental preferences for recreational and racing skiers.[1]

Environmental variable	Preference category	Recreational Numbers	Recreational Percent	Racing Numbers	Racing Percent
Landform[2]	Flat to gentle	56	29.0	10	12.8
	Rolling hills	101	52.3	47	60.3
	Mountainous	14	7.3	10	12.8
	No preference	22	11.4	11	14.1
Vegetation type	Spruce	10	5.2	6	7.9
	Hardwoods	14	7.3	8	10.5
	Spruce-Hardwood	97	50.5	33	43.4
	Other	22	11.5	9	11.8
	No Preference	49	25.5	20	26.3

[1]N = 284, but "no-response" cases have been omitted. Percentage calculations are based only on active responses.
[2]Statistically significant at the 0.05 level of chi-square.

Table 3. Summary of facility development preferences for recreational and racing skiers.[1]

Facility development variable	Preference category	Recreational Numbers	Recreational Percent	Racing Numbers	Racing Percent
Trails	No trails	7	3.7	0	
	Developed trails	159	83.7	73	94.8
	No preference	24	12.6	4	5.2
Trail length	0-3 miles	21	13.3	7	10.0
	4-9 miles	95	60.1	38	54.3
	10 or more	42	26.6	25	35.7
Parking	Yes	107	56.3	41	53.2
	No	83	43.7	36	46.8
Trail marking	Yes	114	60.0	55	71.4
	No	76	40.0	22	28.6
Overnight shelters	Yes	45	23.7	10	13.0
	No	145	76.3	67	87.0
Trail lighting[2]	Yes	64	33.7	57	74.0
	No	126	66.3	20	26.0
Warmup hut[2]	Yes	64	33.7	52	67.5
	No	126	66.3	25	32.5

[1]N=284, but "no-response" cases have been omitted. Percentage calculations are based only on active responses
[2]Statistically significant at the 0.05 level of chi-square.

tion, should help managers better understand the specific needs of recreational and racing cross-country skiers, particularly with regard to appropriate management strategies.

Results

The results of all comparisons are presented in tabular form. Those displaying statistical significance are identified and discussed in more detail. Since this was an exploratory study, all results may be important from a management perspective.

Participation Patterns of Skiers

The variable measured in terms of participation patterns are shown in Table 1. Most skiers of both classes had two or more years of skiing experience.

Differences in participation patterns between the two skier classes show, in frequency of participation, skiing distance per day and type of group. The racing skier participated much more frequently and skied greater distances. The significant difference for type of group may be attributed to the lack of family participation as a group in racing skiing.

Environmental Setting

User preferences for landform and vegetation type are shown in Table 2. Skiers generally preferred rolling hills; however, preference for landform by the recreational skier was skewed more to the flat-to-gentle category. The spruce-hardwood mixture was the vegetation type preferred by both classes of skiers. It must be noted, however, that greater than 25 percent of each skier classification showed no preference for vegetation type.

Table 4. Summary of service preferences for recreational and racing skiers.[1]

Service variable	Preference category	Recreational Numbers	Recreational Percent	Racing Numbers	Racing Percent
Snow removal at parking	Yes	100	52.9	36	46.8
	No	89	47.1	41	53.2
Brush, limb removal	Yes	106	56.1	52	67.5
	No	83	43.9	25	32.5
Trail grooming[2]	Yes	105	55.6	69	89.6
	No	84	44.4	8	10.4
Food concession[2]	Yes	13	6.9	23	29.9
	No	176	93.1	54	70.1
Safety, maintenance patrol	Yes	19	10.1	17	22.1
	No	170	89.9	60	77.9

[1]N=284, but "no-response" cases have been omitted. Percentage calculations are based only on active responses
[2]Significant difference at the 0.05 level of chi-square.

Facility Development

Facility development often plays a critical role in user choice to participate, assuming the environmental setting is attractive (Jubenville 1986). But it is also the most expensive capital outlay; thus, it is important that the manager understand the perceived needs of the user. Table 3 summarizes facility preferences. All skiers preferred developed trails, with medium length (4-9 miles) the most preferred. Trail markers and parking were preferred by both classes, whereas overnight shelters were not deemed necessary.

The perceived need for trail lighting and warming huts were different for the two skier classes. The racing skier preferred these facilities; the recreational skier did not. In an attempt to determine other facility needs, each respondent was also asked to list other desired facilities. There were only thirty responses to an open-ended question on the need for other facilities. Of these responses several identified a need for toilets and trail maps.

Services

Nearly 93 percent of all respondents expressed an interest in some service. The specific services are shown in Table 4. Although the differences in perceived need for trail grooming, food concession, and safety/maintenance were statistically significant, both recreational and racing skiers showed similar trends. Trail grooming was perceived as needed by both classes of skiers; however, the racers overwhelmingly supported trail grooming. The food concession and safety/maintenance patrol were not perceived as needed, but more racers were in favor of such services than recreational skiers. Snow removal at the parking areas and removal of brush and limbs from the ski trails were perceived as needed by a majority of all skiers.

An open-ended question was asked regarding the need for management regulations. In general, respondents were not interested in regulating use (N = 94), except to prohibit the following on ski trails: snow machines and other vehicles (N = 94), dogs (N = 58), pedestrians (N = 23), and other impacts to trail quality and safety. This is similar to other survey findings (Knopp and Tyger 1973).

Conclusions

In summary, this exploratory study of participation patterns and site characteristic preferences by recreational and racing cross-country skiers points to few significant differences between the two classifications of skiers. Differences that may develop into conflicts appear to be temporal and readily resolved by management strategies, rather than two separate trail systems. Future research on winter recreation such as cross-country skiing will be needed as numbers of participants increase, available open spaces decrease, and participation patterns and preferences change.

Racing skiers ski faster, farther, and more frequently than recreational skiers, but these participation patterns have minor effects on preferences of site characteristics. From a management perspective, racers need groomed trails for speed and consistency. Recreational skiers may not require such intensive trail grooming, but generally they prefer set tracks to eliminate rough surfaces and the need to break trail. Wide, groomed trails with parallel tracks in areas frequented by racers would facilitate passing and minimize conflicts between the two groups. A new racing technique, called skating, has changed the trail design and maintenance to extremely wide trails for racing and set track along one edge for the recreational skier.

Most cross-country skiers prefer medium-length trails that are developed, marked, maintained, and groomed, with the brush and limbs removed. Two important differences from a management perspective are the perceived needs by racers for trail lighting and warming huts.

Are there sufficient differences to warrant separate sites and management programs for each group of skiers? Probably not. The perceived needs of recreational skiers are much fewer than those of racing skiers, but the recreational skier can be accommodated on trails developed and maintained for racing. The real differences, however, may only be temporal. Many of the specialized needs of the racers could be accommodated on trails designed primarily for the recreational skiers by using portable or temporary warming huts, toilets, tracksetter, or even food concessions.

Considering the short winter days of interior Alaska and the regular training participation by the racers, it is desirable to provide a facility such as the lighted ski trail at Birch Hill. It fits the racer's perceived needs well, while it remains available for the recreational skier. Other trails need meet only minimum requirements in order to be acceptable to the recreational skier, and many of these could be made temporarily acceptable to the racer. In terms of allocation of natural and fiscal resources, this seems to be an optimal management solution because, as suggested by the distribution of the overall sample, the larger subgroup with less need for specific facilities and services is the recreational skier. □

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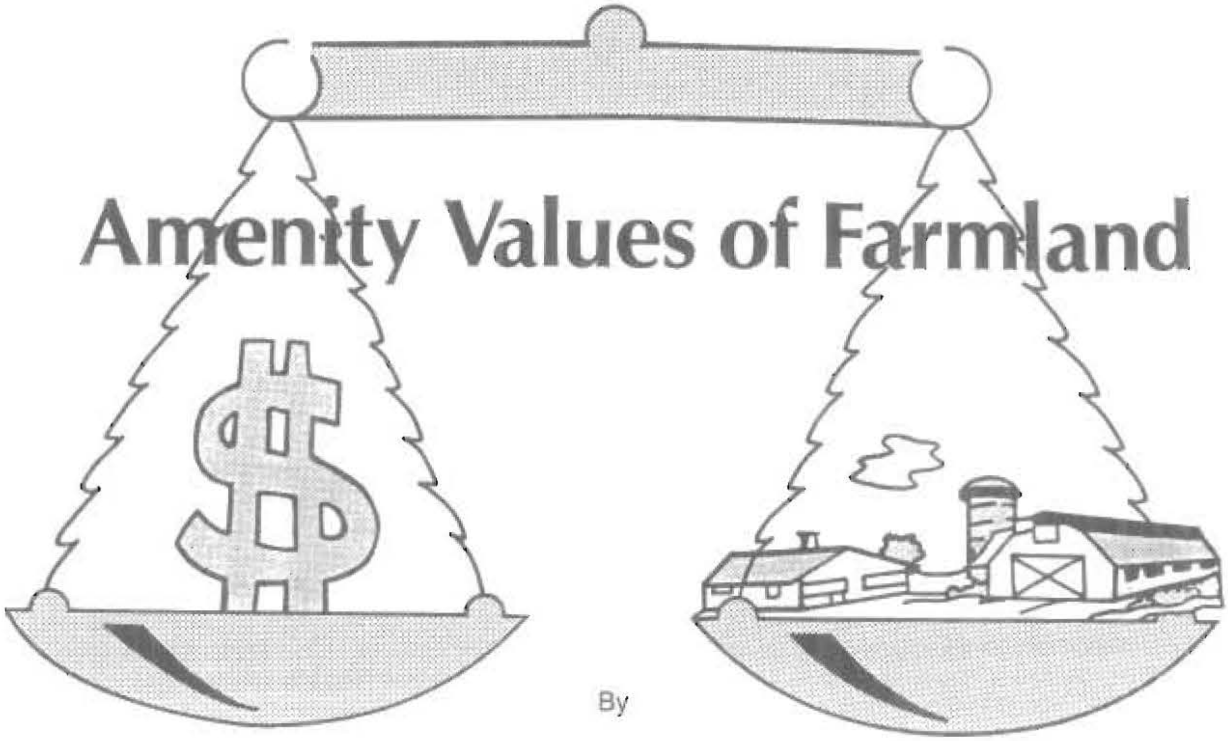
Amenity Values of Farmland



By

Steven D. Beasley* and William G. Workman**

Introduction

The conversion of farmland to residential sites and to other nonagricultural uses is a significant public policy issue in many regions of the U.S. and other parts of the world. While loss of potential food production and the decline of a local farming industry are often-cited objections to these shifts in resource use, a more significant issue in such land-rich regions as Alaska may be the site-specific losses of open space amenities associated with agricultural enterprise near population centers. In this article we report on a recent attempt to value these quality-of-environment benefits of farmland in the Old Colony and Homestead areas of the Matanuska and Susitna Valleys of southcentral Alaska.

Amenities as Collective Goods

The food and fiber outputs of agricultural production in the U.S. are exchanged in well-organized, largely competitive markets with the potential for providing efficient quantities of these private goods. The open space and other environmental amenities associated with urban fringe agricultural lands, however, are unpriced public, or collective, goods. As such, these benefits have two distinguishing characteristics: (1) the impracticability of excluding the consumer who does not pay for the good (i.e., *nonexclusiveness*), and (2) consumption by one consumer does not reduce the quantity available to others (i.e., *nonrivalry*) (Mishan 1969). These qualities make it difficult for market transactions to systematically result in socially optimal amounts of the collective good. First, on the supply side, the nonrivalry characteristic suggests that the cost of making the good available to an additional consumer is zero. This means that the socially efficient price for the good is also zero, and at a zero price no farmer-businessman will be willing to invest in supplying the good (Gardner 1977). On the demand side, since no one can be excluded from consumption, whether or not he pays for the good, individuals have an incentive to not reveal their true willingness to pay for the good. Provided the good were made available, an individual could, as a "free rider," still benefit from its presence.

Alaska has a great abundance of open space and related environmental amenities to offer its residents and visitors. Since market signals are absent with regard to the production of these collective goods, there is little evidence available as to how much these amenities are worth. It seems reasonable, however, that the highest marginal value would be placed on these benefits in situations where they are in short supply. In relatively urbanized areas, these benefits may take on high value indeed. The importance of the environmental effects of agricultural-land preservation is reflected in the criteria by which choices among qualified parcels would be made in a recently proposed Matanuska-Susitna Borough development rights purchase program: (1) agricultural productivity, (2) susceptibility to conversion, and (3) contribution to attractiveness of the area (Planning, Inc. 1983). Based on these considerations and the associated historical attraction of the area to tourists, the Old Colony and Homestead lands have been singled out as a priority for preservation.

***Instructor, Economics, Department of Economics, University of Alaska-Fairbanks.**

****Associate Professor, Economics, Agricultural and Forestry Experiment Station and Department of Economics, University of Alaska-Fairbanks.**

Procedure and Results

But what is the value of preserving the amenity benefits—the environmental advantages as well as the historical values—of these agricultural lands? If public expenditures are to be made in this effort as is often advocated, some notion of the return on this investment would certainly be helpful to policymakers. One index of value is the maximum amount that beneficiaries are willing to pay for the opportunity to enjoy such a good or service. Given the collective-good nature of the environmental amenities associated with urban-fringe farmland, some nonmarket measure of this willingness-to-pay (WTP) must be employed. The procedure used in this study involved on-site interviews in which area residents were simply asked how much they would be willing to pay to maintain the open space character of specific lands.[1]

The first part of the questionnaire consisted of a short text explaining the purpose of the survey and an introduction to the general topic of shifting land uses at the urban fringe. This was followed by some factual information including maps relating to quantity, location, and other characteristics of farmland in the local area. This was considered especially important so that the individual bids or valuations asked for later in the interview would be specific to the local situation and not be seen to refer to some general state or national trend in agricultural land conversion.

The next part of the interview process presented the interviewee with a series of color photographs depicting potential levels of housing development for existing agricultural lands in the local area. Photographs associated with Situation A represented the status quo, or no development, for the farmland remaining in the Old Colony and Homestead areas in Palmer and Wasilla. Situation B depicted moderate levels of housing development in photographs showing a landscape with a mixture of housing and farmland. Finally, Situation C showed a landscape dominated by housing development with no farmland visible in the photographs.

Using situation A as a reference point in each bidding game, the respondent was asked a series of questions designed to reveal his or her maximum willingness to pay annually to prevent the development scenario first in Situation B (i.e. WTP_{B-A}), and then in Situation C (i.e. WTP_{C-A}) for the entire remaining farmland acreage in the Old Colony and Homestead farming areas. The respondent was given a choice of payment vehicles: an increase in local sales taxes, an increase in property taxes, or a voluntary contribution to a special local farmland preservation fund. The interviewer started the bids at $25 per year and asked respondents whether their household would be willing to pay the amount to prevent the development scenario under consideration. A "yes" response resulted in raising the bid by $25 increments until the interviewee answered "no." At this point, the amount was lowered in decrements of $5 until, again, a "yes" resulted. This final amount was interpreted as the maximum WTP. Similarly, an initial "no" response was followed by bid decrements of $5 until a "yes" resulted.

Over a period of approximately four weeks during the summer of 1983, some 153 randomly selected households in the Palmer, Wasilla, and outlying areas of the Matanuska-Susitna Valleys were surveyed. Some of the respondents indicated that they would pay nothing to prevent one or both development scenarios from occurring. Researchers in previous bidding-game studies have queried such respondents with follow-up questions to ascertain the motivation for such responses.[2] For those respondents indicating that the amenity actually has no value, the response is typically recorded as a true zero bid. However, for those interviewees objecting to, say, the method of payment or to the idea of having to pay for an amenity that they believe is already rightfully theirs, the typical procedure is to label such responses as "protest" bids and to omit these data from analysis. Similar procedures were adopted for this study resulting in approximately 20 percent of the sample being treated as protest bids (Beasley et al. 1986).

Analysis of the survey data included both an attempt to explain variation in the bids and an aggregation and extrapolation of bids to estimate the aggregate value of the amenities associated with the farmland included in the study area. In the first instance, multiple regression procedures were used to estimate the linkage between respondents bids and factors hypothesized to be important in determining these bids. The proportion of variation in bids explained by the models was relatively low. However, the statistical significance achieved by individual regressors such as household income, development scenario under consideration, and previous awareness of urban-fringe land use conflicts suggested that bids offered by survey respondents were systematically linked to these factors and were not merely "random noise" (Beasley et al. 1986).

Bids to prevent moderate levels of housing development (i.e. WTP_{B-A}) ranged from 0 to $760 with a mean value of $76 per household annually. Bids to avoid conditions associated with development Situation C (i.e. WTP_{C-A}) varied from 0 to $1,000 with an average of $144. Estimates of the annual amenity benefits accruing to local residents from the retention of the designated farmlands in agriculture were obtained by aggregating the individual bids in the sample and extrapolating these results over the area population. The results of these calculations were $626,000 per year and $1.284 million per year, respectively, for aggregate WTP_{B-A} and WTP_{C-A}.

[1]Hypothetical valuation procedures are controversial in the natural resource valuation literature. For two recent expressions of opposing views of this technique see Rowe and Chestnut (1983) and Randall et al. (1983).

[2]See, for example, Randall et al. (1983) and Daubert and Young (1981).

Discussion and Conclusion

Previous work by Workman et al. (1979) estimated the potential cost of a state government-sponsored development rights purchase program for Alaska agricultural lands. The estimated cost, in 1978 prices, of purchasing these rights on lands located in roughly the same area as that addressed in the current study was $15.165 million. Indexed to reflect price level changes, this figure would now be approximately $20.25 million. In addition, the earlier study estimated that such a program would involve administrative costs of $80,000 annually.

Combining the results of these two studies, one can evaluate both the benefits and costs of an effort to retain the Old Colony and Homestead lands in open space. In this case it seems reasonable to consider only the benefit estimates associated with avoiding development Situation C since any program that would prevent Situation B from occurring would also prevent Situation C. Treating the aggregate bid estimates (less administrative costs) as a measure of annual benefits that would flow in perpetuity, the net present value of the development rights purchase investment can be calculated for various discount rates. These results are presented in the accompanying table. For example, when an interest rate of 5 percent was employed to discount all future benefits and costs to the present so that they could be compared, benefits exceeded costs by $3.83 million. The "internal rate of return"—the interest rate that equates discounted values of benefits and costs and serves as an alternative index of investment productivity—was calculated at 5.9 percent.

Net Present Value of Open Space Retention ($ million)

	Discount Rate (%)					
	1	2	3	4	5*	6
Net Present Value	100.2	39.95	19.88	9.85	3.83	-.183

*Internal Rate of Return = 5.9%

Several caveats or suggested directions for further inquiry can be offered. First we recognize that individuals other than local area residents may benefit from the retention of open space and other amenity values associated with these farmlands. For example, both in-state and out-of-state tourists who travel through this historic and scenic agricultural area may also enjoy the amenity features of this environment. Thus our measures of the value of retaining these amenities may be lower limits.

Our study design limited the levels of nonagricultural development to two (i.e., Situation B and C.) In addition, respondents were asked to bid on retaining the entire remaining Old Colony and Homestead area as farmland. Thus our resulting investment analysis treated the "all-or-nothing" case. Future work should recognize the heterogeneous nature of the lands in the area regarding their scenic qualities and should attempt to value various patterns and quantities of open-space retention. It is quite possible that the preservation of a smaller amount of strategically located open space would yield higher net social returns.□

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Publications List for 1985

JOURNAL ARTICLES

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THESES AND DISSERTATIONS

Engelbrecht, C. 1985. Policy implementation: A case study of Alaska's agricultural policy, 1976-1982. Master's Thesis. University of Alaska-Fairbanks.

Moore, T.A. 1985. Seasonal fungal biomass dynamics in an interior Alaskan paper birch stand and effects of long-term fertilization. Ph.D. Dissertation. University of Alaska-Fairbanks. 230 pp.

Alaska, but it is also of importance to waterfowl specialists and wildlife habitat managers. Such information is obviously of academic interest too because it enlarges understanding of an important plant and biological functions in an array of habitats.

The work includes seasonal measurements and observations of grass growth and development and chemical analyses of components in the plant as well as those of water and soil (mud). The distribution and natural occurrences of *Arctophila fulva* are being mapped for selected areas in the Prudhoe Bay vicinity from east to west (Endicott Causeway to Oliktok). Besides examinations of the plant in its natural settings, various transplanting to new habitats to test various environmental factors are also underway. Preliminary results indicate that *Arctophila fulva* can be successfully transplanted into some oil-damaged soils and that it has an unusual capacity for vegetative propagation.

Jay D. McKendrick, associate professor agronomy, and research associates **Pete Scorup, Anna Vascott,** and **Janice Dobson** are the primary personnel assigned to the project from the AFES Palmer Research Center. Students will also be directly involved in working on the project. Standard Alaska Production Company is providing two environmental scientists, two scientific experts for field assistance, and coordination and major funding for the research. The U.S. Fish and Wildlife Service is providing waterfowl expertise and assisting with project design and monitoring. Scientists from the universities of Colorado and Idaho are involved as advisors and reviewers of research design.

Alan Jubenville, associate professor of resource management, is on sabbatical leave through December. During his six-month leave, Dr. Jubenville will be writing a new, theory-based textbook on outdoor recreation management. This will be Dr. Jubenville's third textbook on this subject; the first two are now out of print.

Dr. Jubenville has been instrumental in developing new management theory and concepts over the past several years. As no existing text emphasizes management theory, Dr. Jubenville is writing this book at the urging of several colleagues in the field of outdoor recreation management.

After an introduction to basic management theory and concepts, the reader will be guided through succeeding sections on resource, visitor, and service management. The book will be directed at the advanced undergraduate.

L. Ben Bruce, assistant professor of animal science at the Palmer Research Center, has assumed the duties of dairy scientist in addition to those of beef cattle scientist. This restructuring of Dr. Bruce's duties is the result of economy measures implemented at AFES.

The dairy research program will emphasize dairy cattle nutrition as Dr. Bruce is a ruminant nutritionist by training. Immediate plans for the dairy science program include conclusion of an experiment by **Arthur Brundage,** professor emeritus, using salmon meal as a protein source for dairy cattle rations. A major project has begun involving Alaskan feedstuffs, their trace mineral content, and subsequent suitability as ration ingredients for dairy cattle. Future research plans include projects aimed at improving Alaskan rations and the uses of various Alaskan feedstuffs. Dr. Bruce foresees a major effort in these areas to support the growing and successful Alaskan dairy enterprise.

Chien-Lu Ping, assistant professor of agronomy and soil scientist, is currently focusing his research on soil genesis and classification on the volcanic ash soils of Alaska. Volcanic ash soils have unique properties which are important in land use and management. Dr. Ping is studying the chemical, physical, and mineralogical properties of thirty soil pedons. These pedons were collected from such diverse areas of Alaska as the Aleutian Islands, southeast, southcentral, and the Cook Inlet regions. Both the collections and the investigations are being conducted in cooperation with the Soil Conservation Service, United States Forest Service, and Tohoku University of Japan. As a result of this work, this month Dr. Ping will attend the first International Soil Correlation Meeting held in the Pacific Northwest. He will present a paper entitled "Properties and Classification of Volcanic Ash Soils in Alaska," coauthored by Sadao Shoji of Tohoku University and Joe Moore of SCS.

Dr. Ping is also managing a research program on soil fertility in cooperation with Cooperative Extenstion Service's **Allen Mitchell.** A study on the effects of liming on phosphorus and potassium fertilizers on crop yield in the Point MacKenzie area has been concluded, and the results will soon be published.

Jenifer H. McBeath, associate professor of plant pathology, has returned recently from an academic year's sabbatical leave. Last September Dr. McBeath traveled to USDA's Agricultural Research Center in Beltsville, Maryland, where she worked with Dr. Gideon Schaeffer, research scientist at the Plant Molecular Genetics Laboratory. The research was on anther culture work with early-maturing, winter-hardy, hard red winter wheat. Dr. McBeath's successful efforts to produce androgenic haploid plantlets will provide an alternative means for selecting grains by genetic traits—an alternative not possible under field conditions. This means that researchers will be able to provide growers with new varieties through hybridization or somalclonal variety selection. In addition, Dr. McBeath also studied extracellular enzymes of snow molds of wheat and grasses, of which several have been identified. Enzymes will be used in the future in the selection of wheat varieties resistant to snow mold.

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Edmond C. Packee, assistant professor of forest management, and **Glenn P. Juday**, visiting associate professor of plant ecology, presented a program on the commercial and ecological aspects of Alaska's interior forests in June for a group of business leaders from the People's Republic of China. The purpose of the tour to Alaska was to provide an opportunity for Chinese business people to become familiar with the forest products of interior Alaska and to establish personal contact with individuals associated with forestry industry and research in Alaska. This visit was one of a series of three such tours organized for delegates from Korea, Japan, and China by the Alaska Department of Commerce and Economic Development and located on the University of Alaska-Fairbanks campus.

The Agricultural and Forestry Experiment Station's program of international workshops on forestry at high latitudes has become affiliated with the International Union of Forest Research Organizations (IUFRO). The program is recognized by IUFRO as working party S1.05-12, Northern Forest Silviculture and Mangement. Prior to IUFRO affiliation, workshops were held in Alaska; Sweden; and British Columbia, Alberta, and New Brunswick, Canada. Since affiliation, the working party has met in Lulea and Gallivare, Sweden, in June of 1985 and Grand Prairie, Alberta, and Dawson Creek, British Columbia, Canada, in August of 1986. Future workshops are planned for northern Finland in August 1987, northeastern People's Republic of China in summer of 1988, and Newfoundland, Canada, in 1989.

Current focus of the working party centers on regeneration problems and approaches to prompt forest regeneration. Proceedings of the workshops are published jointly by the Agricultural and Forestry Experiment Station of the University of Alaska-Fairbanks and the USDA Forest Service Pacific Northwest Forest and Range Experiment Station. Working party participants include interested persons from government agencies, universities, and industry. **Edmond C. Packee,** assistant professor of forest management, is currently the working party chairman.

Allen Richmond, AFES research associate, **Tony Gasbarro**, forestry agent with the Cooperative Extension Service, and **George Sampson**, forest-resource development specialist with USDA-Forest Service, are working on two studies to determine the potential availability of timber in the Tanana Valley which can be converted to wood chips and the feasibility of burning them in combination with coal at local power plants. Funding for this research was obtained through the Alaska Power Authority from the Pacific Northwest and Alaska Bioenergy Program. Both studies are scheduled for completion by December 31, 1986.

The first study is designed to determine the volume of wood chips that can be produced on an annual basis from different lands in the Tanana Valley. The lands being examined are state-owned forest lands in the Tanana Valley, lands owned by the Federal government under jurisdiction of the military, lands owned by Native corporations, and lands held by the state and proposed for agricultural projects. The first three provide a land base on which to determine a volume which can be produced on a sustainable annual basis, while the fourth represents a short-duration supply of chips. In addition to the volume information, the economics of delivering wood chips in the Fairbanks area will be examined. This information will help to determine the feasibility of producing wood chips in the Interior.

The second study, in cooperation with the U.S. Army, is designed to determine the volume of chips which can be burned mixed with coal at the Fort Wainwright Steam Plant without modifying the stoking system. Two different types of chips will be test burned: chips from green trees and chips from fire-killed trees. Once the maximum chip-coal mixture is identified for each type of chip, stack emission testing will be performed to determine changes in particulate and other emissions levels from those experienced when coal is burned alone. The test burns are scheduled for October 13-24, 1986. The information obtained will identify a level of coal replacement which may be achieved at other power plants through the cofiring of wood chips and coal.

Agricultural and Forestry Experiment Station
UNIVERSITY OF ALASKA-FAIRBANKS
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