Agroborealis

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Agricultural Experiment Station
University of Alaska - Fairbanks

From the Director's Desk:

Recently, the Production Credit Associations of the United States sponsored a study by the Battelle Memorial Institute entitled *Agriculture 2000: A Look at the Future.* A major part of this study involves predictions on new developments in research and technology to provide a futuristic glimpse of U.S. agriculture.

For example, new plant-growth regulators developed by U.S.D.A. researchers are predicted to increase crop yields at little additional cost. Plant cell and tissue culture will speed development of improved crop varieties. Sensors on combines will determine the moisture content and condition of grain and adjust the settings of the combines for efficient harvesting with the least damage to grain.

Techniques for embryo-transfer reproduction will be applied to beef cattle to produce genetically superior beef animals with uniform sex, weight, age, and feed-efficiency characteristics. Hog production will see increased use of confinement systems with controlled environment, and leaner meat will be produced with substantial improvements in feed efficiency.

These predictions are based on research that is currently in progress and on new technology that will have application in farming. In addition, they reflect more than a century of agricultural research and development in the 48 conterminous states that have given U.S. agriculture a competitive advantage worldwide.

Agricultural research and development in Alaska are scattered and less intense than in other parts of the U.S. For example, new lands now being developed for crop production in Alaska have only five years or less of farming history and research. Nevertheless, a number of results from agricultural research in Alaska are being adopted to increase production efficiency.

Superior varieties of small grains and forages developed for Alaska by the Agricultural Experiment Station are being grown on new lands. Fertilizer recommendations for new lands are based on current research in the Delta and Point MacKenzie agricultural projects and on the Kenai Peninsula. Boron deficiencies have been detected in soils of interior Alaska and corrected with applications of trace amounts of boron to the soil.

Seed for 'Otal' barley, an early-maturing variety developed at the Alaska Agricultural Experiment Station, is now licensed for production in Alberta, Canada, as well as in Alaska. 'Otal' is well adapted for use in the Peace River Valley of northern Alberta, where growing conditions are similar to interior Alaska.

Moreover, research results in northern Alberta may have application in Alaska. Preliminary research reported by Alberta's Agricultural Research Council shows that barley with as much as 45 per cent moisture content can be straight combined without yield losses, an important finding for environments with cool, moist harvest seasons.

Other research in Alberta is devoted to screening winter wheat varieties for resistance to snow mold in cool, moist climates. Studies at the Alaska Agricultural Experiment Station indicate that the control of snow mold can lead to the successful production of winter wheat in Alaska.

Research in progress by Agriculture Canada indicates that boron sprayed on barley foliage is more effective than boron applied to the soil in increasing the selenium content of barley grain. This could be an important avenue for research in Alaska where boron deficiencies have been identified in the soil and where supplementation of locally produced feed grains with selenium may be beneficial for livestock health.

As new agricultural research is developed in the north, scientists will discover new ways of applying the results to improve the efficiency of agricultural production. These improvements will occur in Alaska as agricultural research and farming experience increase in the state. They are likely to be as dramatic as those predicted in *Agriculture 2000: A Look at the Future.*

James V. Drew

James V. Drew, Director

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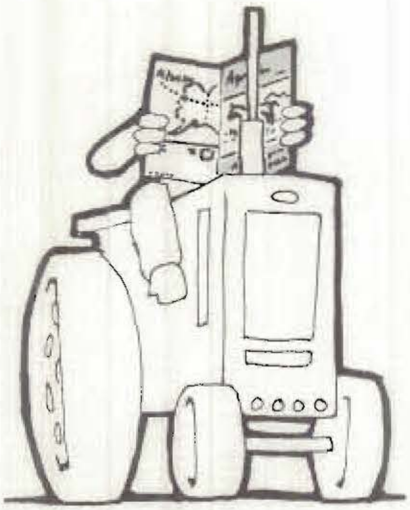
ABOUT THE COVER . . . *Roseann Hartke Leiner, technical assistant in Horticulture at the University of Alaska's Agricultural Experiment Station Palmer Research Center, inspects progress of potato plantlets cultured under aseptic conditions. This work is the basis of a potato-seed-production program being developed cooperatively by the Agricultural Experiment Station and the Division of Agriculture's Plant Materials Center. Program goals include increasing yields and decreasing storage losses by eliminating disease organisms from the seed. Disease organisms (fungi, bacteria, viruses) can injure or kill individual potato plants in the field, or cause harvested tubers to rot in storage. The use of top-quality, disease-tested seed is the primary step in minimizing losses to disease. The disease-tested seed produced by this program, used in combination with appropriate production and storage procedures, will enable Alaska's potato growers to produce high yields of top-quality potatoes.*



AES Notes

Dr. Gary A. Laursen, mycologist, has joined the Agricultural Experiment Station staff at the University of Alaska-Fairbanks as a visiting assistant professor of microbiology after having spent two years at the Office of Naval Research (ONR) in Arlington, Virginia. While at ONR in the Washington D.C. area, Dr. Laursen participated in the Intergovernmental Personnel Act (IPA) program as a program manager with the Division of Biological Sciences where he developed a Cold Program for the support of basic research that addressed problems relevant to US Navy and Marine Corps cold-regions maneuvers.

Prior to his Washington assignment, Dr. Laursen was the associate director at the Naval Arctic Research Laboratory (NARL) in Barrow, Alaska, from 1976 to 1980 where he was responsible for all science conducted. His duties on Alaska's north slope were performed at a time when the University of Alaska was the prime contractor responsible for all NARL operations. He joined UAF in 1976 for this assignment. Dr. Laursen came to Alaska from Virginia Polytechnic Institute and State University after completing his Ph.D. in Botany in 1975 and conducting a fourteen-month postdoctoral fellowship. A full-time research appointment currently permits Dr. Laursen to conduct studies on the fungi from tundra, boreal, alpine, and subalpine environments.

An MS was earned from the University of Montana Biological Station in 1970. Teaching high-school biology from 1965 to 1971 put to use information gleaned during his BA studies at Western Washington University (1960-1965) in Bellingham, Washington. His wife Beth and two daughters, Shawna and Heather, are happy to return to Alaska.

Dr. Edmond C. Packee has joined the Fairbanks staff of the Alaska Agricultural Experiment Station as assistant professor of forest management. Dr. Packee will be working to build a research program in forest management with emphasis on timber management in interior Alaska. His specific goal is to develop timber-management practices that will result in the production of maximum, practicable per-acre yields of usable wood fibre. He is a strong advocate of multiple use.

Dr. Packee was previously senior silviculturist with the Woodlands Services Division of MacMillan Bloedel Limited in coastal British Columbia. He worked the entire B.C. coast and was located on Vancouver Island for fifteen years. Dr. Packee received a B.Sc.F. from the University of Montana in 1962, a M.F. from the Yale School of Forestry in 1963, and a Ph.D. from the University of Minnesota in 1976. He and his wife, Judi, make their home west of Fairbanks with their four children and their Irish setter.

John Brooks III joined the experiment station as an agricultural assistant in June, 1982. John received a B.S. in Animal Science from North Dakota State University in 1979, graduating with honors, and received a M.S. in Range Science from Utah State University in 1981. John has considerable experience in range-animal nutrition and has published results of his studies in the *Journal of Animal Science, Journal of Wildlife Management,* and *Journal of Zoo Animal Medicine.* In addition, John brings to the Agricultural Experiment Station much practical experience obtained as manager of a large diversified farm/ranch in northern Minnesota.

John is stationed in Kotzebue, where his responsibilites are to conduct range science field studies and to assist animal science and animal health researchers who are conducting reindeer research in western Alaska. John has initiated a much-needed study to determine the major factors which contribute to snow conditions encountered by reindeer in western Alaska. He has also set up a microcomputer system for the range-science project which greatly facilitates data analysis, filing, and communications.

John and his wife, Wendy, enjoy the outdoor activities available around Kotzebue. They have acquired several dogs and a couple of sleds and are addicted to dog mushing. John also recently earned his private pilot's license.

Mary Lou Herlugson was promoted to research associate in Animal Science at the Palmer Research Center in April. Mary Lou earned her B.S. degree in biology, with minors in mathematics and chemistry, from New Mexico Institute of Mining and Technology, Socorro, with high honors. She has completed a

Continued on page 53

University research plots at Point MacKenzie.

Soil Fertility Considerations for Barley And Oat Forage Production at Point MacKenzie

By

Gary J. Michaelson*, Joseph R Offner**, and Chien-Lu Ping***

The Point MacKenzie Project includes 13,940 acres divided into twenty-nine tracts. The tracts range from 297 to 641 acres in size with both restricted (for dairy only) and unrestricted tracts. Soils of the project area are predominately of the Kashwitna and Homestead series. These series are overlapping in characteristics, with silt loam surface layers of 10-20 inches over a sand and gravel mixture.

A relatively wide range of soil pH has been observed within the project boundaries. The pH of the surface 6 inches of mineral soil ranges from 5.0 to 6.4 and a buffered (SMP) pH from 5.5 to 6.1. These pH values span the range in which soil acidity may be limiting to the growth of pH-sensitive crops and to phosphorus availability.

Soil-fertility research in the Point MacKenzie area thus far has been directed at forage crops which may be used in the developing dairy operations. Two crops grown in Alaska, oats and barley, differ in their tolerance to soil acidity and may be grown for grain or forage. Fertility trials have been underway since 1981 on the University of Alaska's tract at Point MacKenzie. Oats and barley have been grown for two field seasons to determine their responses to lime and fertilizer on these newly cleared soils. Other trials have been conducted with forage grasses by William Mitchell and with vegetable and rape crops by Don Carling and Winston Laughlin.

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Soil Acidity: Measurement and Liming

The total acidity of the soil is made up of both active and reserve acidity. Active acidity is measured by soil solution pH (equal parts soil and water) and indicates the soil solution hydrogen ion concentration to which the plant root is exposed. Reserve acidity is the amount of hydrogen ions held by the mineral soil and organic particles. These reserve ions have the potential to go into the soil solution and affect the soil solution pH. Total acidity (active and reserve) can be measured by a buffer pH of the soil.

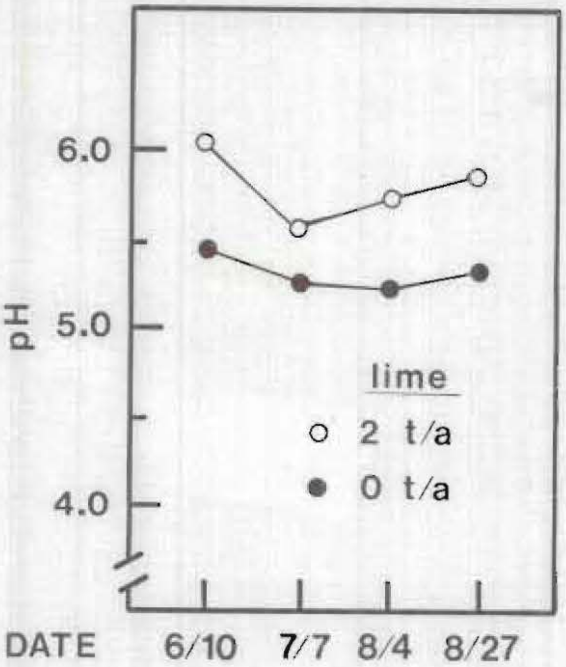

Figure 1. The seasonal variation in pH on a limed and unlimed Point MacKenzie soil (Homestead silt loam) for the year following lime application.

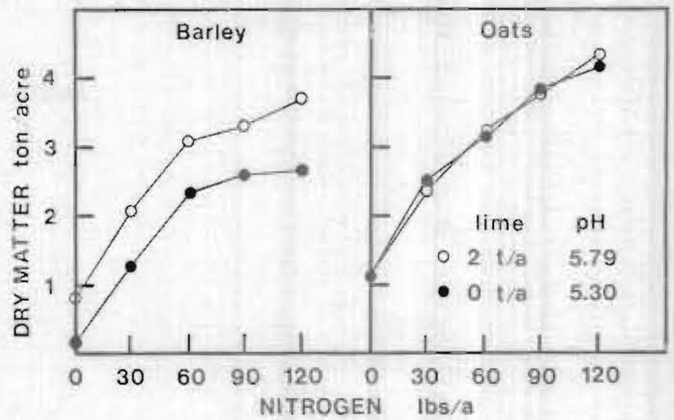

Figure 2. Barley and oat dry-matter production as a function of N application on a limed and unlimed Point MacKenzie soil (Homestead silt loam, with adequate P and K fertilization).

Crops differ in their tolerance to soil pH. When considering a suitable crop for a soil, the soil solution pH (or soil pH) should be considered. A buffer pH is necessary to measure the total soil acidity to be neutralized when liming to raise the soil pH. The buffer pH has been calibrated for Alaskan soils (Loynachan 1979) and can provide a good estimate of the amount of lime necessary to change the soil pH.

Figure 1 illustrates the pH of a more acidic Point MacKenzie soil with the seasonal and liming effects on pH. This Homestead silt loam had an initial (0-6 in depth) pH of 5.3 after land clearing. The addition of 2 ton/A of agricultural limestone raised the pH to 5.8 by the end of the first field season. A slight midseason depression in pH is evident in both limed and unlimed soils.

The yields of weal barley, a pH-sensitive crop, were affected by the difference in pH of 5.3 versus 5.8, but yields of toral oats were unaffected by the same pH differences (Fig. 2). Barley dry-matter yields were increased by over 1000 lbs/A at all nitrogen rates when 2 tons/A was added to change the soil pH from 5.3 to 5.8. Experimental plots on Point MacKenzie soils with a pH of less than 5.5 have shown that a depression in yield of barley should be expected and be weighed against the use of lime, or consideration should be given to the growing of an acid-tolerant crop such as oats.

As mentioned earlier, the pH of Point MacKenzie soils varies, and many areas have soils with a pH greater than 5.5. In these areas, soils are suitable for the growth of oats or barley without pH limitations on barley yield. Because of the known pH variability and the possible pH limitations to yield which have been experienced at Point MacKenzie, it is very important that the soil pH be known and considered in making crop and fertilizer decisions.

General Fertilizer N, P, and K Responses

Newly cleared soils of interior Alaska have been proven extremely deficient in both N and P for crop production (Michaelson et al. 1982). Potassium has been generally adequate for lower levels of production, but limiting at higher production levels. The newly cleared Point MacKenzie soils are also extremely deficient in N and P with only slight responses to K additions (figs. 3 and 4). Provided sufficient P and K were available, additions of up to 90 lbs/A produced relatively large increases in dry-matter production of both barley and oats. With rates higher than 90 lb/A N, yields continued to increase but response to applied N was reduced for both crops. Oats and barley grown on unlimed soil with a pH greater than 5.5 responded to P applications of up to 60 lb P_2O_5 /A (fig. 5). The more acid soils reduce availability of applied P_2O_5 and make it necessary to apply up to 90 lbs/A P_2O_5. Thus, pH should also be considered when deciding what rate of P_2O_5 to be applied. Soils with pH less than about 5.5 will respond to P_2O_5 applications of up to 90 lbs/A, whereas soils with pH greater than 5.5 may only respond to P_2O_5 applications of up to 60 lbs/A.

Barley and oats responded only slightly to potassium additions (figs. 3 and 4). The largest response to potassium was seen when N was applied at rates of 90 lbs/A and over, and when phosphorus was not limiting. This indicates that potassium additions should be made when fertilizing for higher yields. It should also be expected that, without some added potassium, soils will be depleted of this nutrient within a few years, especially at higher crop-yield levels. Barley dry-matter production (fig. 3) increased only slightly with addition of 24 lbs. K_2O/A. Oat dry-matter production increased only slightly at the 60 lbs K_2O/A rates of fertilization (fig. 4).

The use of ammonium nitrate had only a very small advantage over urea in dry-matter production (fig. 6). The first year after clearing, ammonium nitrate treatments outyielded urea treatments by less than 1/4 ton/A at the 60 and 90 lbs/A N rates and by 1/2 ton/A at the rate of 120 lbs/A N. There was little difference in N utilization or uptake for either N source except at the rate of 90 lbs N/A where there was slightly more N uptake with urea than with ammonium nitrate. In the second

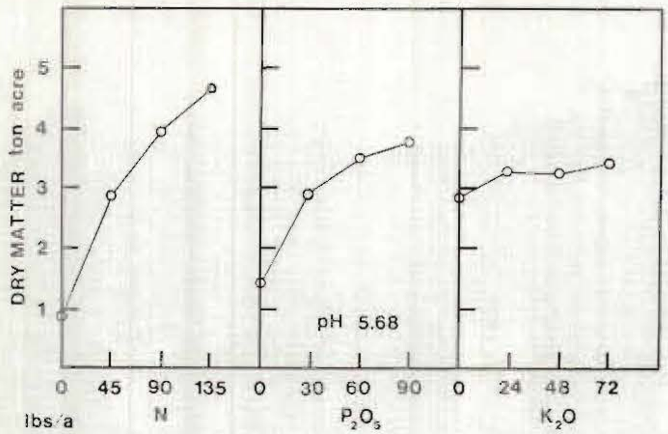

Figure 3. Barley dry-matter production as influenced by N, P_2O_5, and K_2O additions on a Point MacKenzie soil.

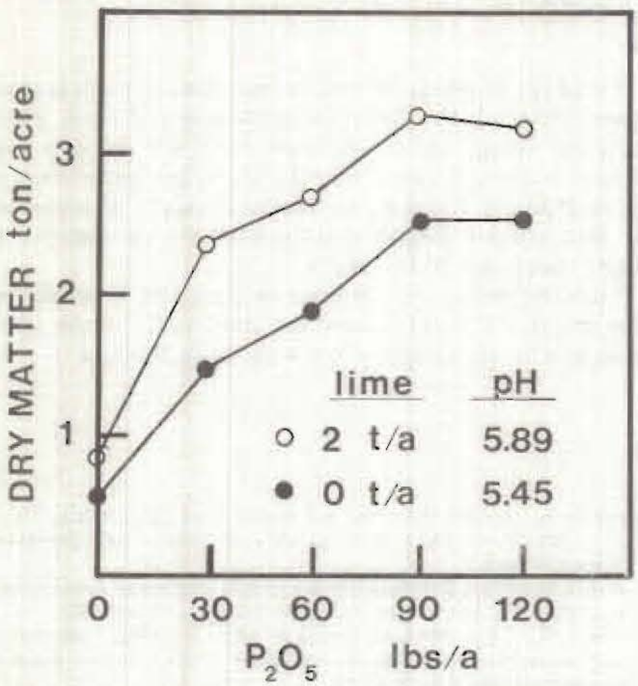

Figure 5. The 1981-82 average dry matter production for barley as influenced by P_2O_5 additions on a limed and unlimed Point MacKenzie soil (Homestead silt loam, with adequate N and K additions).

year of oat production, lower urea treatments of 30 and 60 lbs N/A showed a slightly higher dry-matter production and N uptake, but there was little difference in crop response between urea and ammonium nitrate when 90 to 120 lbs N/A was applied.

For the 2 years 1981 and 1982, there was no clear advantage to the use of one N source over the other. Both N sources (urea and ammonium nitrate) are generally considered equal in ability to supply the plant with N when applied properly. Urea, when applied to annual crops such as barley and oats, should be incorporated soon after it is broadcast. When applying urea to perennial forage grass stands, the field conditions should be moist enough to dissolve prills such as just before or just after a rain or heavy dew.

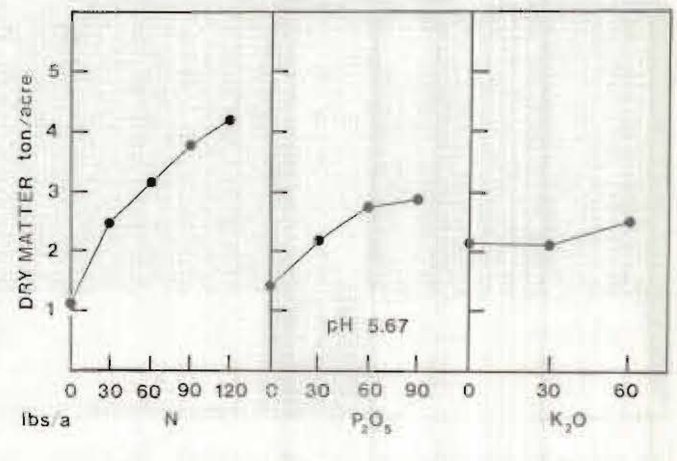

Figure 4. Oat dry-matter production as influenced by N, P_2O_5, and K_2O additions on a Point MacKenzie soil.

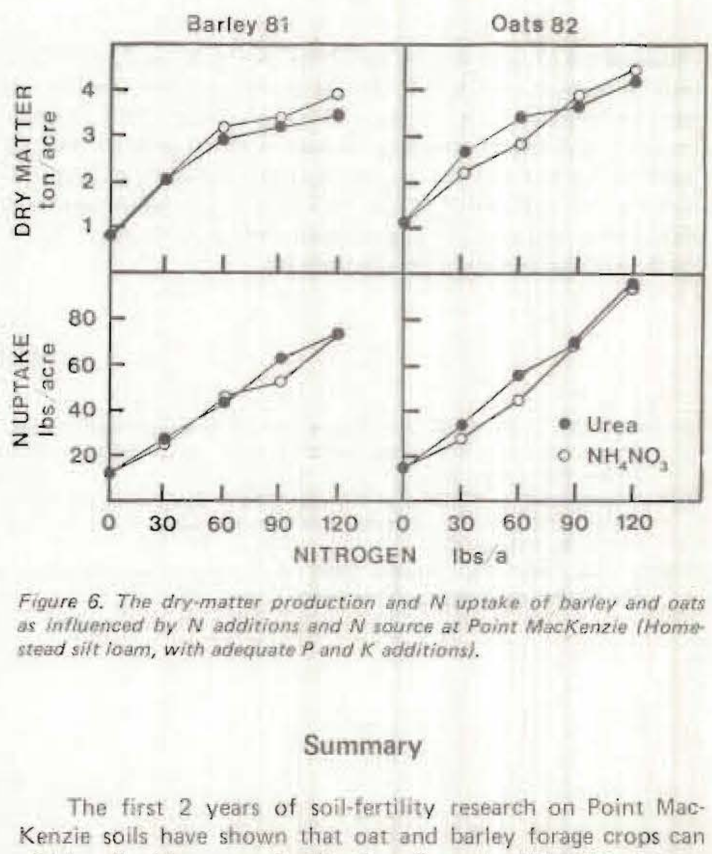

Figure 6. The dry-matter production and N uptake of barley and oats as influenced by N additions and N source at Point MacKenzie (Homestead silt loam, with adequate P and K additions).

Summary

The first 2 years of soil-fertility research on Point MacKenzie soils have shown that oat and barley forage crops can yield well with proper fertilization. Several soil-fertility factors should be considered when planning a barley or oat crop for Point MacKenzie soils. First, there is a significant variability in soil pH within the project area. Barley yields may be limited in soils with pH less than 5.5. In these more acid areas, an acid-tolerant oat crop is an alternative to liming. This means that knowing the soil pH after clearing is especially important at Point MacKenzie.

A second consideration is adequate fertilization with all three major nutrients: nitrogen, phosphorus, and potassium.

On a soil with an initial pH of 5.45, liming allowed root proliferation in the top 6 inches (left) whereas unlimed treatments showed deeper root exploration (right). The forage yield of the 90 lbs/A P_2O_5 – 2 ton/A lime treatment (left) was 0.75 ton/A greater than the unlimed treatment (right).

Highest yields were obtained with applications of a complete fertilizer (right N-P_2O_5-K_2O).

Application of only one of the three nutrients, N, P, or K, will not be adequate to increase forage production. Both barley and oats respond to N fertilization of up to at least 120-135 lbs/A in the first years of cropping. In soils with pH greater than 5.5 both barley and oats show yield response to phosphorus applications of up to 60 lbs P_2O_5 /A. In very acid soils of pH less than 5.5, barley responds to P applications of up to 90 lbs P_2O_5 /A both with and without lime applications.

Potassium should be applied to maintain soil levels as crops remove native soil K. Potassium applications of up to 24 lbs K_2O/A for barley and of up to 60 lbs K_2O/A for oats have increased dry-matter yields only slightly at the higher levels of crop production. However, an adequate supply of potassium may help prevent lodging and decrease the vulnerability to disease (Tisdale and Nelson 1981).

Little difference was observed in yield and N uptake between the two N sources, urea and ammonium nitrate, when broadcast and incorporated into the soil immediately. ▫

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What Happens to Fertilizer Nitrogen?

By

Stephen D. Sparrow*, Charles W. Knight**, and Larry D. Hinzman***

Nitrogen (N) is one of the most deficient plant nutrients in Alaska's soils; hence, it is widely used as a fertilizer in Alaskan agriculture, often in combination with other elements. Nitrogen in soil has been studied extensively in other regions, but little is known about what happens to fertilizer N after it has been added to subarctic agricultural soils.

Fertilizer N in the soil can undergo a number of changes, or transformations. Some of these transformations are beneficial to agriculture; others are detrimental. The rate at which nitrogen transformations occur in soil is dependent upon such soil factors as temperature, moisture, pH, and aeration, among others. The same nitrogen transformations which occur in agricultural soils in other regions also occur in subarctic soils; however, their rates and magnitude may differ because of low soil temperatures and short growing seasons.

Many forms of N are used as fertilizer. One, gaining wide acceptance because it is generally cheaper than other N sources, is urea. Urea N is not directly available to plants, but under warm, moist conditions urea is rapidly hydrolyzed (broken down) in the soil to form ammonium. Ammonium N is usable by plants. Other forms of N that are widely used as fertilizer and which are directly available to plants are various formulations of ammonium and nitrate.

Some farmers in Alaska as well as researchers at the University of Alaska have observed that crop response to urea application sometimes appears to be less than that from other N fertilizers such as ammonium nitrate. Since soils in Alaska are cold, one might expect that the rate of urea hydrolysis is too slow to permit the N in urea to become available early enough in the season for the crop to make maximum use of it. However, preliminary work at the Palmer and Fairbanks research centers has indicated that most or all of the urea applied in spring is hydrolyzed within 2 weeks.

Application of either urea or ammonium fertilizers can, under certain conditions, result in loss of N through ammonia volatilization. Some of the ammonium in soil is converted to ammonia, a gas. Under conditions of high soil temperature, high soil pH, and rapid drying, large losses of N can occur through ammonia volatilization. This is especially true for fertilizers which are broadcast and left on the soil surface. Alaskan soils are generally quite cool and are often acidic, thus one would not expect much loss of N through ammonia volatilization.

Most soils contain bacteria called nitrifiers. By a process called nitrification, these organisms convert N from the ammonium form to nitrite and then to nitrate. Nitrification can be

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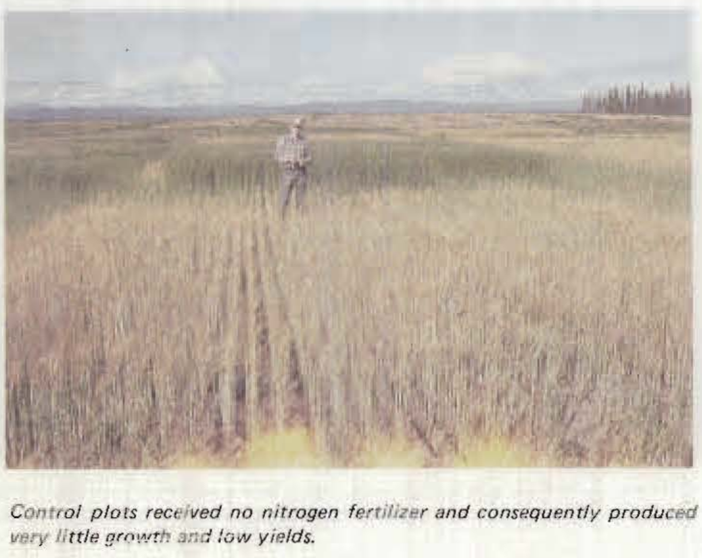
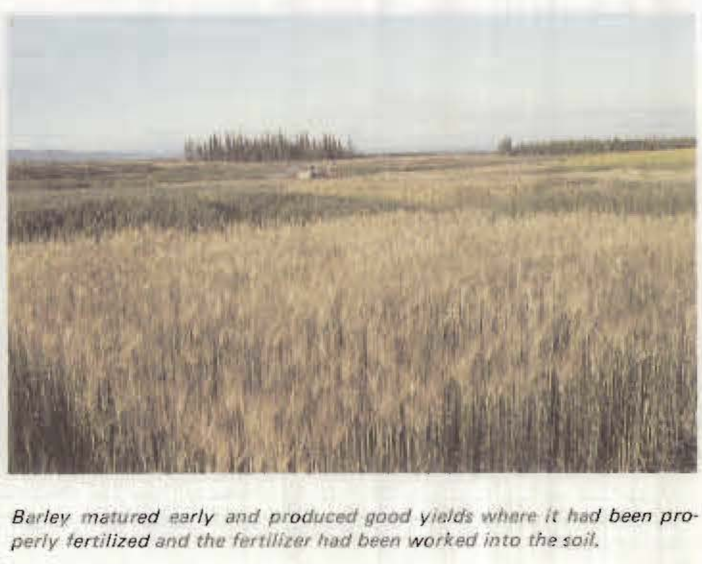


Control plots received no nitrogen fertilizer and consequently produced very little growth and low yields.



Barley matured early and produced good yields where it had been properly fertilized and the fertilizer had been worked into the soil.

considered a mixed blessing by the farmer. Nitrate N is generally considered to be more readily available to crop plants than is ammonium N, but nitrate can also be lost easily from the soil. Nitrate moves easily with water in the soil; therefore, as water moves downward through the soil, it carries nitrate with it (leaching). If the nitrate is leached below the root zone, it is for all practical purposes lost. If nitrate is leached through the soil, it can get into ground and surface waters, where at high concentratrations it can be a serious pollutant. In most agricultural areas of Alaska, rainfall is low, thus one might not expect much leaching. On the other hand, many of our soils are underlain at a shallow depth by coarse material such as sand and gravel. Since water can move through these materials easily, nitrate leaching may occur after heavy or prolonged rains.

Certain bacteria in the soil can, under conditions of limited oxygen supply, convert nitrate to gaseous forms of nitrogen such as nitrous oxide and dinitrogen (denitrification). These gases are lost from the soil, hence denitrification results in a loss of fertilizer nitrogen. Although denitrification probably occurs to a small extent in all soils, it is usually most significant under very wet, poorly drained conditions.

Microorganisms in the soil can utilize both nitrate and ammonium N. The nitrogen is incorporated into their tissues and becomes a part of the soil organic matter. This process is called immobilization. Immobilized nitrogen is not available to plants, hence immobilization can be viewed as a temporary loss of fertilizer N. On the other hand, immobilized N is not lost through leaching or denitrification, thus it can be viewed as a storage form of N in the soil. When organic matter decomposes, some nitrogen is released in forms available to plants. This process is called mineralization. Immobilization and mineralization occur simultaneously in the soil. Which one predominates is dependent on soil conditions.

Another way in which nitrogen is lost from the soil is through crop utilization and subsequent removal of the crop from the field at harvest. It is, of course, desirable to the farmer that as much fertilizer N as possible be utilized by the crop. A goal of both farmers and researchers is to determine rates, materials, and application methods in order to maximize crop utilization of the applied fertilizer N, and to reduce N losses through nonproductive means.

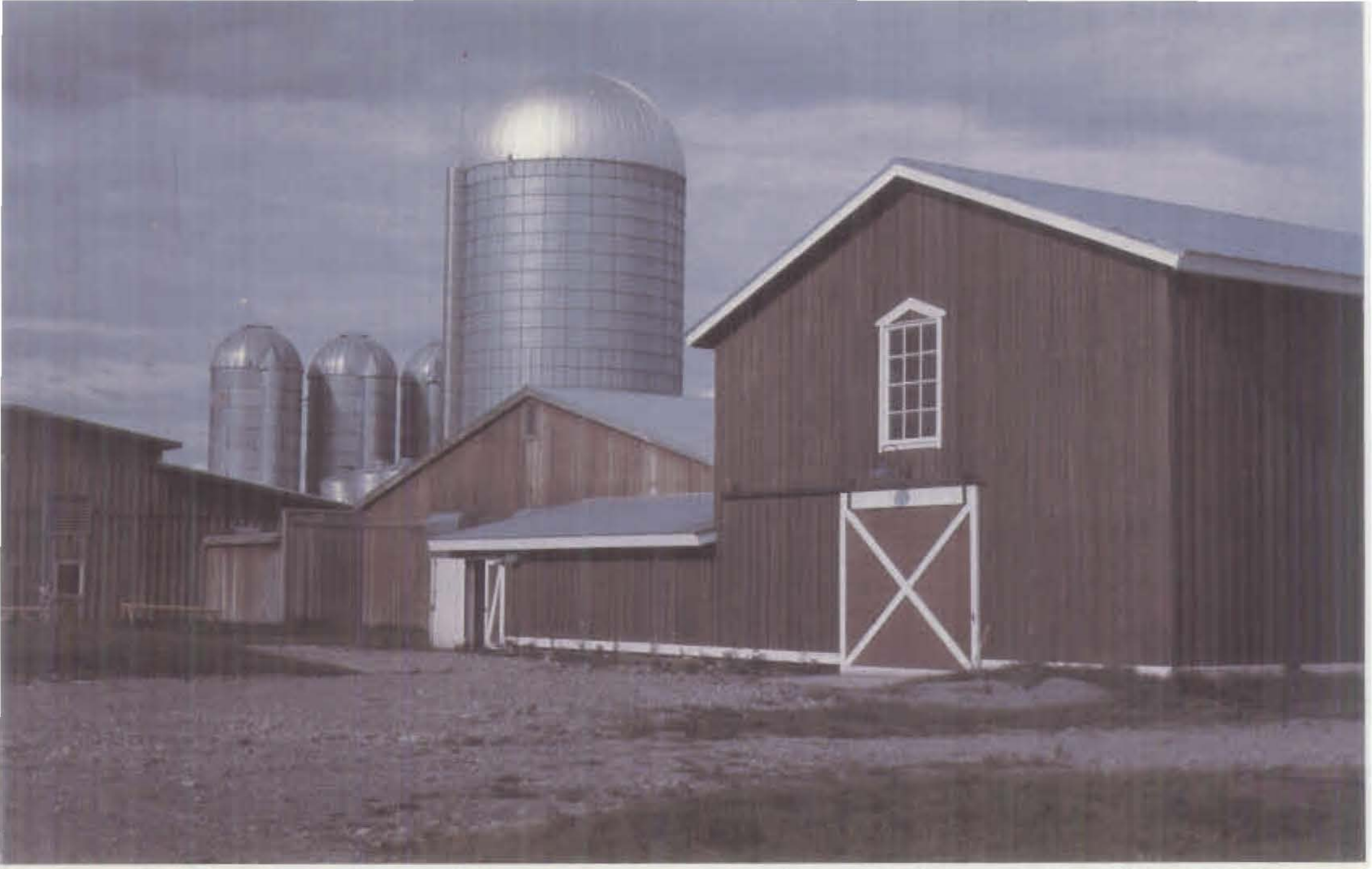
We have received a grant from the Alaska Council on Science and Technology in order to conduct a 3-year study to determine what happens to fertilizer nitrogen after it is applied to an agricultural soil in Alaska. The specific goals of this study are:

- Measure crop uptake and determine efficiency of fertilizer N use by crop plants;
- Determine the rate of urea hydrolysis in a field soil;
- Determine nitrate leaching losses;
- Estimate gaseous loss of N from soil (i.e. ammonia volatilization and denitrification);
- Determine net seasonal immobilization or mineralization of N in a field soil.

We chose to do this study at the University of Alaska Research Farm near Delta Junction because it is in an area in which a large amount of land is undergoing agricultural development. Two kinds of fertilizer N, urea and calcium nitrate, are being used in the study with barley as the test crop. A nonradioactive tracer of nitrogen (^{15}N) is used to monitor the transformations that the fertilizer N undergoes. Nitrate leaching is monitored by collecting deep soil samples and by collecting water (using special devices called suction-cup lysimeters) as it moves through the soil. These soil and water samples are then analyzed for nitrate and nitrite. Plant samples are collected regularly to monitor crop uptake of nitrogen. Analysis of the plant samples for ^{15}N also allows us to determine what portion of the plant nitrogen came from the fertilizer source, and what portion came from mineralized organic matter within the soil.

This study should give us a better understanding of which transformations of N are important and the rate at which they occur in agricultural soils in Alaska. Additional laboratory studies will tell us how such factors as soil temperature and moisture affect some of these transformations. This information will then be used to determine ways to minimize unwanted losses of N from the soil and to maximize crop utilization of applied fertilizer N. □

If the fertilizer has been broadcast on top of the soil and not incorporated, even though proper application rates have been used, barley maturity may be considerably delayed due to insufficient early rainfall. Rain is needed to leach the nutrients into the rooting zone where they are accessible for use by the plants.



Dairy center, Matanuska Research Farm. Strawmix building on left, multipurpose housing in center, freestall housing for dairy herd on right. Thirty-by-sixty-foot silo and three twelve-by-thirty-foot research silos in the rear.

Using Alaska Feeds In Dairy Nutrition Research

By

A.L. Brundage* and M.L. Herlugson**

Dairy cows in Alaska were once of Siberian origin, brought here to provide fresh milk for Russian settlers (Gasser 1946). Little evidence remains of these cattle, and, today, Holsteins are the major breed in Alaska dairy farms. It is probable that, while today's dairy cow was born in Alaska, her sire is or was in a distant bull stud. She traces her ancestry to the lower forty-eight states and often has sisters in dairy herds scattered across America. Although not uniquely Alaskan and having much in common with contemporaries across the U.S., she often is truly unique and Alaskan as well. This contradiction is resolved by recognizing that although part of the U.S., Alaska is a land of contrasts by comparison and uniquely defines the lifestyle of her dairy animals.

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Pasture and Summer Feed

While many cows have the opportunity to graze on green pastures and bask in the sun, the Alaska dairy cow spends more of her time inside the barn than outside braving the elements. The picturesque, pastoral scene is not unkown in Alaska, and cows are turned out to graze (Brundage 1953). But, because Alaska pastures can produce an abundance of feed that rapidly reaches maturity and loses its nutritive value, the challenge is to develop pasture-management systems that permit rationing over the summer to ensure continuous supplies of high-quality feed — never too little and never too much (Brundage 1960, 1961; Brundage and Sweetman 1956, 1958, 1960, 1964; Brundage, Sweetman, and Bula 1956; Brundage, Sweetman, Hodgson, and Bula 1956).

Even using temporary electric fences to provide new pastures each day does not satisfy these requirements completely. Intensive pasture management does accomplish desirable goals and has a place in summer feeding programs for dairy animals, but the pastoral scene often has been replaced on Alaska dairy farms by that of cows standing in the barn or in the feed lot waiting impatiently for silage or the day's harvest of green feed.

Bromegrass is grown for pasture in Alaska, but its rapid growth in early summer and slow recovery after midsummer harvest makes it more suitable for hay and silage (Brundage and Sweetman 1954). Most dairy cows take alfalfa and alfalfagrass pasture, hay, and silage for granted – that is what cows eat in addition to corn silage. Alaska does not grow corn for silage, but does have an alfalfa of Siberian origin that is adapted to survival during Alaska winters. It is, however, relatively unproductive when compared with bromegrass and competes poorly in mixed plantings. Common, unselected alfalfa from California and the Southwest have been grown as summer annuals with orchard grass in southcentral Alaska. Orchard grass does not head appreciably during the long summer days of Alaska. The mixture has produced very high quality forage and may yet find a place on Alaska farms (Brundage and Branton 1967; Brundage et al. 1963).

Small Grains for Silage

In addition to grass, small grains also are used as roughage components of rations for Alaska dairy cows, usually by ensiling the whole plant (Brundage 1973, 1974). Oats once were considered the best small grain for silage because the scabrous awns of barley have very real potential to cause actinomycosis (lump jaw) and other traumatic diseases of the mouth and throat of cattle. R.L. Taylor, however, has developed varieties without awns, and barley now is an excellent small grain for silage (Taylor 1972).

Cooperative research with R.L. Taylor and L.J. Klebesadel (Brundage and Klebesadel 1968, 1970; Brundage and Sweetman 1967; Brundage, Taylor, and Burton 1979) on oats, barley, and peas for dairy feeds has provided considerable information to Alaskan farmers. Although peas add protein to the mixture, seed is relatively expensive, and peas compete poorly with oats and, especially, barley. Oats are also limited in ability to compete with barley for available moisture and plant nutrients.

An acceptable stage of maturity of small grain for silage is a compromise between the need for high-quality feed and the need for adequate yields. Present recommendations are to plant barley and oats in alternate strips and harvest when barley is in early dough stage (Brundage, Taylor, and Burton 1981). At this time, oats are in the milk stage, and high yields can be obtained without unduly compromising feed quality.

Straw for Livestock Feed

While straw is also a form of roughage, low feed value usually restricts its use to bedding in the dairy barn. Currently, we are investigating the possibility of using straw from the Delta Barley Project in rations for milking dairy cows. A Danish strawmix machine provided by Alaska Commercial Fishing and Agricultural Bank is being used to chop straw and blend it automatically with molasses, beet pulp, supplemental protein, and chelated trace minerals to produce a nutritionally balanced feed for ruminants such as dairy cows. The Danes report good livestock production on strawmix, as well as an increase in the amount of land available for grain production, rather than for hay and silage crops. If similiar results are possible in Alaska, one more step will be taken in developing an Alaska feed base for dairy production.

Rotational grazing of bromegrass pasture. Note previously grazed pasture in foreground.

Concentrate Feeds for Energy and Protein

The dairy cow requires coarse, fibrous feeds in her diet for maintenance of proper rumen function and acceptable levels of milk fat in milk produced. It is impossible, however, for a high-producing dairy cow to consume such feeds as hay, silage, or strawmix in sufficient quantities to meet her total nutrient requirements. Therefore, most dairy cows in the U.S. are fed concentrated feeds in addition to roughages. The Alaska dairy cow is no exception.

Small grains may be ensiled as whole-plant silage, or harvest may be focused on the mature grain, leaving the straw in the field, using it for bedding, or possibly, in the future, using it in strawmix. When harvested in Alaska, much of the barley grain is too wet for safe storage without supplemental drying. Often, when field drying is attempted, inclement weather damages the standing crop prior to harvest or even eliminates harvest altogether.

Practical methods have been developed to seal high-moisture barley direct from the combine in large plastic bags supported inside 4 x 4 x 4-foot plywood boxes. Each unit contains about 2000 pounds of barley. The contents are well preserved until the seal is broken for feeding; once opened, the barley must be used within about 30 days to prevent spoilage. This fermented, high-moisture barley is a high-quality feed and provides an alternative to drying prior to storage (Brundage 1970; Brundage and Allen 1965, 1968, 1971). It can be fed whole, but digestibility is enhanced when it is rolled or coarsely ground in a hammer mill.

With the exception of field peas, most roughages fed Alaska dairy cows are low in protein compared with alfalfa fed their sisters to the south. Soybean meal is a major source of supplemental protein in dairy feeds, but it must be imported into Alaska from elsewhere in the U.S. Alaska does have other sources of protein, however. Meat and bone meal, a byproduct of oil extraction from meat scraps by Don's Chemical Company (now Alaska Mill and Feed), has been shown to be a suitable protein supplement in dairy feeds (Brundage and Sweetman 1963).

Rations used to evaluate meat and bone meal also included one in which whole fish flour was used for protein supplementation (Brundage and Allen 1965). The cows performed exceptionally well on this material, but the product, suitable for human consumption, was too valuable for routine use in dairy feeds. However, Seward Fisheries now processes waste from both shellfish and fish processing into dry, stable meals. Crab waste generally was not considered an acceptable feed for inclusion in dairy rations due to low nutritive value and limited palatability. However, University of Alaska dairy cows did eat feeds containing both King and Tanner crab meals (Brundage, Husby, Beardsley, and Burton 1981; Brundage, Husby, and Burton 1981; Calcaterra 1982). There were limits to the addition of crab meals to dairy feeds beyond which feed was rejected and animal performance was reduced. Concentrates containing up to 300 pounds of Tanner crab meal per ton were satisfactory; cows accepted these feeds readily after a brief period of adjustment and maintained acceptable levels of milk production and body condition. Milk produced had no objectionable characteristics (Brundage 1983).

Salmon meal is much higher in protein and is more digestible than crab meals (Brundage and Husby 1982; Brundage, Husby, Burton, and Franklin 1979). In other areas of the U.S., salmon meal is too expensive compared with other protein feeds such as soybean meal for routine use in feeds for dairy animals. In Alaska, however, salmon meal is priced competetively with soybean meal on a unit-protein basis. Research is now in progress at Palmer to study the use of salmon meal for supplemental protein in feeds for dairy cows, for growing dairy animals, and for finishing dairy steers. Supported by Seward Fisheries, these investigations may provide yet another source of protein for Alaska dairy cows which does not have to be imported, as well as providing a market for processing waste from Alaska's maritime fishing industry.

If we are what we eat, the Alaska dairy cow is truly unique compared with her sisters elsewhere. However, to the extent that the Alaska dairy cow can be maintained economically on Alaska feeds, she will be able to compete successfully with her sisters to the south, and milk produced in Alaska by Alaska dairy cows for Alaskans will not pass into history. ▫

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The Earthen Storage Basin for Dairy Farms in Alaska

By

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Introduction

High-organic dairy waste from improperly managed operations can enter our streams, lakes, and groundwater supplies, degrading our environment. Dairy manures can cause high chemical oxygen demands, become major substrates for the breeding of flies, and produce foul odors if mishandled. Since the continued supply of high-quality, fresh water is a major national concern, waste produced in dairy facilities must be handled with the best available management practices.

In continuing efforts to improve systems for handling dairy wastes, new methods and equipment are being used. Components of such systems provide for removal of waste from buildings to storage facilities which are separate from the dairy housing facility. The major handling systems provide for collection, transfer, storage, and land application, and are divided into two groups: those for handling liquid manures and those for handling semisolid manures.

Many types of manure-handling systems are used in the United States. Not all of these systems, however, are adapted to northern climates. The Alaska Department of Environmental Conservation currently has no code of practice for these waste facilities; however, the department must be notified for approval of waste-treatment systems used in dairy enterprises. One handling system, the earthen storage basin, is suitable for and complies with current state codes in the northern United States and Canada (Cullum 1983).

Earthen Storage Basin

Earthen storage basins are designed and constructed to prevent contamination of ground and surface waters while providing long-term storage of manure near the barn for low to moderate investment. These basins for cattle manure produce relatively little odor during the storage period because a floating crust of bedding and organic matter develops over the surface. If the unit is properly located and earthen banks are well cared for and fenced to prevent intrusion, its contents need not be noticeable to the casual observer. The storage basins should be located downwind of nearby residences.

These basins are not lagoons. Lagoons are treatment structures that biologically decompose the manure into liquid and, if designed and located properly, do not fill with sludge. The United States Public Health Service has several lagoon systems in Alaska for human waste at least as far north as Fort Yukon. However, the bacteria necessary to carry out the biological degradation are not as active in the low temperatures of the subarctic as they are in the temperate zone. Therefore, lagoons do eventually fill with sludge and may pollute surface and ground water. Earthen basins, however, are designed as storage containers with emptying facilities.

Earthen storage basins (Figure 1) are usually built by using the earth excavated from the basin to construct the surrounding

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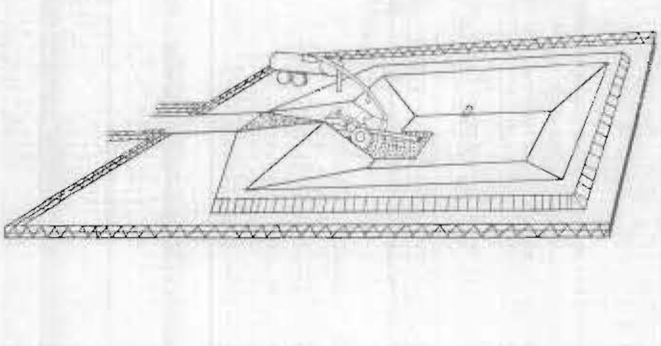

Figure 1. A typical outside, earthen-basin, liquid-manure storage. The drawing illustrates use of a chain-link fence, a necessary safety feature.

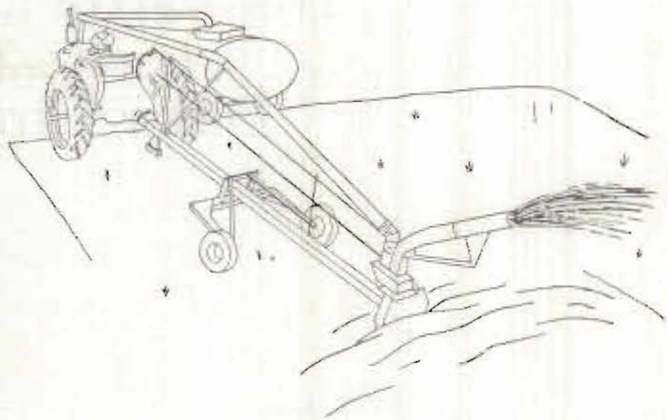

Figure 2. Open-pit pump provides convenience and fastest agitation or pumping from earthen basins.

dikes. Other than the earthwork, the only other consideration is a concrete ramp extending down the slope into the storage at one end. This ramp provides for lowering a tractor-drawn pump into the manure as the storage is emptied. These basins should be constructed in relatively nonporous soils with low hydraulic conductivity. In cases where compaction will not reduce the conductivity to a sufficiently low level, bentonite additions, chemical treatments, or plastic liners may be required to prevent potential groundwater contamination.

Manure can be added to the storage basin from above using pumps, extensions on gutter cleaners, or tractor scrapers. Manure can also be pumped into the bottom through buried pipelines, providing for even distribution of solids and reducing fly and odor problems because of the floating crust that normally develops. Adding manure from the top often results in a greater accumulation of settled solids below the inlet, particularly during freezing weather.

Manure generally is transferred through the 12-in. pipes by either a pump or pneumatic conveyance system. The manure enters along one side at the bottom of the storage basin, or the pipe is extended toward the center where the manure enters at the bottom of the basin. Both designs work well, but the pipe outlet must be well covered prior to freezing weather.

Earthen basins should be as deep as possible, thus minimizing surface area in order that a floating crust can form readily. This results in less crust area to be broken up and resuspended with the liquids when the basin contents are agitated prior to removal of the manure for land application. On most soils, the inside banks are sloped 2:1 (horizontal to vertical). Inside side slopes of 3:1 have been used, however, this configuration results in a larger surface area, thus requiring more land, catching more rainwater, and developing a larger crust which must be agitated prior to pumping. The width of the embankment surrounding the basin should be wide enough to mow and to provide access for agitation equipment along one side and one end. Outer side slopes should not be steeper than 3:1, with 4:1 preferred for ease of mowing and maintenance. The concrete ramps into the storage should have a slope no steeper than 7:1 with 10:1 or flatter recommended if the ramp is used for anything other than lowering the tractor and agitation pump. A flat, elevated area where a tractor and tankwagon can be conveniently parked for filling should be provided near the ramp. Safety precautions include the construction of a fence around the perimeter and the posting of "danger" signs at several locations along the fence.

Liquids and manure solids in earthen basins generally are agitated prior to land application with a high-capacity manure pump mounted at the end of a long boom (Figure 2). The pump intake should be positioned just beneath the surface or somewhat deeper. For agitation, the discharge from the pump is directed up and over the top of the surface, 60 to 70 ft. from the pump. These manure pumps have a chopper and/or rotating auger at their inlets that further breaks the crust and draws the solids into the pump for thorough mixing with the liquid.

Some earthen basins have a vertical wall or a dike extending out over the surface so that a vertical-shaft, liquid-manure pump can be used for agitation (Figure 3). These pumps, located at the bottom of the vertical shaft, well underneath the surface, also discharge beneath the surface in order to agitate the contents. While these pumps can agitate small basins, they are unable to move pieces of crust to and through the pump, and

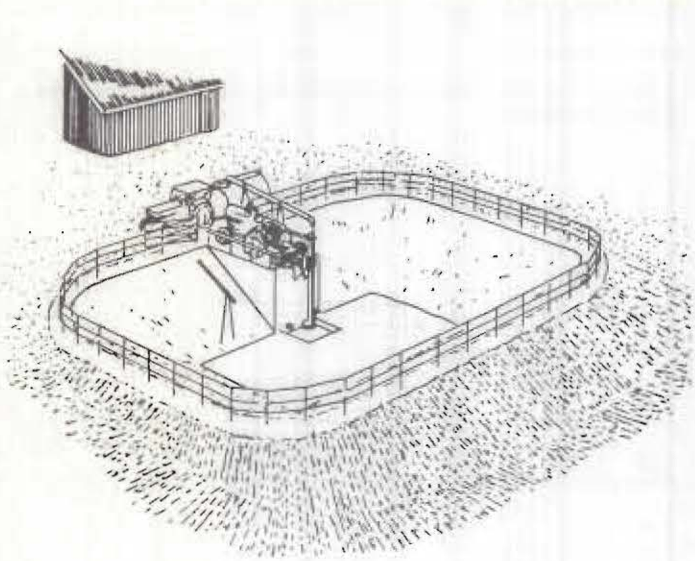

Figure 3. Earthen basin with pumping dock that allows a verticle-shaft manure pump to agitate and pump the liquid material into the tankwagon.

therefore are not as effective as the boom-type pump for breaking up a hard crust.

Propeller-type agitators are also available on booms to be mounted on three-point hitches which can be lowered over an earthen embankment for agitation. These pumps, relatively new to the market, have the capacity to move large volumes of manure with lower power.

Land Application from Earthen Basins

Land application from these basins is accomplished by conventional hauling or irrigation. If faced with a large livestock operation (100 milking cows or more), an operator with confined animals may have problems handling his liquid manure through the conventional hauling method and may have to irrigate.

The conventional hauling method is accomplished with liquid-manure tankwagons loaded with agitation pumps or paddle-type conveyors positioned in the basin. Surface broadcasting is usually not recommended due to odor problems and high losses of nitrogen through volatilization. These problems are usually prevented when using the haul method by incorporation of these manures directly into the soil.

Soil-injection equipment is an available option from most tankwagon manufacturers. Injection equipment may be rear or side mounted on the three-point hitch of the tractor (Figure 4). Injection is a very effective method of odor control and nutrient conservation in land application. Either injection or immediate soil incorporation through discing or plowing should be practiced with any application system. Some of the cost of the manure-handling system can be offset by taking advantage of the nutrient value of the manure and making appropriate adjustments in the recommended application rates of commercial fertilizers.

Moving liquid manure under high pressure is not a new concept, but equipment has been significantly improved in the past few years. In the past, the equipment was not effective if the manure contained such foreign objects as straw, hay, hair, or string or had a solids content of more than 5 per cent.

Chopper pumps and other equipment have been so improved that many operators are now pumping waste rather than hauling it. Several high-pressure, centrifugal, chopper pumps are available which will handle waste with 10 per cent solids; lift waste from storage pits 10 to 15 ft. deep; and chop straw, weeds, hair, and other waste materials that are in the manure-storage area. The suction lines have been adapted to pump from underground pits, earthen pits, or aboveground storage facilities. Choppers are a series of rotating knives or blades which reduce manure solids to particles of less than 1.25 in. in diameter so that they will pass through the pumps. The chopped manure can be discharged through nozzles as small as 0.5 to 0.75 in. in diameter. Most pumps that produce up to 160 psi at rates of 500 to 600 gpm can pump manure at 7 to 8 per cent solids content as far as 1.5 miles and distribute it through irrigation equipment using 6-in. diameter pipe.

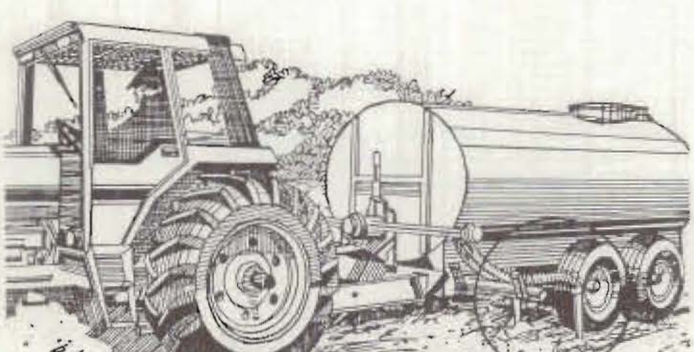

Figure 4. Side-mounted, adjustable, spring-loaded knives inject manure into the soil from the tankwagon.

Aluminum pipe, 6 in. in diameter and 30 ft. long, is used in most operations to facilitate layout and removal. Couplers should be of a type that can be unhooked manually and that will not come unhooked accidentally, especially during start up. Alterations of the standard coupler used to connect two pipes for irrigation have been made. PVC pipe is being installed underground in large operations and where aluminum pipe will cause a traffic problem around the farmyard. Flexible hoses also are being used by large operators or in custom pumping operations. Pipe up to 6 in in diameter is available on a large reel for transporting.

Large irrigation guns are being redesigned to turn with an outside drive mechanism. This allows the gun to operate in a partial circle at lower pressure and without stalling, thereby eliminating constant attention by the operator and uneven spreading of manure. The traveling gun (Figure 5) has been the most widely used irrigation system. The most common size, using a 4- to 4.5-in. irrigation hose and flow rates of 500 to 600 gpm, produces an application rate of greater than 4000 gal/acre. This system allows flexibility as well as multiple ownership, which is becoming increasingly popular.

The small amount of manpower required, the ability to operate in very wet conditions or on frozen soil, and flexibility have made the irrigation method very acceptable. Another important factor to consider is that the same equipment used for irrigating with liquid manure can also be used for irrigating with water. Two disadvantages associated with the irrigation method, however, are nutrient loss and odors which might be problems in highly populated urban areas where dairy operations frequently exist.

A remedy to the disadvantages of the irrigation method is the concept of injection through a trailing hose. This method of handling livestock waste has only recently come into common use. It became even more popular in 1982 when the two-hose method was developed and proved to be practical. Attaching a manifold system to a chisel plow or soil saver also has been introduced in this system to accomplish both tillage and manure injection in one trip, thus minimizing soil compaction.

Conclusions

The earthen basin has become popular as a result of development of large piston-type transfer pumps and pneumatic conveying systems for moving manure from barns to outside storage facilities. These basins are used to extend the storage

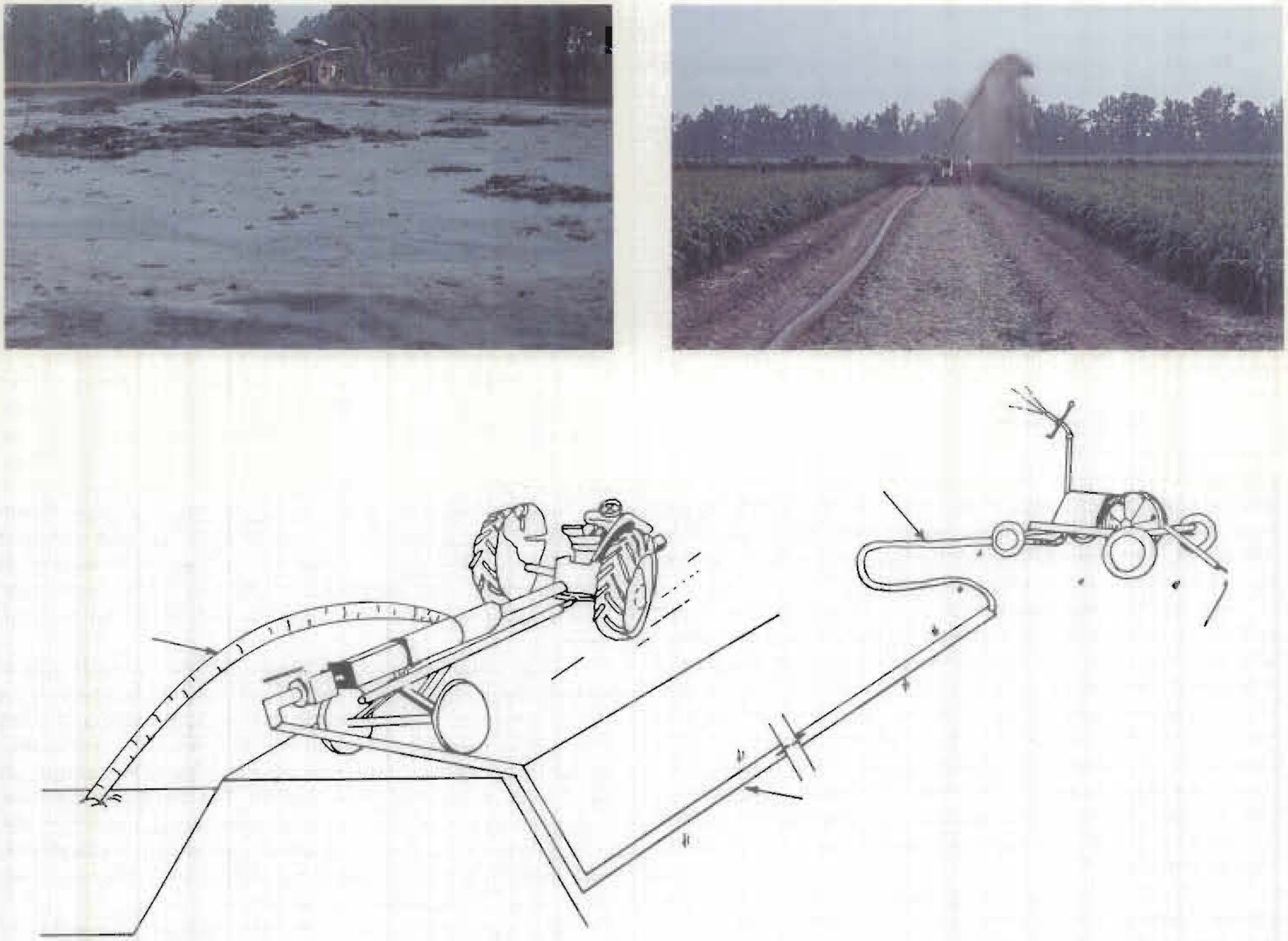

Figure 5. The traveling-gun-irrigation system, shown in schematic, consists of an open-pit manure pump (photo, left), aluminum pipe, flexible pipe, and the traveling nozzle (photo, right).

capacity of existing under-barn tanks or to provide the total storage needs in daily enterprises. They allow for freedom in selecting specific times for unloading the manures instead of daily hauling.

The earthen basin, as with any manure-disposal system, has its share of problems. Consequently, no one best system exists to collect, transfer, store, and dispose of manure from dairy operations. Managerial, environmental, and economic factors must be considered in selecting a manure-handling system for the modern dairy. There is need for continued improvements, research, and innovations in this area. ▫

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Research Associated with Registration Of Pesticides and Drugs in Alaska

By

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Introduction

Major chemical and drug companies spend millions of dollars every year researching and developing chemicals and biocontrols for use in combating pests and diseases in crops and animals. This effort involves the screening of thousands of experimental compounds and intensive evaluation of a relative few. Those compounds passing the initial screening process are subjected to extensive laboratory and field evaluations to determine effectiveness and safety. In the view of industry, these developmental efforts are warranted only if potential demand will offset developmental costs. Thus, research is targeted largely toward solving pest and disease problems associated with such "major" crops as corn, wheat, rice, and soybeans and such animals as cattle, pigs, and chickens. Relatively little effort is directed toward "minor" crops such as strawberries, potatoes, carrots, lettuce, and cole crops and such animals such as reindeer, rabbits, goats, geese, and ducks that are important to Alaska's primarily small-scale agriculture.

Fortunately, the U.S. government has recognized that there is a discrepancy in the amount of research being conducted by private industry toward solving pest and disease problems in major and minor crops and animals. The U.S. congress has provided legislation and funding to help ensure that pesticides, biocontrols, and drugs are available for use in minor-use crops and animals. The Interregional 4 (IR-4) program administered by USDA and section 24(c) of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provide means for minor-use registrations.

The IR-4 Program is a cooperative effort between USDA, EPA, FDA, state agricultural experiment stations, pesticide and drug manufacturers, and farmers. Through state liaisons, IR-4 determines which pesticides and drug needs have the highest priority, develops research protocols and, with the cooperation of EPA, FDA, and the manufacturer, prepares pesticide and animal drug petitions for EPA approval. Research by state scientists is partially funded by IR-4 to answer the following:

1) Will the compound control targeted pests or diseases?
2) Does the compound damage the crop or animal?
3) To what extent (if any) does the compound accumulate in the crop or animal? EPA must know this to evaluate possible health risks.

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Foxtail barley (Hordeum jubatum) seriously reduces pasture quality in interior Alaska. In 1983, research was undertaken aimed at its control.

Pesticide registrations sought by IR-4 for minor uses of pesticides could be for a single state, several states, or for the entire nation. In contrast, registrations obtained through section 24(c) of FIFRA are on a single-state basis. Using this avenue, manufacturers, private individuals, or grower groups may apply to the state for registration of a pesticide or biocontrol. As with the IR-4 Program, data on effectiveness and toxicity must be presented. A committee of experts reviews the supporting data and recommends whether the state should issue a registration. In Alaska, the commissioner of the Department of Environmental Conservation must approve any 24(c) registrations. EPA can veto such registrations within 90 days following issuance by the state.

Minor Use Pesticide and Drug Research in Alaska

Research on minor-use pesticides and drugs through IR-4 has been focused on control of weeds in rapeseed and smooth bromegrass and on control of external and internal parasites in reindeer. Work began in 1979 to determine the effectiveness and safety of dinitramine (COBEX), trifluralin (TREFLAN), and nitrofen (TOK) for weed control in rapeseed. Rapeseed could be a high-value rotational crop with barley; however, a lack of a registered herbicide for weed control in this crop makes its culture unfeasible.

Due to lack of interest by the manufacturer, COBEX was dropped form the research program. TOK was also deleted since it had been taken off the market because of possible terratogenicity. Testing of TREFLAN took place between 1979 and 1982 and was shown to be effective in controlling weeds in rapeseed, did not damage the crop, and was not present in samples taken from the rapeseed plant. Despite these results, ELANCO, manufacturer of TREFLAN, was not interested in pursuing registration because the product persists in soil and could damage subsequent crops. Research performed in 1982 and 1983 indicates that TREFLAN soil residues do not lower subsequent barley yields. This additional data will be presented to ELANCO in hopes that they will consider registering TREFLAN for rapeseed production in Alaska with the stipulation that only barley be planted following a rapeseed crop.

In 1983 a research project was started to investigate control of foxtail barley, *Hordeum jubatum*, in smooth bromegrass using napropamide (KERB). KERB is registered for this use in Canada and is quite effective. Foxtail barley is the single most important weed in smooth bromegrass fields in interior Alaska. Initial research with KERB involved evaluating the effects of various application rates on control of foxtail barley and on growth of smooth bromegrass.

Dr. Richard Washburn conducted research during the 1970s on famphur (WARBEX) for control of warble fly larvae in reindeer. This work was initially performed through the IR-4 Program. In January 1982, IR-4 funding was approved for research to determine the effectiveness and safety of Ivermectin to control warbles and internal parasites in reindeer. Dr. Robert Dieterich, who is doing this research, found a marked reduction of warble larvae in treated versus untreated reindeer in a small preliminary study conducted prior to IR-4 funding. This research is significant since parasites represent one of the major problems faced by the reindeer industry. Warble fly larvae burrow through the skin on rear legs, move up the back, and feed on tissue fluid. These parasites destroy the quality of reindeer hides, slow weight gain, disrupt herding practices, and have been implicated in the transmittal of brucellosis. Such internal parasites as lungworms and intestinal roundworms also result in decreased herd productivity, but are controlled by Ivermectin.

Data obtained from research performed during 1981 and 1982 at Delta Junction and at the Agricultural Experiment Station's experiment farm were used to support a 24(c) registration of metribuzin (SENCOR) for broadleaf weed control in barley. Unlike most postemergence broadleaf herbicides, SENCOR will control chickweed (*Stellaria media*) and provide full-season weed control. Crop tolerance and weed control were evaluated at various rates of SENCOR application. Barley varieties grown in Alaska were screened for differential sensitivity to this herbicide. The result is the registration of a very effective herbicide for use in growing Alaskan barley.

Both the IR-4 and 24(c) programs have been important to the development of agriculture in Alaska. These programs will continue to play an important role since many of the crops grown in Alaska are not grown in high volumes nationally. Hence, pest-control agents are relatively lacking. The Federal government provides some support for research on minor-use pesticides and drugs but this support generally amounts to less than one-quarter of the costs incurred in research efforts aimed toward registration. The rest of the costs must be borne by the states receiving the benefits of this work. ▫

Note: Cooperative investigation of Science and Education Administration, Agricultural Research, U.S. Department of Agriculture; and the University of Alaska Agricultural Experiment Station. The use of trade names implies neither endorsement nor criticism of these products by USDA-ARS or the University of Alaska.

Growing Winter Grains in Alaska

By

F.J. Wooding* and J.H. McBeath**

Introduction

Several projects are now being undertaken by the state of Alaska to expand substantially the amount of land currently in crop production. A major portion of this new lands development centers around a grain-based agriculture located in the Interior within a 125-mile radius of Fairbanks where spring cereals, namely barley, oats, wheat, and rye, are now being grown on a small scale. Winter grains, particularly wheat and rye, have been grown in Alaska for more than 70 years with varying degrees of success or failure. In general, winter grains mature earlier than spring grains and are better able to use moisture from snowfall. However, winter grains frequently have poor winter survival which results in low yields. The availability of hardy cultivars of winter grains could extend both the planting and harvest season in Alaska, thus making large-scale grain production more feasible.

Since 1971, winter grains, with emphasis on wheat, have been tested at the Agricultural Experiment Station of Fairbanks to determine if existing cultivars developed in Canada, Europe, and nothern-tier states have sufficient hardiness to withstand Alaska's harsh subarctic winters. During this testing period, standard cultivars of spring-sown grains have been grown for yield comparisons.

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Growth Cycle and Winter-Spring Mortality

In the temperate regions of the world, winter grains are planted in late summer or early fall (September and October). They produce a low, rosette-type growth before going into winter dormancy. These plants then lie dormant during the winter months. When spring arrives, growth is resumed, but in

Figure 1. Winter wheat in a low, rosette-type growth before the onset of winter.

Figure 2. Snowmold may appear as a few cobweb-like strands when small patches of the soil surface are exposed as the snow melts in the spring.

Figure 3. Snowmold can develop into a thick cottony mat of mycelial growth within a few days after the snow cover is gone.

an erect or upright form. The entire growth cycle from planting to production of mature seed is usually completed in 9 to 10 months.

In contrast to more temperate regions, winter grains grown in a subarctic environment must be planted in late July or early August because of the short growing seasons and long winters. The dormancy period begins earlier, starting in late September or early October and continuing into May. Maturity usually occurs in August. Completion of the growth cycle frequently requires 12 to 13 months.

Figures 1 to 12 are a series of photographs taken at various stages in the growth cycle of winter wheat at Fairbanks, Alaska. Figure 1 shows winter wheat in late September, just before freeze-up. Interior Alaska has a continuous snow cover for 6 to 7 months of the year, beginning in early October and extending into late April. During this period, the rosettes may die from freezing injury if not hardened off properly or if the insulating snow cover is blown away. Beginning in early April, there are freezing and thawing conditions in which the snow cover gradually melts over a 3- to 4-week period.

When the snow is almost gone and the soil surface is exposed in small patches (Figure 2), a type of disease known as snowmold begins to show up. Snowmold sometimes appears as a few cobweb-like strands, barely visible except at close range. However, the organism may also develop into a thick, white, cottony mat of mycelial growth which forms and feeds on plant tissue (Figure 3). In areas of the field where this mat is heavy, there is virtually no survival of winter wheat. Several fungi are capable of causing snowmold disease on winter wheat and winter rye in Alaska. Among these, *Sclerotinia borealis* is the most prominent. Snowmold fungi usually infect the host plants during the fall, develop on host plants through winter under snow cover, and eventually manifest themselves in the following spring after break up.

Besides snowmold and winter kill, several other environmental factors result in winter-grain mortality. As the snow cover leaves in the spring, winter wheat plants are mostly green in color (Figure 4). However, once the snow is gone, there is frequently a period of 1 to 2 weeks of widely fluctuating day-night temperatures when the daily minimum temperature may drop well below freezing. This causes the plants to die back to the soil surface and turn brown (Figure 5) and may result in death. In early to mid-May, when temperatures become favorable for growth, green shoots push through the dead tissue of surviving plants (Figure 6). If the month of May is droughty, green-up time is slow, and fewer plants survive (Figure 7). Also, soil cracking may cause physical injury to the roots and expose them to desiccation (Figure 8).

Figure 4. When the snow cover first disappears in the spring, winter wheat plants are mostly green in color.

Once green-up has occurred, growth is rapid under conditions of almost continuous daylight (Figure 9). Surviving plants tiller profusely, which compensates to some extent for sparse stands resulting from high winter and spring mortality. Grain heads begin to emerge about the third week of June (Figure 10). Plants are fully headed, and seeds are developing by the first of July (Figure 11). Physiological maturity is attained by late July or early August (Figure 12). Combine harvesting at moisture levels of 12 to 15 per cent can usually be carried out by the middle of August. Harvest almost always occurs more than a year after planting.

Winter Wheat Performance Trials

A series of tests of winter wheat began in the fall of 1970 with the planting of thirteen cultivars at the Fairbanks Research Farm. The winter was severe and long, with deep snow cover. During spring breakup, snowmold was prevalent over much of the test-plot area. As is evident by the results (Table 1), 'Froid', a Montana release, was the only cultivar to produce an encouraging yield, and even at that, the 26.2 bushels per acre was not impressive (the average U.S. yield is approximately 30 bu/A). Most of the cultivars in the test yielded little more than the seeding rate of 2 bushels per acre. The test was repeated the following year with similar results.

Figure 5. Once the snow cover is gone in the spring, a 1-to 2-week period of freezing and thawing temperatures often causes the exposed plants to die back to the soil surface.

Figure 6. In early to mid-May, when temperatures become favorable for growth, green shoots push through dead plant tissue.

Figure 7. Initial spring growth is often slow because root reserves are depleted and soil-moisture supplies may be low.

Figure 8. Soil cracking may cause physical injury to roots and expose them to desiccation.

Figure 9. Once spring green-up has occurred, growth of winter wheat is rapid under conditions of almost-continuous daylight.

Figure 10. The late-boot to early-head growth stage occurs about the third week of June.

Table 1. Winter wheat-performance trials conducted at the Fairbanks Research Farm during a 3-year period.

Wheat Cultivar	Crop Year 1970-71	1971-72	1972-73
	-------Yield (bu/A)-------		
Froid	26.2	28.8	53.9
Sawmont	9.4	20.4	74.1
Shoshoni	8.2	13.3	68.6
Kharkov	8.9	*	*
Omaha	1.7	3.8	45.0
Trapper	1.9	12.9	68.2
Trader	4.0	10.7	*
Lancer	4.9	8.8	*
Warrior	4.0	8.4	*
Winalta	2.8	5.6	*
Cheyenne	2.6	2.5	*
Scout 66	0.5	1.9	*
Blackhawk	2.9	*	*
NB 66403	*	15.7	65.1
Average	6.0	11.1	62.5

*Cultivar not included in trials for year shown.

Overall, yields in the 1971-1972 crop year were slightly higher, but 'Froid' was the only cultivar producing a respectable yield. The number of cultivars planted was reduced to six in the third year of testing. It was in this year that all of the cultivars came through the winter with good survival. The winter was less severe than the previous two, and there was very little snowmold in the spring. The six cultivars produced an average yield of 62.5 bushels per acre, with a range of 45.0 to 74.1 bushels per acre between the lowest- and highest-yielding cultivar. It is interesting to note that, in a good year for survival, 'Froid' came in second to last place in yield. This type of year occured two out of five years of testing.

After the third year, testing of winter wheat cultivars was continued on a smaller scale, with only two or three new entries being compared with 'Froid' as a standard. Newer releases, such as 'Sundance' and 'Norstar' from Canada and 'Roughrider' from North Dakota, have demonstrated considerable winter hardiness some of the time but have not showed the consistency of 'Froid'.

Winter Wheat and Spring Wheat Compared

During this entire winter wheat-testing period, spring wheat was grown under similar conditions for comparison. Spring wheat was planted each year in May, as soon as the soil was dry enough to be tilled. Figures 13 to 16 show a comparison of 'Park' spring wheat and 'Froid' winter wheat at two different dates. Figure 13 is a photo of 'Park' spring wheat taken on June 30. At this time, 'Park' is still in the boot stage of development. On this same date, 'Froid' winter wheat is fully headed (Figure 14). 'Park' was planted on May 16, while 'Froid' was planted on August 10 of the previous year. Photos were again taken 1 month later, on July 31. The spring wheat (Figure 15) is in the milk stage of development, while the winter wheat (Figure 16) on this same date is physiologically mature.

Table 2 gives planting dates, maturity dates, days to maturity, and yields for 'Froid' winter wheat and 'Park' spring wheat during five years of testing at Fairbanks. The average maturity date for winter wheat is August 10 and that of spring wheat is August 20. The winter wheat provides an extra 10 days of harvest time, which can be an important factor when farming in the subarctic. When yields are compared for these same 5 years, the winter wheat averaged 35.8 bushels per acre, and the spring wheat averaged 60.6 bushels per acre. Yield of spring wheat was approximately 70 per cent higher than that of winter wheat.

Winter Rye and Spring Rye Compared

Although major emphasis has been devoted to wheat, other types of winter grains have also been evaluated. Winter oats lack hardiness and have absolutely no survival when grown under subarctic conditions. Winter cultivars of barley and triticale have had very low survival. Winter rye, on the other hand, appears to have a definite advantage over spring rye.

Table 3 gives planting dates, maturity dates, days to maturity, and yields of 'Saskatoon Selection 70R' winter rye and 'Prolific' spring rye grown at Fairbanks for 3 years. The winter rye had an average maturity date of August 15 compared with September 1 for spring rye. Thus, an extra 16 days of harvest time was gained by planting winter rye. Winter rye also had a noticeable yield advantage over its spring-sown counterpart. For the 3 years, yield of winter rye was 70 per cent higher than that of spring rye.

Table 2. Performances of 'Froid' winter wheat and 'Park' spring wheat compared over 5 harvest years.

	Harvest Year* 1971	1972	1973	1975	1976	Average
FROID WINTER WHEAT						
Planting Date	Aug. 12	Aug. 6	Aug. 10	July 30	Aug. 2	Aug. 6
Maturity Date	Aug. 13	July 27	Aug. 18	Aug. 10	Aug. 12	Aug. 10
Days to Maturity	366	355	371	376	375	369
Yield (bu/A)	26.2	28.8	53.9	22.0	48.0	35.8
PARK SPRING WHEAT						
Planting Date	May 20	May 17	May 16	May 13	May 10	May 15
Maturity Date	Aug. 25	Aug. 7	Aug. 29	Aug. 23	Aug. 17	Aug. 20
Days to Maturity	97	82	105	102	99	97
Yield (bu/A)	64.3	56.0	69.3	54.2	59.4	60.6

*The test was not conducted in 1974.

Figure 11. Plants are fully headed, and seeds are beginning to develop by the first of July.

Figure 12. Physiological maturity is reached by late July or early August.

Figure 13. 'Park' spring wheat is in the boot stage of development on June 30.

Figure 14. 'Froid' winter wheat is fully headed on June 30.

Figure 15. 'Park' spring wheat is in the milk stage of development on July 31.

Figure 16. 'Froid' winter wheat is physiologically mature on July 31.

Table 3. Performances of 'Saskatoon Selection-70R' winter rye and 'Prolific' spring rye compared over 3 harvest years.

	Harvest Year*			
	1972	1973	1976	Av.
SASK. SEL. WINTER RYE				
Planting Date	Aug. 12	Aug. 10	Aug. 1	Aug. 8
Maturity Date	Aug. 15	Aug. 11	Aug. 20	Aug. 15
Days to Maturity	368	366	384	373
Yield (bu/A)	51.4	50.6	52.7	51.6
PROLIFIC SPRING RYE				
Planting Date	May 16	May 12	May 10	May 13
Maturity Date	Aug. 24	Sept. 2	Sept 8	Sept. 11
Days to Maturity	100	113	121	111
Yield (bu/A)	21.8	45.9	23.4	30.4

*The test was not conducted in 1974 and 1975.

Outlook for Production of Winter Grains

Winter grains, grown in combination with spring grains, could effectively spread out the annual work load more evenly for large-scale farms in Alaska's interior. They would help to avoid the seasonal crunch during planting and harvesting. On the basis of limited data, winter rye apppears more feasible than winter wheat. At this time, the yield differences between winter and spring wheat are probably too great to make winter wheat an economically viable crop. Also, the chance for failure is high. In areas subject to high winds during the winter months, the loss of snow cover can result in total winter-kill. This frequently occurs on many of the farms in the Delta Junction area. The research data collected at Fairbanks should apply only to areas where snow cover is maintained throughout the winter months.

Research is currently being conducted at Fairbanks to evaluate contact and systemic fungicides for snowmold control. Cultural practices designed to accumulate snow cover are also being studied. In other northern areas of the world, plant breeders are developing snowmold-resistant lines. If these studies result in management practices that consistently lower winter-spring mortality, the feasibility of growing winter wheat in Alaska will likely increase. ▫

Icelandic horses in use on the Seward peninsula include willows in their winter diet.

The Introduction and Suitability of Icelandic Horses in Northwestern Alaska

By

William B. Collins* and John Brooks III**

Introduction

Horses played a significant role in exploration and settlement of Alaska during Gold Rush days. However, with the increase in mechanized transportation, horses became less important and generally too expensive to keep for purposes other than recreation. Some would argue that horses are too expensive to keep even for that purpose. In 1982 a different breed of horse – one which appears well adapted to living off the range in summer and winter with little supplementation – was introduced to the state. The following is a brief description of that breed, its history, its requirements, potential uses, and special adaptations which make it more satisfactory than its predecessors as a work or pleasure horse in tundra regions.

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The Breed

About 1000 years ago, settlers from Scandinavian countries and the British Isles began arriving on the volcanic island of Iceland. These Viking farmers had crossed the North Atlantic in open boats, bringing with them all that they thought essential for pioneering in their new, often harsh, environment. Perhaps the most enduring of their precious cargo were their horses. Their horses were relatively small (13-15 hands and 850-900 lbs.) typical of European horses at that time. During the next 1000 years, Icelandic horses were to remain isolated from other horse populations. This was made possible when the Althing (the oldest parliament in the world) passed a law in 930 forbidding the importation of horses in order to maintain the purity of the breed. Some scholars have suggested that the establishment and long existence of the Althing was made possible by the horses which enabled the Icelandic chieftans to travel across the rugged country in order to meet. From the time of settlement until the beginning of the 20th century, Icelandic horses represented the sole means of transportation for people and goods. Had there been a network of roads and bridges, perhaps a larger horse would have been bred to pull wagons and carriages. The Icelandic horses, however were well suited to cross-country travel and could be kept year-round on open range.

People outside Iceland have become increasingly aware of the selfsufficiency, stamina, fecundity, and longevity of the Icelandic horse. The horse has also become well known for being the only remaining European breed to retain five distinct gaits, the most notable of which is the Tolt, or running walk. The Tolt disappeared from Europe as larger horses were bred for the purpose of carrying mail-clad soldiers and pulling wagons and carriages.

The Icelandic horse is also ideal for the native sport of "trekking," in which the horse is ridden cross-country 20-40 miles per day over several consecutive days, resting and grazing at night. The breed has a variety of colors as it was bred only in accordance with strict standards of gait quality.

In addition, extremely severe winters which occurred at intervals from 1200 to 1800 AD acted as a rigorous force for selection of weather-resistant individuals having relatively low requirements for supplemental feed and an exceptional ability to forage through ice and wind-pack snow. With the exception of the Yakutian horse found in Siberia (Luick 1978), no other breed is known to exhibit such special adaptation to severe winter environments.

Several decades before the riding qualities of the Icelandic horse made it popular with recreational riders outside of Iceland, Porsild (1929) promoted use of the horse for reindeer herding in North America. He said:

> The Iceland pony, particularly, would be well suited to this country, as it would need no more care or protection than the reindeer and would do well on practically the same feed. All cross-country travel during the summer has, at present, to be done on foot with pack-dogs, which means that tent, blankets, etc., must be dispensed with, also that on account of scarcity of game, dog feed must be carried. To a future reindeer industry, ponies should prove a factor of great importance and would make herding much easier and more attractive.

However, more than 50 years were to pass before Icelandic horses would be tried for reindeer herding in North America.

In June 1982, NANA (a regional Alaska Native corporation headquartered in Kotzebue) purchased seven geldings and one mare for purposes of herding reindeer and transporting camp supplies during the summer, when snowmachines cannot be used. NANA chose Icelandic horses over other breeds because they had learned from prior experience that larger breeds were too expensive to maintain during the 6 or 7 months the horses were idle each year.

Indeed, with the exception of freight companies in the early part of this century, most who have tried to justify the keeping of horses on a cost-benefit basis have found it is much too expensive to maintain them through the winter. In Klondike days, horses were generally used for a season and slaughtered as winter approached. Replacements were then brought in the next year. With the larger breeds NANA originally used, it appeared it might have been less expensive to fly the horses south for the winter than to try to winter them in the Kotzebue area.

Baldwin Penninsula in late summer. Horses feeding on a robust sedge, carex saxatilis.

Francisco Esparsa

Taking a break.

Francisco Esparsa

Bluejoint range in midsummer.

Performance

Icelandic horses have several advantages for reindeer herders. Herders have much greater ability to stay with the herd on horseback than on foot. Anyone who has ever tried walking any distance over tussock tundra can readily appreciate this fact. Unlike snowmachines and three-wheelers, the horses can also swim rivers and streams. From atop the horse, the herder commands a much better view of herd movements, a definite advantage, considering the huge expanses of tundra which lack promontories of any type. Increased view of the herd should prove especially valuable as the practice of herding with dogs is reestablished among western Alaska reindeer herders. Herders are also able to approach and calm the reindeer more readily when on horseback. In addition to actual herding advantages, horses provide a ready means of transporting camp cross-country. Finally, Icelandic horses have a demonstrated ability to forage productively on most tundra sites.

NANA's eight horses responded with amazing resilience and stamina to the stress and work to which they were subjected immediately following their purchase. First, they were shipped by truck from British Columbia to Alaska, after which they were rested for a week. They were then flown to Kotzebue where they were ridden by the local children during much of the 4 days they were rested there. The horses were next ridden out of Kotzebue overland a distance of 100 miles to Church Rock. The 5-day journey took the herd through a great deal of rough country and made it necessary for the horses to ford many streams and rivers swollen with the spring runoff. After resting from the roundup at Church Rock, horses and riders set off once again, this time for Calahan, a 2-day ride covering nearly 70 miles. From Calahan, the herd traveled to Arctic Circle where they were used to round up the butcher herd.

Once the horses left Kotzebue on their way to the roundups they received little grain and, instead, foraged on native vegetation. While used in roundups, the horses were worked 12 hours per day, almost daily – a practice not recommended and since discontinued. When working, they received 7.5 lbs. of barley per day, but, nevertheless, they declined in condition until the work load was reduced.

Much of the summer reindeer herding took place in areas of knee-high tussocks, the interspaces of which are spongy, wet ground. In contrast to the larger breed previously used, the Icelandic horses negotiated this type of terrain extremely well. This is particularly noteworthy in that most of the herders had never ridden a horse prior to June of 1982. The horses tolerated the variety of riders very well. They were also tolerant of the clouds of mosquitoes which attacked thier faces and bellies. Insect repellent reduced the mosquito and fly attacks, but even when without its protection, the horses did not appear overly distressed. The horses remained in relatively good condition, except when worked hard on a daily basis. A few additional horses should have been used in the NANA operation so that rested stock could be rotated under the riders, at least every 3 days. During the peak of the work season, the horses simply expended more energy than they could safely consume and received inadequate rest.

Nutrition and Care

We used the bite-count technique (Wallmo and Neff 1970) to determine the diet composition of NANA's horses during summer and winter. Simulated bites of each forage species were then hand clipped, oven dried, and weighed to form the basis for weighting bite-count totals and for later nutritional analyses. Nutritional analyses were performed at the Plant and Soil Analysis Laboratory at the Palmer Research Center. Metabolizable energy (ME) was calculated at $[(.99 \times \%\ \text{IVDMD} - 1.01) \times 34.2 + 45.0] \div 1000$ (Tilley and Terry 1963; Reid, J.T., as cited by Brundage et al. 1981).

Preliminary observations suggest that the Icelandic horse will consume a wide variety of plant species found on ranges in

Table 1. Diet composition of Icelandic horses in northwestern Alaska by dry weight per cent.

Summer	
Water sedge (*Carex aquatilis*)	10.4
Sedge (*Carex saxatilis*)	8.1
Sedge (*Carex* spp.)	34.5
Dunegrass (*Elymus arenarius*)	35.0
Bluejoint (*Calamagrostis canadensis*)	7.0
Bluegrass (*Poa* spp.)	0.7
Tufted hairgrass (*Deschampsia caespitosa*)	0.4
Sea-beach sandwort (*Honkenya peploides*)	0.2
Wild iris (*Iris setosa*)	+[1]
Beach pea (*Lathyrus maritimus*)	3.3
Oxytrope (*Oxytropis* spp.)	+
Arctic dock (*Rumex arcticus*)	0.2
Meadow horsetail (*Equisetum arvense*)	+
Winter	
Tussock cottongrass (*Eriophorum vaginatum*)	89.8
Northern Labrador tea (*Ledum decumbens*)	1.8
Willow (*Salix pulchra*)	7.9
Mountain cranberry (*Vaccinium vitis-idaea*)	0.5

[1]+ = trace amount.

northwestern Alaska. It utilizes a much wider array of plants than do other breeds and continues to forage under severe climatic conditions. Table 1 shows a summer diet typical of that which the horses consumed while in the Calahan vicinity. The principal species in this diet were dunegrass (*Elymus arenarius*) and carex (*Carex* spp.). We did not quantify fall diets, but we observed that, after the first snow in October, there was a shift to tufted hairgrass (*Deschampsia caespitosa*) and fescue (*Festuca* spp.). Then, beginning in mid-November, the horses consumed primarily diamond willow (*Salix pulcra*) and bluejoint (*Calamagrostis canadensis*) growing beneath the willow. From mid-December until mid-March, the diet (Table 1) consisted almost entirely of cottongrass (*Eriophorum vaginatum*), the predominant grasslike plant on the Baldwin Peninsula where the horses were kept for the remainder of the winter. It should be emphasized that the dietary preferences reported here were greatly influenced by relative availability of forage species (the range on which the horses wintered had a vegetative composition very different from those range types where summer and fall feeding preferences were observed).

The great disparity between energy recommendations by Bjarnason (1979) and NRC (1978) (Table 2) causes one to question which, if either, recommendation is the most accurate because it is difficult to believe that a 40 per cent difference in requirements could actually exist. Since energy intake is a matter of critical importance to animals, NRC recommendations are made 10-20 per cent high in order to provide a margin of safety. Ellis and Laurence (1980) reported digestible energy (DE) requirements of New Forest and Welsh ponies equal to only 110 Mcal/$W^{0.75}$ which would be equivalent to 9.46 Mcal/day for a mature Icelandic horse of average weight. This value is only 20 per cent greater than that determined by Bjarnason and represents a difference which conceivably could be accounted for by a lower actual energy requirement in the Icelandic breed.

Estimates of DE and metabolizable energy (ME) in the summer and winter diets (Table 2) by methods developed for ruminants are tenuous, and, hence, we question their accuracy, particularly those estimates for the winter diet. *In vitro* digestion of forages with dairy-cow rumen fluid may differ greatly from digestion in the horses, particularly one adapted to range vegetation. We doubt that the DE and ME content of the winter diet was nearly as low as was estimated. That the horses remained in relatively good condition while totally dependent on winter forage suggests that adequate energy was obtained by grazing. The possibility that the horses increased their intake in winter to compensate for low energy and protein availability should be investigated, since it is suggested that horses utilize this behavior to increase "access" to nutrients (Janis 1976).

Table 2. Recommended daily nutritional allowances for maintenance of a 840-lb. Icelandic horse (Bjarnason 1979), as compared with NRC (1978) recommendations and values estimated in range diets of Icelandic horses in northwestern Alaska.

	Recommendations				Availability in range diets, N.W. Alaska (per kg. feed)	
	Bjarnason		NCR			
	per day	per kg feed	per day	per kg feed	Summer	Winter
metabolizable energy (ME) (Mcal)	6.12[1]	1.15	10.94[2]	2.07[2]	1.88	0.58
digestible energy (DE) (Mcal)	7.46[2]	1.40[2]	13.34	2.52	2.24	0.88
digestible protein (g)	260	49	228	43	ND	ND
crude protein (g)	ND[3]	—	513	97	84	37
calcium (mg)	22,000	4,100	17,100	3,200	3,700	2,700
phosphorus (mg)	20,000	3,600	10,500	2,000	1,400	437
sodium (mg)	22,000	4,200	30,000	5,700	4,600	16,700
potassium (mg)	ND	—	22,800	4,300	13,700	1,300
magnesium (mg)	ND		4,900	900	2,600	700
zinc (mg)	200	38	240[4]	45	17	69
copper (mg)	50	9	54[5]	10	3	5.3
vitamin D (IU)	1,500	283	2,500[6]	472	ND	ND
thiamine (mg)	10	2	18[6]	3.5	ND	ND
vitamin B_{12} (mg)	0.04	0.0075	0.06[7]	0.01	ND	ND
daily feed (kg)	5.3		6.0			

[1]Value converted from fat feedunits to Mcal ME.
[2]Estimated by authors: ME = 0.82 DE
[3]ND — no data.
[4]Requirement for growing foal or pregnant or lactating mare.
[5]Requirement for growing foal.
[6]Not adequately established.
[7]At this dietary level, horses continue to excrete more than fed.

Digestible protein in summer diets (Table 2) appears somewhat low in comparison with recommendations. However, these data are probably misleading since the horses were being worked hard and were supplemented with barley during the period of observation. Many of the forages utilized by the horses were relatively high in crude protein and abundant on the range, and it is most likely that they would have been consumed in relatively larger quantities had the horses not been worked or fed barley. We do not doubt the adequacy of summer range in terms of digestible-protein availability. However, the winter diet of the horses, particularly sedge-tussock tundra, was definitely deficient in digestible protein (Table 2). For this reason, we recommend protein supplementation in winter unless the horses are kept on other range types having greater protein availability.

Levels of zinc (in summer) and copper (in summer and winter) were apparently low (Table 2). Requirements for trace minerals are not well understood (Hintz and Meakim 1981), but the low levels of copper we observed probably do represent real deficiencies. Copper deficiencies have been reported or suspected for a number of different herbivores on many different ranges in Alaska (McKendrick,[1] pers. comm.). That the horses exhibited an extreme amount of pica (craving, exhibited by abnormal amount of chewing on wood, bones, etc.) reinforces our belief that they were not obtaining adequate levels of minerals in their diets. Mineral deficiencies are relatively easy and inexpensive to prevent by use of mineralized salt. We also believe that regular mineral supplementation will help prevent digestive upset caused by sudden changes in diet, which would occur under emergency feeding.

We did not measure vitamin levels for comparison with Bjarnason's recommendations, but deficiencies are unlikely. Horses generally obtain sufficient vitamin D from range vegetation and/or exposure to sunlight. Thiamin is found in most forages in adequate amounts, in addition to being synthesized in the digestive tract and absorbed in the cecum. Vitamin B_{12} is also synthesized and absorbed in the large intestine, and supplementation is deemed unnecessary in mature horses (NRC 1978). We are certain the horses consumed adequate vitamin A because they ate significant amounts of living, green plant tissue year-round. The cambium of willow, leaves of mountain cranberry (an evergreen shrub), and winter production of cottongrass provided vitamin A in winter. Additionally, a 5- to 6-month supply of this vitamin is stored in the liver following good summer grazing.

We were impressed that these horses continued to forage through snow, iced and packed by wind, more than 20 in. deep. According to S.H. Magnusson[2] (pers. comm.), only when ice layers occur right at the plant/ground surface are the horses unable to break through, making it necessary to supplement with hay at approximately 9 lbs./day. It is also noteworthy that NANA's horses appeared tolerant of winter winds which averaged 10 to 20 mph at temperatures of 0° to -30°F in an area which afforded little protection from the wind. These observations support Bjarnason's recommendation that Icelandic horses be wintered on the range and supplemented only as needed. Supplementation for mares becomes mandatory in the last 2 months of gestation and in the first 2 months of lactation. One supplement which Bjarnason recommends is presented in Table 3. This can be fed to supplement grazing, or it can be fed in a 1:3 ratio with good-quality hay to provide a complete ration for maintenance. An alternative complete ration which also meets the nutritional allowances recommended in Table 2 is presented in Table 3. In Iceland, a common means of supplementing energy, protein, and minerals is to set out barrels of salted herring which are consumed by the horses on an ad lib basis at approximately one fish per day. Not only do Icelanders believe it is nutritionally practical to winter Icelandic horses on the range, but they believe it is advisable from the standpoint of enabling the horses to develop strong tendons and joints. According to Bjarnason (1979), "good tendons and strong joints are more valuable than weight."

"Happy Birthday" taking late-winter lunch from tops of cottongrass tussocks. Lichens were rejected.

Energy demands of any animal are greatly increased by work. The Icelandic horse is no exception. Where Bjarnason (1979) recommends only 8 Mcal ME per day, he recommends almost 10 Mcal/day for "easy movement" and nearly 12 Mcal/day for a 840-lb horse which is ridden 2 to 3 hours daily. Thus, it is easy to understand why NANA's horses declined in condition when worked 12 hours per day, even when receiving 7.7 lbs. supplemental barley per day. This quantity of barley supplied 6.6 Mcal ME which meant that even if the horses were worked only one-fourth as much as they were, they would need to obtain at least 5.4 Mcal additional ME by grazing, a most unlikely possibility, given that they would have less than 12 hours per day in which to do so. Morrison (1961) recommends that the horse doing heavy work be provided its grain supplement in three feedings per day (morning, noon, and night), a practice equally commended to those using Icelandic horses in herding reindeer.

It should be recognized, however, that no amount of supplementation can allow a horse to be overworked. One may get away with such abuse in the short term, but will greatly reduce the years of satisfactory service from the horse. Anyone considering the use of Icelandic horses should not be so impressed by the horse's strength and hardiness as to abuse it. The fact is, if properly treated, the Icelandic horse has the

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[2] *S.H. Magnusson: Icelander presently working as a reindeer herder on Seward Peninsula.*

potential to work for 25 to 30 years, and has a life expectancy of 35 to 40 years. At least one Icelandic horse was reported to be alive and well at 53 years. Both mares and stallions remain reproductively fit until approximately 25 years.

Conclusions

Gunnar Bjarnason[1], Iceland's expert on horses, has said "There are many incredible things about our unique horse which are difficult to understand and accept in the beginning" (pers. comm.). Perhaps the most incredible characteristics of this horse are its ability to utilize tundra vegetation as its principle source of food year-round and to remain fit in the far-north environment with minimal energy and protein supplementation. It is a willing servant in terrain and conditions where most other breeds are reluctant to go. These characteristics alone commend the attention of individuals considering the acquisition of horses for use in tundra regions. Add to the above that the Icelandic horse can provide far more years of service than other breeds, and it becomes apparent that their purchase may be economically justified for many purposes.

In the long history of the breed, the Icelandic horse has unquestionably demonstrated its willingness and usefulness as a riding, herding, pack, and draft animal. In the past year, it has demonstrated its value in Alaska's reindeer industry. We can think of many other potential uses for this horse in our state. It would appear to have prospects as a pack animal in sport hunting and fishing, and it is conceivable that sports like trekking or dude riding could become significant attractions to recreationists and tourists in some of our communities. We cannot imagine a more enjoyable way for one to get out and enjoy the beautiful tundra lands of our state.

Researchers in Iceland have produced considerable information on the husbandry of these animals. However, some additional work should be done to evaluate the quality of diets consumed on Alaskan rangelands and to determine nutritional values of some locally produced hays and grains. At present, we are growing test plots of a variety of forages and grains which can be used as supplemental horse feed to determine if it is feasible to produce them in northwestern Alaska.

The Icelandic horse apparently is well adapted to the far north tundra environment and exhibits characteristics which make it suitable for a variety of uses. However, successful husbandry requires a good understanding and careful consideration of the horse's limitations and requirements. Indeed, it has been widely said that to enslave a horse is easy, but to serve a horse is an art. ▫

[1] *Gunnar Bjarnason: Professor of Animal Science, Agricultural Research Institute, Reykjavik, Iceland.*

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A Grass from Alaska Gives Promising Results in Icelandic Trials

By

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Introduction

The grass species *Deschampsia beringensis* (Bering hairgrass) has aroused much interest in Iceland since it was introduced into the country in 1974 in a seed-exchange program between Prof. Wm. W. Mitchell at the Agricultural Experiment Station at Palmer and the Agricultural Research Institute in Reykjavik.

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Bering hairgrass is not indigenous to Iceland, but a close relative of it, *D. caespitosa* (tufted hairgrass), is frequently dominant in old seminatural hayfields around the country. Beside *D. caespitosa,* only three other grasses are of any significance in these hayfields: *Agrostis tenuis* ('Colonial' bentgrass), *Festuca rubra* spp *richardsonii* (red fescue), and *Poa pratensis* (Kentucky bluegrass). Varieties have been bred of the fescue and the bluegrass, but seed-production problems have hampered their use. Consequently, introduced varieties have been used for new hayfields.

Bering hairgrass of Alaskan origin is the pre-eminent grass to endure in this small-plot research project that tested a number of grasses for revegetation purposes in Iceland.

Phleum pratense (timothy) is by far the most popular of the introduced grasses for hayfield establishment. One Norwegian variety, 'Engmo', and two Icelandic varieties, 'Korpa' and 'Adda', are sufficiently persistent and winterhardy to be on Iceland's national list of recommended grass varieties.

Much grass seed is planted to combat the extensive soil erosion in the country. The loess-like soils are sensitive to wind erosion, especially where grazing has been heavy. The most common approach to erosion control and to revegetation of denuded land is aerial application of seed and fertilizers. The grass species most used in this work has been red fescue.

Continual improvement in plant performance in agriculture and in the revegetation efforts is being sought through plant breeding and plant introduction. Plant introduction is regarded as very promising, especially in view of the low number of plant species (about 430) in the Icelandic flora. This low number is thought to be a result of the geographic isolation of the country following the Ice Age.

Alaska is particularly attractive for source material with its much larger flora (about 1700) and large regions that have a climate similar to that of Iceland. Many interesting species have in fact been brought to Iceland from Alaska, such as Sitka spruce (*Picea sitchensis*), Pacific poplar (*Populus trichocarpa*), and many willow species e.g. *Salix alaxensis,* that have grown well in Iceland.

The nitrogen-fixing lupine *Lupinus nootkatensis* has proved to be a very successful pioneer plant on denuded land and will be used increasingly in revegetation work. Another interesting nitrogen fixer is the alder *Alnus crispa* spp *sinuata* which has only recently been brought into Iceland. It is noteworthy that most of the above-mentioned species have a similar geographic distribution in Alaska (Hultén 1968) which is along the southern coast southwestward to the Alaska peninsula area. This is also the distribution of *Deschampsia beringensis.*

Trials with Bering Hairgrass

The Alaska Agricultural Experiment Station accession IAS 19 was first tested together with other introductions on a wide range of soil types, including rather acid peat, loessial, and sandy soils. In 1976, Bering hairgrass IAS 19 also was included in a large screening test designed to find suitable grasses for erosion control and for the revegetation of denuded gravelly and sandy soils on locations ranging from the seashore on the south coast to 550 meters (1,800 feet) above sea level in the central highlands (Arnalds et al. 1979).

Early results from these tests were very favorable (Tomasson 1979). The Soil Conservation Service of Iceland, therefore, contracted with the Agricultural Experiment Station at Palmer for seed production of the grass. During the years 1979-1982, this production approximated 2 tons.

Because of this good seed supply, it has been possible to appraise this germplasm rather thoroughly under a wide range of conditions of soil, climate, and management. Several farmers in most districts of Iceland have established hayfields with this introduced seed to obtain an evaluation of how it performs in practice.

Soil Adaptation

Bering hairgrass IAS 19 has been proven to grow well on a wide range of soils. It performs very well on the rather acidic organic soils and also on dry, sandy, or gravelly soils. It seems, however, less well suited to the common loessial, silty soil where the mature tufted hairgrass thrives well and is often the dominant species. Reasons for this are unclear, but *D. beringensis* may be more sensitive than *D. caespitosa* and *Phleum pratense* to the solifluction of these soils, which is often pronounced owing to the frequent freeze/thaw cycles during winter.

Adaptation to Climate-Winterhardiness

In the screening test for persistence on denuded sandy soils, *D. beringensis* got the highest mark of all species tested on the most-exposed site at an elevation of 550 meters (1800 feet) for cover, persistence, and yield (Arnalds et al. 1979). In a variety trial in the north of Iceland on a field exposed to winter damages, Gudleifsson (1982) rated Bering hairgrass IAS 19 as persistent as *D. caespitosa,* long regarded to be the most winterhardy grass species in Icelandic hayfields. The excellent winterhardiness of this species was further confirmed by Gudleifsson (1982) in laboratory tests for frost and ice-encasement resistance (Table 1). These are the main components of winter persistence in the Icelandic hayfields, while resistance to disease seems to be of minor importance.

From these observations, it seems rather clear that Bering hairgrass ranks as one of the most winterhardy grasses available for hayfield establishment in Iceland.

Yield

Yield capacity has been assessed on different soil types, but best performance has been observed on the organic, rather acidic soils at the agricultural college of Hvanneyri in western Iceland. On these soils, the Bering hairgrass has performed very

Table 1. Frost and ice-encasement resistance of some grass species. (Adapted from Bjarni Gudleifsson, 1982)

Species	Entry	Frost Resistance LD/50 (temp)[1]	Ice-Encasement Resistance LD/50 (time)[2]
		°C (°F)	no. days
Dactylis glomerata	'Juno'	-9.0 (15.8)	15.3
Festuca pratensis	'Salten'	-11.0 (12.2)	19.4
Phalaris arundincea	'Grove'	-4.2 (24.4)	22.9
Festuca rubra	'Leik'	-11.4 (11.5)	28.9
Poa pratensis	04	13.1 (8.4)	32.8
Phleum pratense	'Adda'	-11.9 (10.6)	45.0
Deschampsia beringensis	IAS 19	-10.7 (12.7)	46.7

[1] LD/50 = The temperature at which 50% of the plants die.
[2] LD/50 = The number of days in which 50% of the plants die.
Note: These figures are the result of a laboratory study. In field studies, hairgrass and other grasses have demonstrated ability to withstand much lower temperatures.

well, giving significantly higher yields than timothy as shown in Figure 1. An important difference between the two species is the superior regrowth ability of the hairgrass. Bering hairgrass IAS 19 also provided high yields on sandy soils, but on the loessial, silty soils it has yielded less convincingly, probably due to failure to develop dense stands.

Quality

Deschampsia caespitosa normally drops very rapidly in digestibility and is also generally thought to be unpalatable to stock. In repeated evaluations, however, digestibility of Bering hairgrass IAS 19 has been rather high, and even declined more slowly than that of timothy (Figure 2). Gudmundsson (1983) has further compared timothy and Bering hairgrass for the

1) rate of drying on the ground during curing
2) losses in digestibility during curing
3) voluntary intake (lambs)
4) feeding value (intake x digestibility) .

On the whole, Bering hairgrass IAS 19 gave 5 per cent better animal performance in spite of lower rate of drying with attendant losses in quality.

Use in Erosion Control and Revegetation Work

Bering hairgrass IAS 19 has proved to be eminently suited to grow on gravelly land and on the semimobile sandy soils in the southern central regions of Iceland where soil erosion is a serious problem The stems and leaves are resistant to decay and collect the mobil sand without the plants' being killed in the process. The grass has, however, proved to be sensitive to grazing during the establishment year, in that sheep and geese tend to pull the plants out of the ground (Helgadóttir and Tomasson 1983).

After three years' growth, an Alaskan collection of Bering hairgrass, left, is showing superior performance over other grasses, including red fescue to its right. Red fescue is one of the major grasses seeded in Iceland for reclamation and grazing purposes.

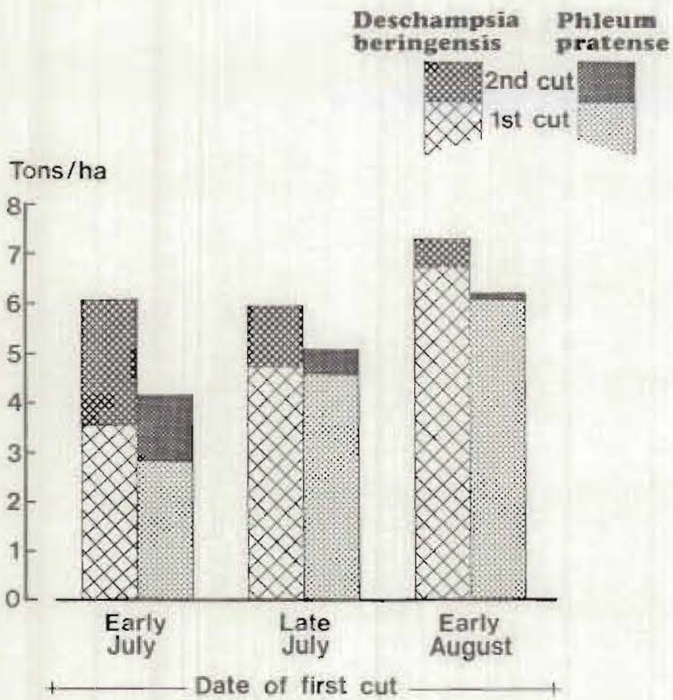

Figure 1. Dry-matter yield of Deschampsia beringensis *IAS-19 and* Phleum pratense *var. 'Korpa'. Second cut taken approximately 7 weeks after first cut. Mean values of 5 years. (Yields in tons per acre equals about half of that in tons per hectare.) (Adapted from Brynjolfsson, 1983)*

Experience from farmers

Several farmers from most districts in the country have sown the Bering hairgrass for practical evaluation on the farms where conditions as well as management practices are varied.

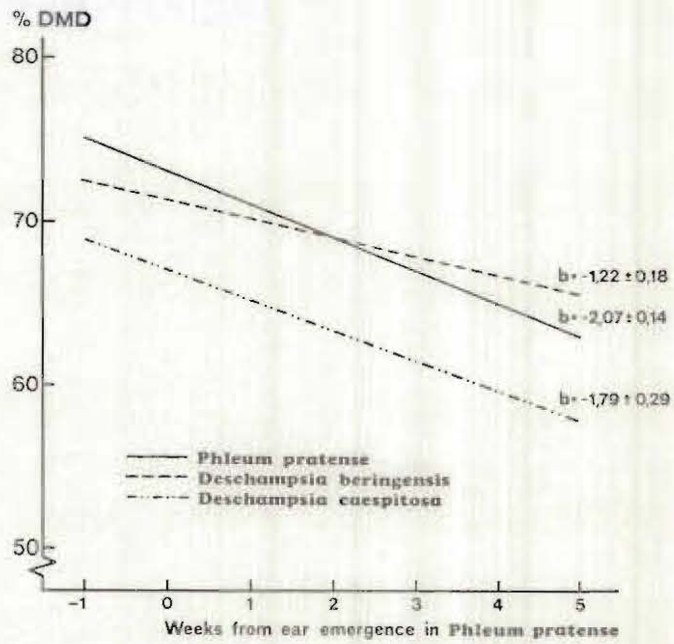

Figure 2. Percentage dry-matter digestibility in three grass species in relation to date of harvest. Mean values based upon results from several experiments. (Adapted from Björnsson, H., and Hermannsson, J., 1983).

The general consensus is very positive (Gudmundsson 1982). Establishment was generally good; curing of the crop either as hay or silage was satisfactory; and good experience was obtained from feeding the crop. Most of these farmers expressed interest in obtaining more seed of this grass for further cultivation.

Conclusions

These initial tests of this new grass have demonstrated that *Deschampsia beringensis* is potentially a very valuable species for both hayfield cultivation and revegetation work. There is considerable interest in the grass and a demand for seed. The possibilities of seed production in Iceland have been studied in some trials; but although the seed is generally of good quality, the unstable autumn climate, with frequent storms, seems to preclude acceptable economic returns. We will be interested in exploring whether or not a seed-production program can be established in Alaska for the Icelandic market. ▫

Editors Note: The Agricultural Experiment Station recently released the variety 'Norcoast' Bering hairgrass based on the material that was used in the Iceland trials. This variety is just now entering commercial production for use both in Alaska and in Iceland.

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Far-North-Adapted Bluegrasses from Areas with Rigorous Winter Climate Perform Best in Southcentral Alaska

By

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It is ill work fighting against heaven. Certainly not by dint of sowing and planting what he himself desires will he meet the needs of life more fully than by planting and sowing what the earth herself rejoices to bear and nourish on her bosom.
Xenophon (434-355 B.C.)

Perhaps another way of expressing the same thoughts 24 centuries later, as Xenophon's observations in ancient Greece apply to modern-day Alaska, would be to say: "For successful crop performance, plant adapted varieties."

Too often growers in Alaska plant whatever seed is cheapest, or crop varieties that "grew well back in Nebraska, or Ohio, or Oregon." Almost invariably, these will be poor choices for successful use under Alaska's unique climatic conditions. This is as true of turfgrass varieties as it is of perennial grasses for pasture or forage production, or for roadside seedings.

Grasses that serve best for lawns in Alaska and elsewhere are those that will tolerate close mowing to produce a fine-leaved, dense, durable, and winterhardy turf (Håbjörg 1979b, Hanson and Juska 1969, Mitchell 1982b). One of the best species for fulfilling these requirements for turfgrass in the northern states, Canada, and Alaska is *Poa pratensis*, commonly called Kentucky bluegrass. This fine-leaved, cool-season, perennial grass spreads by underground stems, called rhizomes, creating a tight sod resistant to wear and valuable in binding soils to prevent erosion.

Hardy varieties of red fescue (*Festuca rubra*) are used also for some lawn plantings in Alaska, but to a lesser extent than Kentucky bluegrass. Many grasses that are much used for turf in the other 49 states (Hanson 1972, Hanson and Juska 1969) are not sufficiently winterhardy for use in Alaska. These include bentgrasses (*Agrostis* spp.), ryegrasses (*Lolium* spp.) zoysiagrass (*Zoysia* spp.), bermudagrasses (*Cynodon* spp.), and bahiagrass and dallisgrass (*Paspalum* spp.).

In addition to its merits as a turfgrass, the superior ability of Kentucky bluegrass over many other grasses to tolerate frequent, close defoliation also makes this species valuable as a pasture grass. Kentucky bluegrass is planted in some pasture mixtures but, whether planted or not, it often invades permanent pastures to become a dominant component (Fergus and Buckner 1973, Smith 1981). The major difference between turf and pasture use is that for pasture, the main concern is the yield and quality of the herbage produced for grazing removal by animals; for turfgrass use, however, the primary interest is not the herbage removed but the appearance of the leaf growth left after mowing.

For seedings to revegetate roadside slopes denuded during construction, Kentucky bluegrass is an ideal choice for its erosion-controlling, soil-binding characteristics, as well as for its long, lax leaves which overlay downslope plants, forming a continuous "thatching" on slopes to further prevent erosion.

There is considerable variability in growth form within the species. Some upright-growing types of Kentucky bluegrass are better suited for pasture and forage production than for turf, as they produce an open, stemmy, and unattractive turf when mowed at low levels. Others are shorter growing, producing a dense, leafy turf with close mowing.

The genus *Poa* contains over 200 species worldwide (Fergus and Buckner 1973). In Alaska, about two dozen species are native, and several others have been introduced and persist at various locations (Hultén 1968).

Irwin (1945) summarized results of early grass trials in Alaska, including many with different species of bluegrass. The first experimental plantings with Kentucky bluegrass in the territory were in 1902 at the Sitka and Kenai experiment stations, with later plantings at the Copper Center, Rampart, Fairbanks, Kodiak, and Matanuska stations. Sources of seed were not recorded. Results were quite variable and frequently unsatisfactory, a not-surprising outcome when seed used was probably of poorly adapted strains, originating from areas far south of Alaska.

Historically, most seed imported for agricultural and turfgrass use in Alaska has come from the Pacific Northwest states. Although the Oregon-Washington area is noted for seed production of grasses, winters there are relatively mild; therefore, extremely winterhardy crops are not required in that area. Moreover, the seasonal photoperiodic (daylength) pattern there, an important environmental factor in grass adaptation (Klebesadel 1971, 1973), is quite different from that of southcentral Alaska. Consequently, the imported grasses used most extensively for many years in Alaska have possessed poor adaptation to our subarctic environment. *Adaptation* can best be defined as an evolved harmony between plants and their environment.

Since the release of 'Merion' in 1947, the first U.S. Kentucky bluegrass variety, many other varieties with distinct characteristics have been developed in various areas of North America (Fergus and Buckner 1973, Hanson 1972, Hanson and

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Table 1. Seeding-year and subsequent oven-dry forage yields of bluegrass (*Poa*) species and varieties; harvest dates and yields are means of two tests unless otherwise noted.

Species, variety, and origin	Seeding yr. 24 Sep	Harvest years following establishment: First 7/8	First 10/11	Second 7/6	Second 10/2	Third 7/9	Third 9/18	Fourth 7/4	Fourth 9/21	Fifth 7/2	Fifth 9/13	Total
	Tons dry matter per acre											
Kentucky bluegrass (*Poa pratensis*):												
'Nugget' (Alaska)	.48	1.13	1.57	1.87	1.89	1.47	2.15	1.97	1.28	1.31	2.19	17.31
'Park' (Minnesota)	.89	.75	1.13	1.57	1.72	1.39	1.68	1.72	.95	1.74	1.48	15.02
'Delta' (Ontario)	.81	.64	1.29	1.54	1.65	1.09	1.51	1.59	.27	1.08	1.11	12.58
'Merion' (PA)	.54	.68	1.65	1.22	1.96	.64	1.25	1.08	.48	.35	1.25	11.10
'Newport' (Oregon)	.74	.15	1.30	.44	1.26	.01	.41	Tr[1]	Tr	Tr	.37	4.68
Big bluegrass (*Poa ampla*):												
'Sherman' (Oregon)[2]	.64	.48	.52	.90	1.32[3]	—	—	—	—	—	—	3.86
Salt bluegrass (*Poa eminens*):												
'Native' (Alaska)[2]	.04	.34	1.27	2.50	1.24	2.81	.75	2.65	.84	1.82	1.28	15.54

[1]Trace amount, insufficient for harvestable yield.
[2]In one test only.
[3]Total winterkill in all plots.

Juska 1969, Smith 1981). In addition to named varieties, much seed is marketed as simply "Kentucky bluegrass." Such unnamed, or "common," Kentucky bluegrass often is less expensive than named varieties; thus it is often purchased for that reason. In other, more southern areas of North America, this common Kentucky bluegrass may perform well. It is a poor choice for use in southcentral Alaska, however, for its anonymity, or lack of varietal name, obscures its identity as to area of adaptation. Common, or unnamed, Kentucky bluegrass may represent a regional strain grown in one of the major seed-growing areas, or it may actually be a variety that could not be marketed under its varietal name because it could not pass certain inspection or quality standards.

A major advance in identifying and utilizing subarctic-adapted bluegrass germplasm in Alaska evolved from a special program funded by The Rockefeller Foundation from the late 1950s through the 1960s. This program enabled Alaska Experiment Station agronomists to travel throughout the state by aircraft, riverboat, and road vehicle to collect and evaluate native plants for various uses. Native grasses grown from seed collected from numerous, diverse sources were planted in field nurseries for comparison with introduced, temperate-zone-adapted varieties of the same species. These comparisons provided insights into the importance of adapted germplasm (Klebesadel et al. 1964), and identified superior lines for increase and utilization. From these and later efforts, the Alaskan Kentucky bluegrass variety 'Nugget' was selected and released (Hodgson et al. 1971). Despite this progress, however, a great deal of seed of poorly adapted bluegrass varieties continues to be imported and sold in Alaska.

Results reported here are from three field experiments at the University of Alaska's Matanuska Research Farm; these tests compared performance characteristics of bluegrasses from numerous sources.

Experimental Procedure

All experiments were planted in Knik silt loam soil. Preplant fertilizer disked into each seedbed supplied N, P_2O_5, and K_2O at 32, 128, and 64 lb/A, respectively. Broadleaf weeds were controlled with a preemergence spray application of dinitro-o-sec-butylphenol in water solution 1 to 4 days after each planting. Grasses in all tests were broadcast-seeded without a companion crop. Randomized complete-block experimental designs were employed and individual plots were 5 feet wide and 15 to 20 feet long in the various tests. All experiments were harvested once near the end of the growing season of the seeding year. A stubble height of about 1.5 inches was left at each harvest.

Experiments I and II: Grasses listed in Table 1 were planted on 16 June 1968 (Experiment I) and 25 June 1970 (Experiment II); three replications were used in each experiment. Following the year of establishment, both experiments were harvested twice per year for 5 years. Fertilizer topdressed each spring of the years after establishment supplied N, P_2O_5, and K_2O at 125, 96, and 48 lb/A, respectively. A midseason topdressing shortly after the first cutting supplied N at 85 lb/A each year.

Experiment III: Six Kentucky bluegrass varieties from various sources (Table 2) were broadcast-seeded 19 June 1974 in four replications. Early spring topdressings in 1975 and 1976 supplied N, P_2O_5, and K_2O at 125, 220, and 58 lb/A, respectively. Midseason topdressings applied shortly after the first and second of four cuttings each year, supplied N at 85 lb/A at each application. Mean harvest dates for the 2 years after establishment were 11 June, 9 July, 14 August, and 25 September.

Results and Discussion

Results presented here were derived from three field-plot studies, two of 6 years' duration and one 3-year experiment. None of the experiments were managed as turf; in two studies (Table 1), plots were harvested twice per year, a common schedule for forage production, and, in the third (Table 2), plots were harvested four times per year, a schedule simulating rotational pasture utilization or periodic harvest for green-chop feeding. Forage yields indicate relative herbage production and stand health of all grasses. The winter injury and survival noted for varieties under the management systems used are believed to

Table 2. Simulated-grazing forage yields and percent winterkill of Kentucky bluegrass varieties of different latitudinal adaptation in a 3-year test at the Matanuska Research Farm near Palmer. Planted 19 June 1974.

Adaptation, variety, and origin	Forage yield (tons dry matter/A) 9 Oct. 1974	Total 4 cuts 1975	Total 4 cuts 1976	Total	Per cent winterkill[1] 1974-75	1975-76[2]
Subarctic-adapted:						
'Nugget' (Alaska)	0.18	4.07	3.19	7.44	1	9
'412' (Iceland)	0.29	4.22	2.90	7.41	6	14
'Atlas' (Sweden)	0.36	3.11	2.28	5.75	43	69
Mean	0.28	3.80	2.79	6.87	17	31
Temperate-zone adapted:						
'Delta' (Ontario)	0.33	2.10	Tr[3]	2.43	70	92
'Troy' (Montana)	0.15	0.90	0.48	1.53	90	75
'Merion' (Pennsylvania)	0.16	1.20	Tr	1.36	94	91
Mean	0.21	1.40	0.16	1.77	85	86

[1] Visual estimates on 6 June 1975 and 26 May 1976 (means of four replications).
[2] Per cent winterkill during winter 1975-76 of grass stand alive in autumn of 1975.
[3] Trace amount, insufficient for harvestable yield.

be valid measures of relative genetic level of winterhardiness of varieties whether managed for turf, pasture, or two harvests per year for forage production.

Winter Survival

Individual winters in southcentral Alaska differ greatly in array and severity of stresses imposed on overwintering plants. (Klebesadel 1974). The dominant harmful stresses apparently are (a) very low temperatures, especially if they persist over a prolonged period, and (b) widely divergent temperature oscillations that impose repetitive freeze-thaw cycles, especially those with warming temperatures that reach well into the thawing range (40-45° F), persist for several days, and are followed by rapid temperature drop to very low levels.

Marginally adapted, introduced perennial grasses may survive one or a succession of mild winters in this area. However, such grasses almost invariably sustain extensive injury or total winterkill during severe winters. Only the extremely winter-hardy, far-north-adapted grasses are capable of surviving consistently the total gamut of winter stresses.

Observations each spring in the experiments summarized here revealed negligible winter injury in the Alaska variety 'Nugget' and the Icelandic strain 412 (Figs. 1, 2; Table 2). In contrast, the Kentucky bluegrass varieties from more southern areas, 'Delta', 'Park', 'Merion', and 'Newport', almost invariably showed apparent, sometimes severe, winter injury, (Figs. 1, 2). In Experiment I, both 'Merion' and 'Newport' sustained extensive injury during the third winter, and both winterkilled completely during the fourth winter. In Experiment II, 'New-

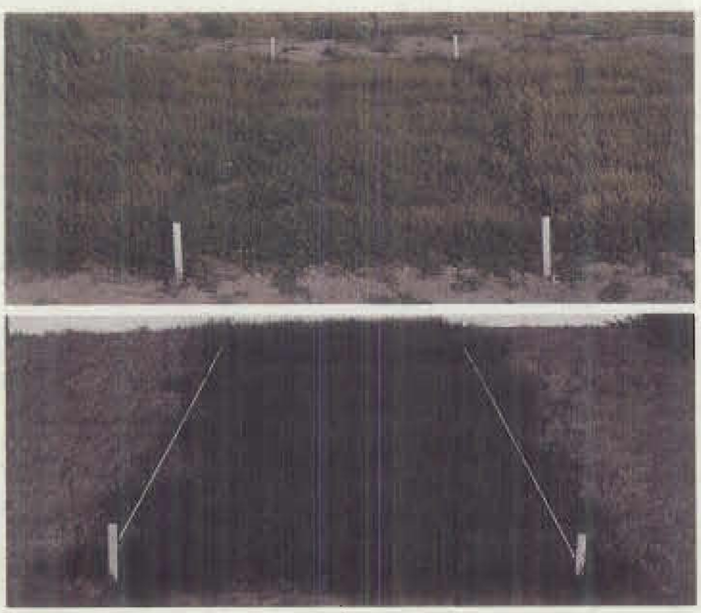

Figure 1. Relative winterhardiness of three Kentucky bluegrasses from diverse origins: (left) 'Newport' from 'Oregon' (center). 'Nugget' from Alaska, and (right) 'Merion' from Pennsylvania. Top photo shows plots on 26 September that had been planted 18 June of the same year. Lower photo shows same plots three years later on 22 June; following that severe winter, temperate-adapted 'Newport' and 'Merion' were severely winter-injured while northern-adapted 'Nugget' showed little injury.

Figure 2. Comparative winter survival at the Matanuska Research Farm of (left) temperate-adapted 'Delta' Kentucky bluegrass selected at Ottawa, Ontario (45.5°N.), and (right) a subarctic-adapted selection of Kentucky bluegrass from Iceland (65 ± 1.5° N.). Photo taken 5 June; plots planted 19 June of the previous year.

port' stands suffered extensive winterkill during the first year, too extensive to permit appreciable recovery during subsequent years.

In Experiment III (Table 2), 'Atlas', from Sweden, sustained greater winter injury than the other northern-adapted strains. Despite the north-latitude location of Sweden, the winter climate there is considerably milder than that of the Matanuska Valley, permitting culture of many crops inadequately winterhardy for use in southcentral Alaska. Such winters impose too little stress to select varieties sufficiently winterhardy for consistent injury-free survival here.

The present results agree with earlier findings (Klebesadel et al. 1964) that showed poor winter survival of 'Atlas' and two other varieties of Kentucky bluegrass from Sweden ('Fylking' and 'Skandia II'); the poor survival of the Swedish varieties in that earlier test, as in Experiment III, was more similar to performance of varieties from Canada and the conterminous 48 states than to Alaskan and Icelandic strains.

These results agree generally with those of Håbjörg (1979b) in Norway who grew over two dozen varieties and strains of Kentucky bluegrass from an array of geographic sources, at six widely separated localities differing in altitude, latitude, and, hence, prevailing climate. He found that midtemperate-zone-adapted strains survived winters poorly when grown at higher latitudes. Most grasses performed best when grown under climatic conditions that approximated those of their area of origin. Moreover, maritime types from 61° to 64° N, such as 'Nugget', showed the widest adaptability to the various climates encountered in arctic, maritime, and continental localities, and at the different test-site altitudes.

Forage Production

Forage yields of all grasses were meager in 1969, the first full-harvest year of Experiment I, due to unusually droughty conditions. This contributed to the abnormally low, first-cutting, mean forage yields of the first harvest year (Table 1).

Grass varieties that survived winters best also produced highest forage yields (Tables 1, 2). 'Nugget', the most winterhardy Kentucky bluegrass in Experiments I and II, produced highest yields, averaging 3.37 tons of oven-dry herbage per acre per year over the 10 harvest years in the two tests. In Experiment III, the northern-adapted Icelandic selection differed little in forage yields from 'Nugget', the two averaging 3.60 tons dry matter per acre per year.

Forage yields of 'Newport', the least winterhardy variety of Kentucky bluegrass in Experiments I and II, were extremely low (Table 1); the varieties ranked as follows in decreasing forage productivity over the full term of both tests: 'Nugget', 'Park', 'Delta', 'Merion', 'Newport'.

On a field scale, the full potential of Kentucky bluegrass as a harvested forage would not be realized through a mowing-raking-baling manner of harvest, as much of the short leaf growth would be lost. To recover maximum herbage yields, as is accomplished by hand-raking in the small-plot studies reported here, the vacuuming effect of a flail-type forage harvester would be required.

An undesirable characteristic of Kentucky bluegrass for use as pasture or harvested forage in more southern areas with hot summers is the tendency of plants to become dormant and unproductive during hot, dry periods (Fergus and Buckner 1973, Smith 1981). In those areas, the grass is most productive during the cool, moist weather of spring and autumn. Summers in southcentral Alaska are relatively cool; therefore, Kentucky bluegrass does not become "summer dormant," and continues to produce herbage actively throughout the growing season. The good forage yields of hardy strains in these tests (Tables 1, 2) and other evaluations made at Palmer (Mitchell 1972, 1982a) confirm that adequately fertilized Kentucky bluegrass can be very productive as a pasture species in this environment throughout the entire growing season.

Turf Quality

Plots used in the experiments reported here were not maintained as turf; however, all Kentucky bluegrass varieties compared, except 'Troy', are considered excellent turfgrasses when grown where they are adapted (Hanson 1972). 'Troy' from Montana, is a tall, erect-growing, pasture-type variety. Strain 412, from Iceland, was planted on the headquarters grounds of the Agricultural Experiment Station in Palmer and has persisted there as a dense, winterhardy turf (Klebesadel and Taylor 1972) for over 20 years.

Several characteristics of grasses contribute to high quality turf. These include density, winterhardiness, growth habit, color, texture, uniformity, wear tolerance, and persistence. Of these, winterhardiness is of primary importance in far-northern areas (Håbjörg 1979b) for without dependable winterhardiness other characteristics of a turf are irrelevant. Winter-damaged turf becomes unattractive, invaded by weeds, and intolerably time-consuming and expensive if frequent partial or total re-establishment becomes necessary. Consequently, in southcentral Alaska only the most winterhardy strains should be selected for use.

Other Bluegrass Species

Big bluegrass (*Poa ampla*) is a bunch-type, drought-resistant perennial, native throughout the western U.S. (Fergus and Buckner 1973, Hanson 1972), but not in Alaska. It is not used for turf but is valued as a palatable pasture grass (Hanson 1972). The species was first evaluated experimentally in Alaska in plantings in 1940 and 1942 at the Matanuska Research Farm. Source of seed used is not known, but it was rated "an excellent pasture grass and quite hardy" (Irwin 1945).

The big-bluegrass variety 'Sherman' was included in Experiment I (Table 1). In that test, it survived two winters, producing only modest forage yields, and succumbed during the third winter. In another experiment, not discussed here since it contained only two bluegrasses, 'Sherman' sustained total winterkill during the first winter (Fig. 3). 'Sherman' big bluegrass, like 'Newport' Kentucky bluegrass, originated in Oregon, located far south of Alaska and lacking in winter stresses that select for high levels of winterhardiness. As such, both are poorly adapted for use in Alaska.

The discrepancy between the present results and the earlier, more promising results with big bluegrass at this same location is somewhat perplexing. It is possible that seed for the

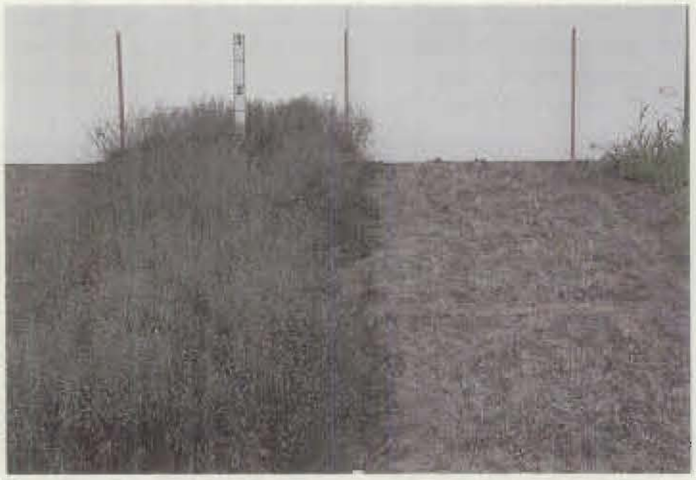

*Figure 3. Comparative winter survival at the Matanuska Research Farm of (left) subarctic-adapted 'Nugget' Kentucky bluegrass (*Poa pratensis*), derived from a collection near 61° north latitude and (right) temperate-adapted 'Sherman' big bluegrass (*Poa ampla*), a variety originating from native collections in Oregon (45.5° N.). Photo taken 21 June; plots planted 15 June of the previous year. Numbers on stake indicate height in feet.*

Figure 4. Comparative heading on 6 July in stand of (left) temperate-adapted 'Merion' Kentucky bluegrass and (right) subarctic-adapted 'Nugget' Kentucky bluegrass planted in June of the previous year at the Matanuska Research Farm. Panicles per square foot: 'Merion' = 22, 'Nugget' = 466.

earlier plantings reported by Irwin (1945) may have originated in an area that conferred greater winterhardiness than the northern-Oregon source of 'Sherman'.

Salt bluegrass (*Poa eminens*) is a tall, coarse, rhizomatous bluegrass native to coastal areas of British Columbia, southern and western Alaska, northeast Asia, and Labrador (Hultén 1968). Seed used in the test reported here was collected on tidal flats in the Matanuska Valley.

Winter survival of salt bluegrass was good throughout the full 6 years of the test, and forage yields approximated those of the highest-yielding varieties of Kentucky bluegrass (Table 1). Considerable lodging of the lax, succulent aerial growth occurred, however. At all harvests, salt bluegrass was several per cent higher in moisture than the mean of the Kentucky bluegrasses compared. Lodging of the salt bluegrass probably would not have occurred at lower levels of nitrogen fertilization. Further tests should be conducted with this species, for it may be found useful in lowlands or other areas too moist for good growth of standard cropland forage grasses. Furthermore, its natural habitat suggests that it may be tolerant of saline conditions.

Production of Seed Heads

The production of seed needed to plant bluegrass is a specialized industry. Some seed of the Alaskan-adapted variety 'Nugget' is grown outside the state and imported for planting. However, a small but vital in-state seed-growing industry has been developing during recent years.

For economic success, seed growers must follow management procedures that maximize production of seed heads. Comparisons of planting dates revealed that early planting is mandatory for maximum production of bluegrass seed heads the following year (Klebesadel 1976). The late-summer and autumn pattern of changing daylength/nightlength prior to winter has been found to exert a major influence on numbers of bluegrass seed heads produced the following year (Klebesadel 1971, 1973). Hodgson (1966) in Alaska and Håbjörg (1979a) in Norway have reported that subarctic and arctic-adapted bluegrasses produce well-differentiated floral primordia prior to winter; these overwinter in unelongated tillers, then develop into panicles that emerge to produce seed the following year.

Bluegrass grown for seed production normally is planted in rows that gradually coalesce during the first few years after planting as the grass spreads vegetatively. An interesting comparison was noted, however, in broadcast-seeded plots of Kentucky bluegrasses, between subarctic-adapted 'Nugget' and temperate-zone-adapted 'Merion' (Fig. 4). Profuse heading occurred the first year after planting in Nugget, while less well-adapted 'Merion' headed sparsely. This suggests that an alternative scenario may be available to Alaska seed growers who normally employ only row seedings.

Some plantings could be broadcast-seeded to produce a single crop of seed during the first year after planting (broadcast seedings head poorly in later years, as do row seedings that have coalesced to form a sod). Following seed harvest, close mowing could be initiated to develop a turf to be marketed as sod.

Bluegrass Maladies

A problem called "silvertop" or "white-top," believed caused by an insect, can cause serious losses in seed production of many grasses in Alaska, including bluegrasses. Affected seed heads emerge but turn whitish and produce no seed due to injury inflicted near the top node of the stem. Incidence of silvertop is usually most prevalent in older stands of grass, but can occur in new stands as well (Fig. 4). This problem occurs also in the northcentral and Pacific northwest areas of the U.S. (Fergus and Buckner 1973).

Certain plant diseases are of significance to bluegrass growers. *Rust* and *powdery mildew* can infect bluegrass foliage, reducing quality for forage or turf purposes. Some growing seasons are more conducive than others to development of these diseases, and varieties differ in susceptibility (Fergus and Buckner 1973, Hanson 1972). The best way to avoid these diseases is to use varieties genetically resistant to these pathogens.

Snowmold causes injury or death to plants beneath the snow, and its effects can easily be mistaken for, or may add to, actual winter injury. Snowmold pathogens are believed to be most active and injurious to overwintering plants in late winter during the snowmelt period. Bluegrass varieties differ somewhat in susceptiblity, and certain fungicides applied prior to winter offer some protection (Kallio 1966). Incidence of snowmold varies from year to year. It occurs most frequently in areas with a heavy snow cover that remains all winter; conversely, it is seldom a problem in areas where strong winter winds often remove the snow cover.

Conclusions

Inadequate winterhardiness is the principal deficiency preventing dependable culture in Alaska of most of the perennial grasses used elsewhere in the world for turf, pasture, harvested forage, or soil cover to prevent erosion. Only a few grass species possess the requisite winterhardiness for dependable use in subarctic Alaska. However, within each of those species, especially those growing over a long north-south range that encompasses our latitude, there may be northern-adapted regional strains, varieties, or ecotypes well suited for use in Alaska, while more southern-adapted regional strains or varieties, even within the same species, may be totally unsuited for dependable culture here, due to poor harmony with north-latitude climatic influences and, hence, possessing inadequate winterhardiness (Klebesadel et al. 1964, Mitchell 1982a).

Kentucky bluegrass represents a species with a considerable range of adaptation (Fergus and Buckner 1973, Hultén 1968). Within such plant species, populations called regional strains or ecotypes evolve through natural selection to a high degree of compatibility between genetically governed physiological functions and the prevailing climatic pattern of the area.

However, when seed is taken from one environment and planted in an area with different climatic conditions, the evolved plant/environment harmony is violated to some degree, often resulting in suboptimal plant performance in the new, unaccustomed environment (Håbjörg 1979 a,b; Klebesadel 1971, 1973; Klebesadel et al. 1964).

The present results reveal that, for best performance in Alaska, bluegrass should be either (a) indigenous to the area (as 'Nugget'), or (b) from other north-latitude areas of the world characterized by severe winter conditions (e.g., 412 from Iceland). These results indicate that 'Atlas', a variety from Sweden, the latitude of which is generally similar to Alaska but which has a milder winter climate, does not possess sufficient winterhardiness for best survival in southcentral Alaska. Similarly, the varieties 'Park' and 'Troy', originating in Minnesota and Montana, respectively, are from areas which have relatively severe winter climates but which are considerably south of Alaska. Hence, when grown in Alaska, far north of their origins, they are exposed to unaccustomed seasonal photoperiodic patterns that differ with latitude; such plant/environment disharmony is known to predispose plants to suboptimal performance (Håbjörg 1979 a,b; Klebesadel 1971, 1973).

The forage yields of Kentucky bluegrass indicate that, with adequate fertility, adapted strains can be highly productive as pasture grasses in this environment where summer dormancy is not a problem. 'Sherman' big bluegrass is poorly adapted for use in this area. However, the winterhardiness and forage production potential of native salt bluegrass suggests that it may be useful in certain situations. ▫

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Do "Slow-Release" Nitrogen Fertilizers Have an Advantage for Lawn Fertilization in Southcentral Alaska?

By

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"Slow-release" fertilizers are generally regarded as those which supply their nitrogen (N) over a relatively long period of time to provide a constant supply for plant growth. They also prevent the loss of N by leaching from sandy soils containing little organic matter in high-rainfall areas.

Materials and Methods

A simple block experiment with six replications and five N sources at two rates (100 and 150 lb N per acre per year) was established in the spring of 1979 on the bluegrass lawn of the Palmer Research Center of the Alaska Agricultural Experiment Station and continued through 1982. Three N sources regarded as "slow-release" fertilizers were compared with ammonium nitrate and urea to determine if slow-release fertilizers would prolong the period of a desirable green color. In addition to the N, all plots received 100, 80, and 90 lb P_2O_5, K_2O, and S respectively per acre each year.

One of the slow-release fertilizers was Regular Super Park and Green with Organiform. This is a 15-4-8 fertilizer containing 9 per cent sulfur, 3 per cent iron, 0.1 per cent manganese, and 0.1 per cent zinc made from "organiform, ureaformaldehyde, hynite leather meal, muriate of potash, ammonium sulfate, sulfa soil, superphosphate, and ammonium phosphate." This fertilizer provides a variety of N sources that differ in rate of N release, some supplying the element over a relatively long time period.

Another "slow-release" fertilizer used in this study was sulfur-coated urea (SCU) which is 38-0-0, containing 12 per cent sulfur, supplied by the Tennessee Valley Authority. The individual SCU granule consists of an inner urea granule coated with elemental sulfur, coated in turn with wax containing a microbicide. Nonuniform coatings among granules result in the release of urea at varying time periods after contact with water; i.e., granules with imperfect coatings release N first and those with the thickest coatings release N last.

The third "slow-release" fertilizer used (ureaform 38-0-0) is composed of a series of low-solubility and water-insoluble carbon-nitrogen units known as methyleneureas. These are formed by reacting urea with formaldehyde under controlled conditions and in prescribed proportions. The final product contains 27 per cent water-insoluble N and 11 per cent N soluble in only a large amount of water. The N in ureaform is released to growing plants by soil bacteria.

A composite soil sample taken in 1979 over the area prior to applying the fertilizers had a pH of 6.0 and showed 14, 18, and 500 lb per acre of available N, P, and K, respectively. Each of the N sources, together with the uniform P, K, and S were topdressed on each 6-by-16-foot plot on 8 May 1979, 9 April 1980, 8 April 1981, and 22 April 1982. During each season the lawn was mowed about once a week through August. No fertilizer was applied other than the spring applications listed above. At intervals each plot was placed into one of four classes visually as to color (0=very yellow; 1=yellow; 2=green, 3=very green). In addition, the average height of leaf blades was measured each year just prior to mowing.

Both visual ratings and height data were subjected to a statistical analysis of variance. Duncan's multiple-range test is used for mean separation.

Results

No interactions between the N source and rate occurred in the data presented in Tables 1 and 3. Tables 2 and 4 present data where interactions between N source and rate occurred.

The data show that N is more quickly released by ammonium nitrate and urea than by ureaform. The rates of N release from organiform and SCU lie between these two extremes.

Grass Color

The differing rates of N release were apparent in grass color throughout the growing season. As noted on 3 June 1980, ammonium nitrate and urea produced a desirable green color; organiform and SCU resulted in slightly yellow grass; and the ureaform resulted in a very yellow color. On 21 May 1982, grass plots that received ammonium nitrate or urea were green, while those receiving SCU and ureaform were yellow; similarly, on 19 May 1980 and 4 June 1982, all grass was a desirable green color except that receiving SCU or ureaform. On 26 May 1981, grass receiving ammonium nitrate or urea was very green; that receiving SCU was slightly yellow; and that receiving organiform

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Table 1. Effect of N source and rate on color visual rating[1] of bluegrass lawn, 1979-1982. Palmer Research Center.

	Effect of N Source[2]					Effect of N rate[3]		
Date	15-4-8 organiform[5]	Sulfur-coated urea[5]	Urea-form[5]	Urea[5]	Ammonium nitrate[5]	100[6]	150[6]	C.V. (%)
4-10-79	1.8bc[4]	2.2a	1.7c	1.9bc	2.1ab	1.6b	2.3a	20.7
10-12-79	1.3b	2.1a	1.3b	1.3b	1.3b	1.0b	1.9a	57.0
5-19-80	1.8c	1.1d	0.8e	2.2b	2.9a	1.7a	1.8a	20.8
6-3-80	1.2c	1.5c	0.1d	1.9b	2.9a	1.4a	1.6a	22.3
7-2-80	2.8ab	2.3c	1.2d	2.6bc	3.0a	2.2b	2.6a	16.4
7-10-80	3.0a	2.7bc	1.8d	2.4c	2.8ab	2.4b	2.7a	14.6
5-26-81	1.1c	1.7b	1.2c	2.8a	2.9a	1.6b	2.2a	22.9
5-18-81	1.7c	1.8c	0.6d	2.3b	3.0a	1.7b	2.0a	21.1
5-26-81	2.5b	2.1c	0.8d	2.6b	2.9a	2.0b	2.4a	16.6
7-6-81	2.9a	2.8a	1.2c	2.5b	2.9a	2.4b	2.6a	13.9
7-23-81	2.8a	2.6a	1.2b	2.7a	2.6a	2.1b	2.6a	16.9
8-5-81	2.6ab	2.8a	1.1c	2.4b	2.6ab	1.9b	2.7a	18.8
9-29-81	0.4b	1.1a	0.2b	0.3b	0.8a	0.3b	0.8a	87.8
5-21-82	1.2b	0.2c	0.5c	1.5b	2.5a	1.0b	1.3a	45.6
6-4-82	2.2b	1.1c	1.0c	2.9a	3.0a	2.0b	2.1a	12.2
6-17-82	2.4b	1.8c	0.5d	2.7a	2.9a	1.7b	2.4a	16.8
6-30-82	2.6ab	2.5b	0.4c	2.8ab	2.9a	2.0b	2.4a	18.8
7-9-82	2.7a	2.6a	0.5b	2.8a	2.8a	2.0b	2.6a	15.6
7-27-82	2.5a	2.1b	0.8c	2.0b	1.8b	1.4b	2.2a	24.1
8-3-82	2.6a	2.6a	1.3b	1.8b	1.7b	1.7b	2.3a	25.7

[1] 0 = very yellow, 1 = yellow, 2 = green, 3 = very green.
[2] Means of 12 measurements.
[3] Means of 30 measurements.
[4] Means within a row for N source or for N rate followed by the same letter are not significantly different at the 5% level of probability.
[5] N source.
[6] Rate: Lb N/A.

Table 2. Interaction of N source and rate on color visual rating of bluegrass lawn, 1979-1982. Palmer Research Center. (Means of 6 measurements)

	7/20/79		6/26/80		7/15/80		5/18/81		5/28/82		6/10/82	
N Source	100[1]	150	100	150	100	150	100	150	100	150	100	150
15-4-8 organiform	1.5b[2]	3.0a	1.0c	1.5c	2.0a	2.8a	0.3c	0.8c	2.0b	2.0b	2.0c	2.8a
Sulfur-coated urea	1.5b	2.8a	1.7b	1.3c	2.2a	2.0b	1.0b	2.2b	0.8c	1.2c	1.3d	2.0b
Ureaform	1.2b	1.7b	0.0d	0.2d	1.3b	1.8b	0.7bc	0.8c	0.3d	1.0c	1.0d	1.5c
Urea	2.3a	2.7a	1.7b	2.2b	2.0a	1.8b	2.0a	3.0a	2.2b	3.0a	2.5b	3.0a
Ammonium nitrate	2.2a	3.0a	2.8a	3.0a	1.3b	2.8a	2.3a	2.5ab	3.0a	3.0a	3.0a	3.0a
LDS 5%[3]	0.7		0.8		0.7		0.2		0.1		0.2	
C.V. (%)	10.5		21.0		24.9		29.3		9.0		14.0	

[1] Lb/A.
[2] Means within a column followed by the same letter are not significantly different at the 5% level of probability.
[3] Means between the two N rates for a specific N source are not significantly different when the difference is less than the LSD for that date.

and ureaform was yellow. On 10 July 1980, all plots showed a desirable green color, although the ureaform plots were more yellow than others. On 4 October 1979, 2 July 1980, and 18 and 26 June 1981, 6 and 23 July 1981, 5 August 1981, 17 and 30 June 1981, and 9 and 27 July 1982, all treatments except ureaform produced grass of a desirable green color (Table 1).

Table 2 also substantiates the different N release rates of the different N sources. On 18 May 1981, at the higher N rate (150 lbs per acre), all N sources but organiform and ureaform produced a desirable green color; at the lower 100-pound-N-per-acre rate, ammonium nitrate and urea produced grass of a desirable green color; SCU and ureaform resulted in yellow grass; and organiform very yellow grass, indicating that at this date little N was available from this source. On 28 May 1982, grass receiving both N rates showed a desirable green color except where SCU or ureaform had been applied. By 10 June 1982, at the higher application rate, all N sources produced a desirable green color except ureaform which produced slightly yellow grass; at the lower rate, all were a desirable green color except that receiving SCU and ureaform. On 26 June 1980, the higher rate of 150 pound N per acre showed ammonium nitrate and urea producing a desirable green color; organiform and SCU

Table 3. Effect of N source and rate on bluegrass height 1979-1982. Palmer Research Center.

	Effect of N Source[1]					Effect of N rate[2]		
Date	15-4-8 organiform[3]	Sulfur-coated urea[3]	Urea-form[3]	Urea[3]	Ammonium nitrate[3]	100[4]	150[4]	C.V. (%)
7-20-79	13.9ab[5,6]	13.1b	11.6c	13.4b	14.7a	12.0b	14.7a	10.5
10-15-79	8.8a	9.6a	9.1a	8.8a	9.0a	8.5b	9.6a	12.6
6-12-80	9.0b	9.3b	7.4c	10.1b	11.8a	9.1b	9.9a	13.2
7-15-80	11.8a	9.9bc	9.3c	10.0bc	11.4ab	10.0b	11.0a	13.6
8-6-80	9.7a	10.1a	9.8a	9.9a	9.3a	9.4b	10.1a	11.1
6-18-81	8.6cd	9.2bc	8.0d	9.5b	11.4a	9.3a	9.4a	11.0
6-26-81	10.6b	9.9b	8.8c	10.8b	12.8a	10.3a	10.8a	9.7
7-6-81	11.2b	10.7b	9.0c	10.8b	12.7a	10.0b	11.7a	13.4
7-23-81	14.1a	11.9c	11.6c	12.6bc	13.8ab	11.7b	13.9a	13.0
6-4-83	10.0b	8.7c	8.3c	10.2b	11.9a	9.6b	10.1a	5.5
6-17-83	11.2bc	11.0c	9.0d	12.2b	15.7a	11.2b	12.5a	10.8
7-12-82	11.8b	11.8b	10.6c	12.6c	14.4a	11.5b	13.0a	8.3

[1] Means of 12 measurements.
[2] Means of 30 measurements.
[3] N Source.
[4] Rate: Lb N/A.
[5] Measurements are given in centimeters.
[6] Means within a row for N source or for N rate followed by the same letter are not significantly different at the 5% level of probability.

Table 4. Effect of N source and rate on bluegrass height August 5, 1981. Palmer Research Center. (Means of 6 measurements).

N Source	100[1]	150
15-4-8 organiform	10.5a[2]	13.7a
Sulfur-coated urea	10.3a	12.3abc
Ureaform	11.2a	10.7c
Urea	10.8a	11.7bc
Ammonium nitrate	10.8a	13.0ab
LSD 5%[3]	0.7	
C.V. (%)	11.4	

[1] Lb N/A.
[2] Means within a column followed by the same letter are not significantly different at the 5% level of probability.
[3] Means between the two nitrogen rates for a specific nitrogen source are not significantly different when the difference is less than the LSD.

yellow; and ureaform very yellow. At the lower N rate, ammonium nitrate, urea, and SCU produced a desirable green color; while organiform was yellow and ureaform resulted in very yellow grass.

On 3 August 1982, all grass but that receiving ureaform was a desirable green; however, grass color indicated that plots receiving ammonium nitrate or urea were running out of N (Table 1). On 29 September 1981, grass receiving SCU was the least yellow, and, on 12 October 1979, only the grass receiving SCU remained a desirable green color.

Usually the higher rate of 150 pound N per acre produced greener grass than did the lower rate of 100 pound N per acre (Table 1). On 20 July 1979, when 150 pounds N per acre was applied, all N sources produced a desirable green, although ureaform grass was slightly more yellow. At the lower rate, all N sources except ammonium nitrate and urea produced yellow grass. On 15 July 1980, when 150 pounds N per acre was used, all N sources produced a desirable green, but at a rate of 100 pounds N per acre, ureaform and ammonium nitrate produced fairly yellow grass. This indicates that most of the nitrogen supplied by ammonium nitrate at the lower rate had been utilized by mid July.

Grass Height

Height measurements taken at intervals agree with the visual evaluations of both nitrogen source and rate. Table 3 shows that, on 2 June 1980, 6 July 1981, and 17 June 1982, grass receiving ammonium nitrate had grown more rapidly than that receiving urea, SCU, or organiform; grass receiving ureaform showed the least growth. On 12 July 1982, the relative growth was: ammonium nitrate > organiform and SCU > urea and ureaform. On 15 July 1980, grass which had received organiform or ammonium nitrate had grown more rapidly than that receiving ureaform. Organiform produced more growth more rapidly than that receiving ureaform. Organiform produced more growth than did SCU or ureaform by 23 July 1981. Generally speaking, growth was most rapid with ammonium nitrate and least rapid with ureaform, particularly for the 20 July 1979 and 18 June 1981 sampling dates at both N rates and for the 5 August 1981 (Table 4) sampling date at the rate of 150 pounds N per acre. On 15 October 1979 and 6 August 1980, at both N rates, and on 5 August 1981, at the lower 100-pound-N rate, no significant differences in grass height occurred. This further indicates that the applied N from all N sources was all utilized by this date.

Conclusions

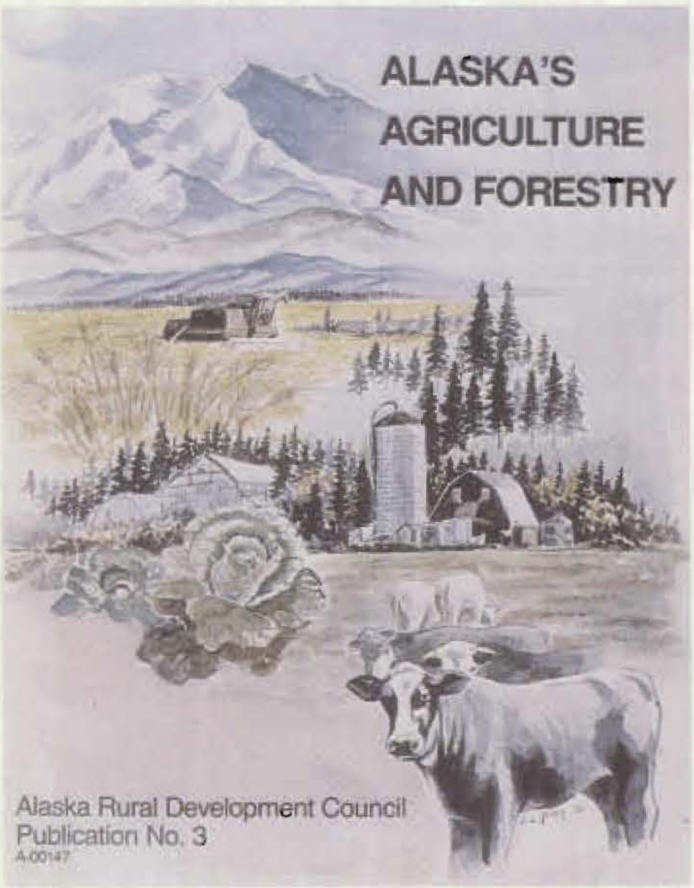
With the exception of ureaform, all of the N sources used produced grass of a desirable green color. Although both ammonium nitrate and urea caused the grass to grow a bit more rapidly, particularly at the beginning of the season, the additional growth does not appear excessive at either N rate. Only in 1981 was there an indication that one "slow-release" N source (SCU) prolonged the desirable green color well into October.

Thus, this particular experiment shows no advantage of using the markedly more expensive "slow-release" fertilizers under these conditions. Ordinarily, insufficient rain falls in the Palmer area to cause leaching of soluble N from the effective rooting zone of the grass.

The 150-pound-N-per-acre application appears adequate when one yearly application of ammonium nitrate or urea is made in the spring. To secure a longer period with grass of a desirable green color with the minimum growth rate, the application of 80 to 100 pounds N per acre as ammonium nitrate or urea in the spring followed by another 50 to 70 pounds per acre shortly after 1 July, should ensure season-long, dark green color and good, but not excessive, growth of lawns. Nitrogen applications after the middle of July would not be desirable and might stimulate grass growth too late in the season to allow it to store up reserves for good winter survival. ▫

Note: Cooperative investigation of Agricultural Research Service, U.S. Department of Agriculture; and the University of Alaska Agricultural Experiment Station. The use of trade names implies neither endorsement nor criticism of these or of other products not mentioned.

Cooperative Extension Service Publishes Major Report



Available from Cooperative Extension Service

A major report on two of the state's most important renewable resources, entitled *Alaska's Agriculture and Forestry*, was published in December 1983 by the Cooperative Extension Service, University of Alaska. The 8½x11-inch, soft-cover book contains 220 text pages and three 1:5,000,000-scale maps in color. Its price is $9.00, plus postage.

Copies of *Alaska's Agriculture and Forestry* are available for purchase at Cooperative Extension Service district offices in Anchorage, Palmer, Soldotna, Homer, Kodiak, Bethel, McGrath, Fairbanks, Delta Junction, Nome, Juneau, Sitka, and Ketchikan. They can also be ordered by mail from Cooperative Extension Service, University of Alaska, Eielson Building, Fairbanks, AK 99701.

The book begins with a brief history of agriculture in Alaska from the time of the Russian occupation in the late 1700s to the start of an agricultural-development project near Delta Junction in 1978.

Efforts to develop agriculture in Alaska are compared with agricultural development in other northern areas such as Norway, Finland, Denmark, and Russia; and the effects of political and social considerations on agriculture in those countries are discussed.

A chapter on agricultural lands in Alaska states that, of the 20.5 million acres of land with potential for cultivatable crops, only about 3 million acres are available for farm development in the near term because of limitations in facilities for the transportation, processing, and marketing of farm commodities and the withdrawal of potential agricultural cropland for other uses. The general location and ownership of agricultural land that merits serious consideration for development by the year 2000 are identified in the chapter.

Another chapter is devoted primarily to a description of the 20.5 million acres of soils with potential for cropland development in Alaska. These soils were identified in *Exploratory Soil Survey of Alaska*, a report published in 1979 by the USDA Soil Conservation Service. The chapter includes information on 200 million acres of soils with rangeland potential rated as good or fair for reindeer or caribou, 195,000 acres rated as good for sheep and cattle and 18.4 million acres rated as fair for sheep and cattle. The chapter is augmented by two 1:5,000,000-scale maps, in color, entitled "Soils with Agricultural Potential and Alaska's Transportation System" and "Soils with Rangeland Potential."

A chapter describing soil fertilization in Alaska includes an extensive list of references to provide readers with opportunities for further study.

Summaries of current knowledge of climatic conditions and water resources of the major agricultural areas of the state and a summary of statistical data on production of crops and livestock from 1960 through 1982 are presented in text, tables, and graphs.

Alaska's Agriculture and Forestry provides descriptions of the status and potential of the state's principal agricultural crops — small grains, forages, potatoes, cool-season vegetables, and grass seed — and on its oilseed crops, fruit and honey production, greenhouse cultivation, and ornamentals industry.

A chapter on Alaska's rangelands includes a review of the literature of rangeland research in the state. Historical and technical information are presented and/or referenced. Each of the four major zones of rangeland in Alaska — coastal forests, boreal forests, arctic tundra, and marine grasslands — are described in terms of their geographical extent; topography, climate, and soils; vegetation; grazing seasons; range carrying capacities; and limitations.

Reports by several authors on the status and potential of livestock in Alaska are included in a chapter on animal production. Alaska's reindeer are described in terms of history and land policy, range, reindeer potential versus game and nongame species, problems of herding, and management and marketing. Sixteen million acres of reindeer rangeland have been mapped on the Seward Peninsula, and there is additional rangeland suitable for reindeer in other parts of the state. However, authors state that conflicts in policies involving the management of rangeland for reindeer and caribou must be resolved before the industry can reach its full potential.

The recent stimulation in hog production in Alaska is traced to the transfer of technology from other states to Alaska for raising pigs in confinement and the increased availability of locally grown barley in interior Alaska. The report states that Alaska's dairy industry also uses environmentally controlled barns and is growing with expanded feed-grain production and increased opportunities for farming. The potential for beef production is assessed based on available data. Authors note that the successful expansion of Alaska's livestock industry will depend on developing the total system for producing, processing, transporting, and marketing agricultural products.

A comprehensive chapter on forestry in Alaska is accompanied by a 1:5,000,000-scale map in color that depicts forested areas of the state. The chapter includes a general description of Alaska's coastal and interior forests, the status of forest resources and management practices, action needed to foster forestry and development of a forest-products industry, and farming and forestry interactions.

Federal and state land-disposal programs, financing, farm management, marketing, and the role of government are explored in a chapter on economic factors in Alaska's agricultural development.

The final chapter describes the transportation system in Alaska and its significance to the state's forestry and agricultural industries.

Alaska's Agriculture and Forestry was edited by Laurie McNicholas, editorial specialist, Cooperative Extension Service; project director was Sig Restad, assistant director, Agricultural Experiment Station, Palmer. *Alaska's Agriculture and Forestry* was prepared through the cooperation of the University of Alaska and nine Federal and state agencies, thirty authors, and the Alaska Rural Development Council (ARDC). The council was organized in 1969 and currently has a membership of fifty-nine state, Federal, and local government agencies and private organizations.

The council's goals are to broaden the understanding of Alaska's rural-development potentials; to increase awareness of technical and development resources of the state; to improve coordination between agencies; and to assist in the coordination of community, regional, and statewide development programs.

ARDC's first publication, *Alaska's Agricultural Potential*, was published in 1974. During the past decade, land-ownership patterns have changed significantly; the state has stepped up its program to transfer land into the private sector and its support for the development of agriculture; and the market for agricultural products has changed. These events and an ever-increasing need for information about Alaska prompted ARDC to organize the preparation of this sequel to its first publication.

Alaska's Agriculture and Forestry is designed to be useful to Alaskan leaders; to community, regional, and statewide planners and administrators; and to farmers, foresters, and others who are concerned about renewable-resource development. In addition, youths involved in education programs in Alaska comprise a significant potential audience for this publication. ▫

Publication List for 1983

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Notes . . . *continued from page 4*

year of graduate study in zoology at Washington State University, Pullman, and is continuing her graduate studies in engineering and science management at the University of Alaska, Anchorage. Mary Lou's research interests are primarily in animal nutrition. She is a member of the American Dairy Science Association and the American Society of Animal Science, and has coauthored publications in their journals.

Mary Lou joined the animal science program at Palmer in 1981 as an assistant in nutritional research on the utilization of marine byproducts by dairy cattle under the Sea Grant Program. Currently, she is working with Dr. A.L. Brundage, professor of animal science, to evaluate the use of barley straw and salmon meal in dairy rations. They also work together on a long-term project to evaluate the consequences of single-trait selection for milk production in dairy cattle breeding. Her other responsibilities include being assistant manager of the Matanuska Valley Breeders Association and coordinating the university's feed-testing program between the Cooperative Extension Service and the Agricultural Experiment Station. As a contact person for the university's computer network, she keeps Palmer's computer terminals on-line and fully operational and assists other Palmer staff members with terminal and computer use. Mary Lou maintains an active interest in Alaska's livestock industries, and for the last two years she has evaluated carcasses for the Alaska State Fair Junior Market Livestock Program to assist 4-H members and leaders in their efforts to produce quality meat for Alaskan consumers.

Dr. Donald H. Dinkel, who retired recently from the Alaska Agricultural Experiment Station, has been awarded emeritus recognition. Such recognition is given to retired faculty members as a recognition for outstanding service to the university during their employment. Dr. Dinkel received resolution conferring the emeritus recognition at the May 8 commencement ceremonies.

Dr. Dinkel was honored as professor of plant physiology, emeritus. Dinkel worked for the university from 1960 to 1966 and returned in 1968. His research efforts have been largely directed to improving the selection of vegetable and flower seed varieties for Alaskan farmers and gardeners. One of his best-known research efforts was growing roses utilizing simulated waste heat such as that from a power plant. He is a graduate of the University of Minnesota and has a doctorate from the same university. He and his family now live in the Matanuska Valley.

Dr. Glenn Juday, visiting associate professor and ecological reserves coordinator, has been named coordinator of the Rosie Creek Fire Research Project. This project was launched unofficially within days of the catastrophic forest fire in late May and early June. The project was funded in late August and is designed to learn the effects of fire of varying severity on productive white spruce and hardwood forests and to devise effective reforestation techniques.

The Rosie Creek Fire began in late May of 1983 about ten miles west of the Fairbanks area when it spread out of control from a small fire started in land-clearing debris. It eventually covered 8,600 acres of forest, including a considerable amount of valuable commercial white spruce forest. Even though prime standing timber, reforestation units, and one-third of the Bonanza Creek Experimental Forest (see *Agroborealis*, Vol. 14, 1983) were burned, many important research opportunities were created.

As researchers and managers evaluated the damage and planned what to do next, a plan for a model research project on fire effects and reforestation in productive white spruce forest evolved, and the Alaska state legislature appropriated funds to support the research. As the importance of the project was realized, the USDA Forest Service reprogrammed research in progress and added new funds. Several University of Alaska faculty made important contributions as well. A well-coordinated team formed, focused on the two-fold task of gathering the most knowledge and completing the most reforestation with the resources available. The Agricultural Experiment Station has provided the coordinator for the project, as well as staff resources at its Forest Soils Laboratory and in its Forest-Management Program. The Division of Forestry is providing field workers, reforestation materials and crews, and administrative support.

Research got underway quickly, in some cases while the ashes were still warm. These early projects included a look at nutrient status and movement in the soil, bark beetle and other insect buildup after the fire, seedfall from surviving trees, a rating system to evaluate chances for survival of partially burned trees, monitoring of soil stability in severely disturbed areas, and natural revegetation. Some early results are already observable. Hardwoods sprouted vigorously, even those burned severely; these stands won't need to be regenerated if the new growth remains free of defect-producing disease. Wood-boring insect populations built up rapidly, and may be a major factor in the 1984 growing season. Soils stayed in place and nutrients were immobile in the dry early and midsummer. A wet August caused an intense burst of nutrient availability, stimulating the development of a dense carpet of ground herbs and shrubs; the seeds of some plants germinated after 160 to 180 years of dormancy. No major erosion problems developed, even after heavy rains. Spruce seedfall was delayed by a cool, wet August, but was abundant where remnant trees survived.

Clearly, new white spruce seedlings will face a major challenge from competing vegetation. Solving this problem will be important, because natural regeneration is much less expensive than planting nursery-grown trees. Maintaining the native gene pool is important as well. Future research will involve stand-spacing studies, wood-product salvage, establishment of an on-site weather station, wildlife research aimed at understanding the response of furbearer prey species, and site-preparation techniques. Most of the projects will require three to five growing seasons in order to obtain meaningful results. In the next few years, forest land managers will be able to obtain some extremely valuable results for making decisions about what to do after a large fire burns through productive upland forest in Alaska's taiga.

Dr. William D. Steigers, Jr., is principal investigator of several studies investigating the habitat values for moose of vegetation communities in the Middle Susitna River basin. Under subcontract to the prime contractor to the Alaska Power

Authority, the Agricultural Experiment Station at Palmer is participating in studies designed to investigate the impacts on moose of the proposed Susitna Hydroelectric Project northeast of Talkeetna. Studies underway or completed during 1983 include completion of a final report for summer 1982 studies, research on plant phenological development in the proposed impoundment areas, and studies on the cost effectiveness of methods to sample moose browse.

A major contract report for 1982 summer studies was completed during April. A preliminary inventory of the availability of browse was conducted for ten vegetation types considered important for moose. The purpose of this research was to document the availability and presence or absence of both summer and winter forage for moose. This information has added to our knowledge of the vegetation composition of the many vegetation types of the Middle Susitna River basin. A similar study in the Alphabet Hills east of the Upper Susitna River was also conducted. This research was designed to inventory the vegetation composition and to assess the area's importance to moose. This inventory was in preparation for a controlled burn by the Bureau of Land Management to increase the habitat values for moose. Documentation of the response of the vegetation to burning and the resultant increase in habitat values is expected to provide valuable knowledge that could be used in the Middle Susitna River basin in the event controlled burning is considered as a mitigation option.

A third study concerned the early-spring development of vegetation along the slopes of the Susitna River Canyon. Early spring can be the most critical time of year for survival of moose. The first growth of new vegetation can be especially important to pregnant cow moose, as well as bears just coming out of their winter dens. The phenology study investigated the effects of elevation, slope, aspect, and types of vegetation present on plant development to make preliminary determinations on what types of plants are the first to initiate green growth in the spring.

Because continuing research on both moose and bear indicates that early-spring plant growth may be especially important to these animals, plant phenology studies were continued during early spring 1983. The results of these recent studies will be used to draw conclusions about the locations in the impoundment zone where new green growth first become available. These locations will then be compared to known local concentrations of moose to determine if they coincide at that time of year. These studies will assist in the final determinations of the relative importance of the impoundment zones and slopes of the Susitna River canyon to moose and bear.

A second study during 1983 was initiated to determine the most cost-effective methods to be used for a large-scale inventory of winter browse planned for summer 1984. The results of this study will recommend the most efficient methods for sampling moose browse while providing the most valuable and useful information for statistical confidence. Pilot studies of this nature assist researchers in maximizing data collection and data quality for large-scale projects while minimizing the cost to the state of Alaska.

Gena Marie Delucchi, School of Agriculture and Land Resources Management 1983 outstanding student, received a Master of Science degree in December. Her degree is in Natural Resources Management and was awarded by the University of Alaska-Fairbanks. In addition to her being 1983 Outstanding student, Ms. Delucchi was also the recipient of a graduate fellowship in resource problems from 1981 through 1983.

She received her B.S. in Agrarian Studies from the University of California-Davis in 1978. Her master's thesis project is entitled "Effects of Broadcast and Band Applications of Three Phosphate Carriers on Barley Growth and Yield in Interior Alaska;" her graduate studies were supervised by Dr. Frank Wooding, professor of agronomy, Alaska Agricultural Experiment Station. Ms. Delucchi looks forward to her continuing involvement in Alaskan agriculture and plans to pursue a career in agricultural advising.

Dr. Wayne Thomas, professor of economics was selected by the United Nations Environmental Programme to participate in a study conference on agriculture and climate. The conference was held in Villoch, Austria. While in Austria, Dr. Thomas visited the International Institute for Applied Systems Analyses (IIASA) in Saxenburg. At IIASA, he discussed agriculture in cold regions with colleagues from Canada, Iceland, the United Kingdom, and Peru.

Dr. Warren Musgrave visited the School of Agriculture and Land Resources Management (SALRM) for two weeks in early December. He was collaborating with **Dr. Wayne Thomas**, professor of economics, on a study of the agricultural-policy process for the federal systems of Australia and the United States. The study was begun in Australia during 1980 when Dr. Thomas visited the University of New England in Armidale, New South Wales, where Dr. Musgrave is professor of agriculture economics. Travel funds for Dr. Musgrave's visit to Alaska were provided by the office of the Vice Chancellor for Research, University of Alaska-Fairbanks.

Dr. Robert Weeden, professor of resource management, School of Agriculture and Land Resources Management, UAF, has been appointed head of the Wildlife-Fisheries Program, Division of Life Sciences. His appointment became effective September 27.

Dr. A.L. Brundage, Professor of animal science at the Palmer Research Center, was elected chairman of the North Central Regional Technical Committee, NC-2, Improving Dairy Cattle through Breeding, with Special Emphasis on Selection, during their annual meeting at Michigan State University in October. The NC-2 research project in dairy cattle breeding has continued with periodic modification of goals and objectives since the first meeting in 1948. Since that time it has included some of the outstanding scientists in genetics and dairy-cattle breeding of North America in its membership. In addition to the north central states (Illinois, Indiana, Iowa, Kansas, Minnesota, Michigan, Nebraska, Ohio, South Dakota, and Wisconsin), Alaska, California, Washington, New York, and Canada all have research projects contributing to NC-2. Alaska's current contributing project was initiated by Dr. Brundage in 1968 to study the consequences of single-trait selection for milk production.

The first sixth-generation calf in this project was born in December of 1983. The 1975 meeting of NC-2 was held at the University of Alaska in Palmer and Fairbanks. The 1984 meeting will be held at the Ohio State University.

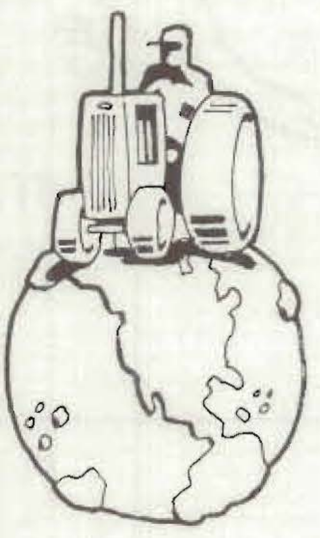
Dr. Glenn Juday, visiting associate professor and Alaska ecological resources coordinator, has been elected to a three-year term on the Board of Directors of the Natural Areas Association (NAA). The NAA is comprised of professionals whose job it is to select, describe, and manage small and moderate-size tracts of undisturbed land for research, education, and conservation — especially conservation of endangered species.

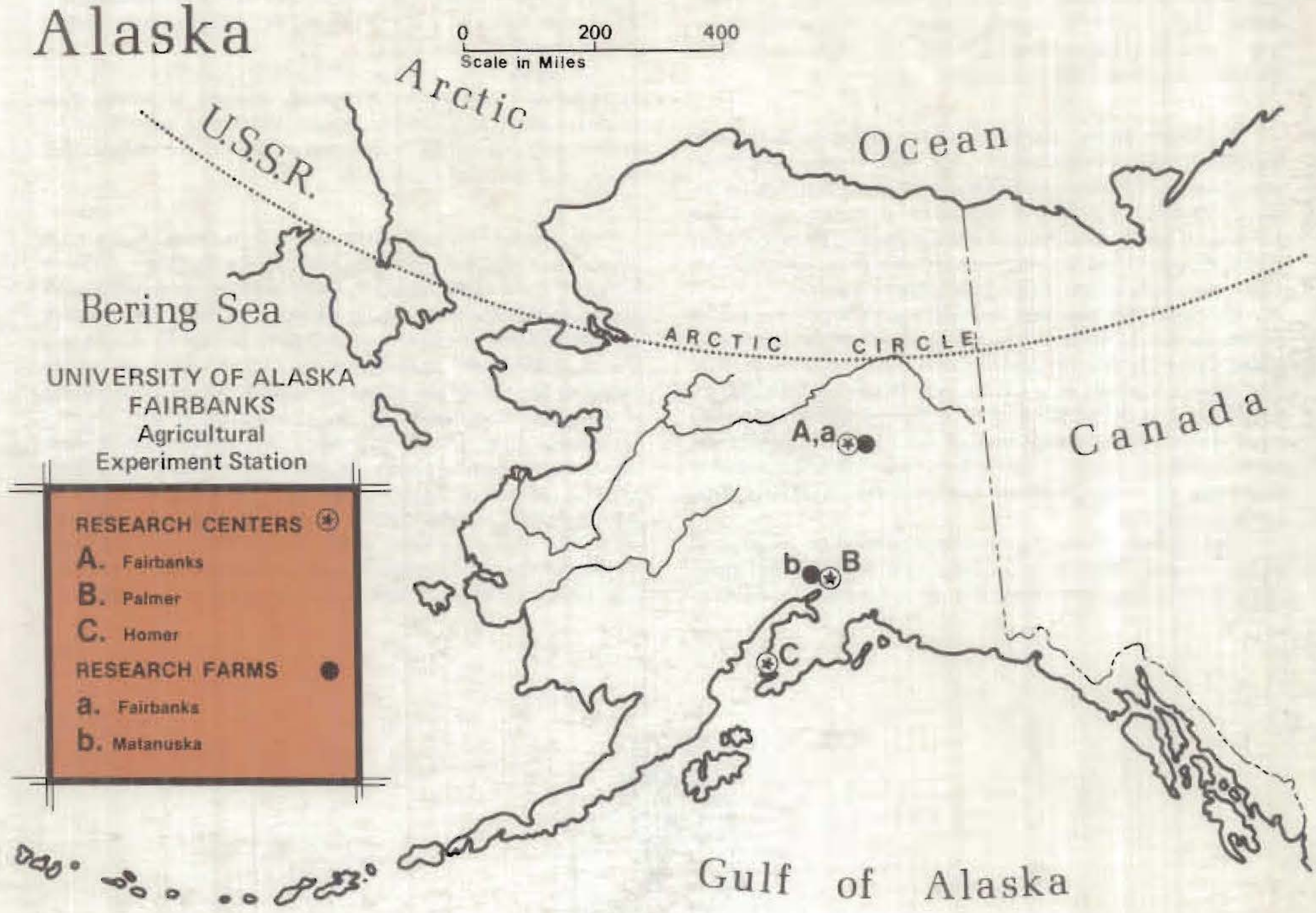
Dr. Juday has also been awarded a contract by the USDA Forest Service to document environmental baseline at the proposed Columbia Glacier-Granite Cove Research Natural Area. The project is aimed at a better understanding of the current environment at the terminus of the Columbia Glacier before the rapid retreat of the glacier changes the area. This may be the last deglaciation event of its kind in North America in that it is the last tidewater glacier on this continent to undergo catastrophic retreat.

The Central Yukon Planning area is another location of which Research Natural Areas have been selected and documented. Dr. Juday undertook this work through a grant from USDA Forest Service and the Bureau of Land Management. Field work included a look at dunes, hot springs, alpine tundra, pingos, and freshwater lakes.

Dr. Juday was a member of the U.S. delegation to the first International Congress on Biosphere Reserves in Minsk, Byelorussia, USSR in September. He participated in sessions on research and monitoring in biosphere reserves and contributed to the final report of the session.

Dr. Jenifer Huang McBeath, plant pathologist, Agricultural Experiment Station, together with **George Sampson**, research forester, and **Forrest Ruppert**, forest-resource development specialist, both with USDA-Forest Service, are using funds supplied by USDA Forest Service through Pacific Northwest Forest and Range Experiment Station to conduct a study of storage methods for frozen wood chips in interior Alaska. This work is a part of a study series for the efficient use of land-clearing residues or other biomass for energy. The current study focuses on the technical feasibility of storing and maintaining land-clearing biomass as frozen wood chips in a large pile for a long period of time. A pile of white spruce chips has been constructed on the Alaska Agricultural Experiment Station's Experimental Farm. The pile is instrumented for monitoring temperature and moisture changes. The study will be completed in 1985. ▫





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