Agroborealis

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Agricultural Experiment Station
University of Alaska

FROM THE DIRECTOR'S DESK

The success of agricultural development now underway in Alaska will depend on how well Alaskan farmers can increase the productivity of their farms in terms of output of farm products per unit of production input. High levels of productivity are essential for the successful commercial production of crops and livestock as well as for successful part-time farming and subsistence agriculture. In view of Alaska's commitment to expand its cultivated agricultural lands to 500,000 acres by 1990, it is of interest to review a few figures about the nature and productivity of American agriculture.

Agriculture is the largest industry in the United States. Its assets are equal to about 88 per cent of the capital assets of all manufacturing corporations in the United States. Agriculture is also the nation's largest employer; one out of every five jobs in private enterprise in the United States is in some phase of agriculture – from growing food and fiber to selling it at the supermarket. Farming itself employs 3.6 million workers – as many as the combined payrolls of transportation, the steel industry, and the automobile industry.

Although the growth in productivity of American agriculture is now higher than in most other U. S. industries, this has not always been the case. Dr. D. Gale Johnson, Distinguished Professor of Economics at the University of Chicago, pointed out recently that U. S. agricultural productivity from 1919 to 1948 increased at an annual rate of only 1.7 per cent, compared to 1.9 per cent for the nonfarm economy as a whole and 2.9 per cent for manufacturing. In contrast, however, agricultural productivity from 1948 to 1973 grew at an annual rate of 3.3 per cent, outstripping the rates of growth of the nonfarm economy and manufacturing, 2.1 and 2.3 per cent, respectively.

Since 1973, this trend has continued and has permitted the United States to become the world's largest exporter of agricultural products. This export surplus indicates that American agriculture has the ability to use resources to produce products at low cost. By producing at low cost, it can compete with producers throughout the world while paying as much or more for domestic resources as any other sector of the economy. Thus, American consumers pay a lower percentage of their disposable income for food than consumers in most other countries. According to Dr. Johnson, the productivity of an agricultural industry depends on the economic and political environment within which it functions and the ability of agricultural research to develop technology for the most efficient production.

Successful agricultural development in the north is demonstrated by the Canadian experience in the Peace River region of Alberta where growing conditions are similar to interior Alaska. Although crop productivity was low during the pioneering years of this development, reports from the University of Alberta indicate that increases in yields of small grains in the Peace River area have resulted from the better use of fertilizers and herbicides, better and larger equipment which allows timely operations, and improved small-grain varieties developed for early maturity and higher yields. With this increase in productivity, the Peace River area now exports agricultural commodities.

Effective agricultural research and the extension of the most efficient agricultural technology to farmers who are now expanding Alaska's agriculture are most important in creating an agricultural industry in Alaska. This issue of *Agroborealis* includes some research results directed toward increasing the productivity of Alaska's farms and forests.

James V. Drew

James V. Drew, Director

Agroborealis

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ABOUT THE COVER . . . *Research Technician Chris Polson is shown measuring tree heights with a SUUNTO Clinometer in a stand of 70-year-old white spruce which has been thinned to a spacing interval of 12 feet. Height and diameter measurements were obtained to determine the post-treatment stand volume as a baseline for evaluation of stand response to thinning at this spacing interval.* *See related story, page 90.* (Photo by Allen P. Richmond)

Band of Dall sheep rams on a revegetated area of Usibelli Mine at Healy.

Stripmine Reclamation and Wildlife in Alaska

By

Charles L. Elliott* and Jay D. McKendrick**

The exploration and development of Alaska has been greatly affected by the region's mineral wealth. The quest for gold in the 1800s with its subsequent environmental and social impacts is perhaps the best example of how the desire for minerals has influenced the state. Today petroleum exploration and development is the dominant extractive industry; but another natural resource looms as a major factor in Alaska's economic future: coal.

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Interest in Alaskan coal is nothing new — underground mining started in 1855 at Port Graham on the Alaskan Peninsula (Conwell, 1976). As the demand for coal increased and new equipment was developed, underground mining was gradually replaced by open-pit mining or stripmining. By 1960, underground mining of coal had virtually ceased in Alaska. Interest in surface mining generally declined during the 1960s, but within the last decade the demands for domestically available energy and energy independence from Third World countries have refocused attention on Alaskan coal. Alaska's coal reserves have been estimated by state officials to equal the world's known oil reserves in energy equivalence and comprises almost half of the nation's known coal reserves (Anchorage Times, 1980). Realizing that coal-mining regulations in the conterminous United States may be unsuited to Alaska's northern environment, Congress commissioned the National Academy of Sciences to evaluate the Surface Mining Act of 1977 with respect to Alaska's unique conditions. A research group, the National Research Council, was formed by the National Academy to conduct the study. One of the Research Council's committees, the Committee on Alaskan Coal Mining and Reclamation, examined the effects of coal mining on wildlife and reported:

> The effects of coal mining on wildlife in Alaska are essentially unknown, and although there is some information on the effects of mining near Healy [site of a large, active stripmine] and from construction activities in several other areas of the state, any assessment of impacts specifically from coal mining must be considered speculative (National Research Council, 1980).

The committee went on to note that coal mining and such related activities as road building may affect wildlife indirectly by modifying or destroying critical habitat or disrupting migration routes.

Prior to the research council's study, scientists at the University of Alaska's Agricultural Experiment Station Research Center at Palmer began investigations to determine what plant species and techniques are best suited for rehabilitating stripmine spoils in Alaska's varied environments. As a result of the research council's study, the ongoing revegetation studies were amended in 1980 to include an investigation of the bird and mammal responses to and use of reclaimed mine spoils. The project is designed to investigate pre- and postmining effects on wildlife.

The premining investigations center around the Beluga coal field, located west of Anchorage (Figure 1). Exploratory digging is now being conducted with a view toward full-scale mining. By examining the large- and small-mammal populations and by doing bird surveys, a predisturbance list of animals that live in or visit the area and the habitat types they utilize is being compiled. An example of some of the mammal species encountered is illustrated in Table 1. This animal-habitat data, when related to plant biomass (also being measured), will provide a quantitative picture of the plant-animal relationships existing in the premining ecosystem. This information can then be compared with the same parameters examined during the active mining state, and in the postmining phase after reclamation (if the research continues). This premining investigation and subsequent analysis will provide scientists with a long-term, overall view of animal responses to stripmining in an Alaskan setting.

Figure 1. Approximate location of principal coal deposits in Alaska. (Adapted from Energy Resouce map of Alaska-1977.)

Table 1. Provisional Mammal Species List for the Beluga Coal Field.

Common Name (Scientific Name)
Arctic shrew (*Sorex tundrensis*)
Arctic ground squirrel (*Spermophilus parryi*)
Black bear (*Ursus americanus*)
Coyote (*Canis latrans*)
Dusky shrew (*Sorex obscurus*)
Grizzly bear (*Ursus arctos*)
Moose (*Alces alces*)
Red fox (*Vulpes vulpes*)
Taiga vole (*Microtus xanthognathus*)
Tundra vole (*Microtus oeconomus*)
Meadow jumping mouse (*Zapus hudsonicus*)

The postmining investigation are oriented in two directions: determine the bird and mammal use of surface-mined areas that have been reclaimed by artificial means (e. g. seeded), and reclaimed by natural plant invasion. The artifically reclaimed study site is located at the Usibelli Coal Mine, Inc. The mine is located east of Healy (Figure 1) in the Healy Creek drainage. Reclamation activities at the Usibelli Mine began in 1972 and have continued to the present. This series of different-aged, revegetated areas offers a unique opportunity for examining the animal use of the sites and how this use changes with plant-community succession.

At each reseeded area, a number of animal-habitat parameters are being measured; plant production is being determined to ascertain the biomass contributed by each plant species. The forage is also being analyzed for seasonal nutrient content. These measurements will indicate what seeded plants have survived and the species contributing the best-quality forage. Small mammals (voles, shrews, ground squirrels) are being trapped and their stomach contents microscopically examined to determine which seeded plants are important food items. Diets of large herbivores (caribou, Dall sheep, moose) and carnivores (wolf, fox, coyote) are also being determined by the microscopic method but only the fecal droppings are collected and examined, thus eliminating the sacrifice of important game animals. Visual sightings and other population analysis techniques are being used to determine habitat-use patterns and habitat preference of each mammal. Bird species frequenting the sites are being identified and density values calculated for those species that nest in the area. Food habits of raptors (owls, eagles, hawks) are being determined by analyzing discarded pellets.

Similar measurements of both plants and animals are being made for an adjacent tundra site so that a comparison can be made between reclaimed and undisturbed lands. Such comparisons will provide an insight into the plant-animal relationships operating in each area and help point out what reclamation methods provide an environment that meets the habitat requirements of the animals using the region.

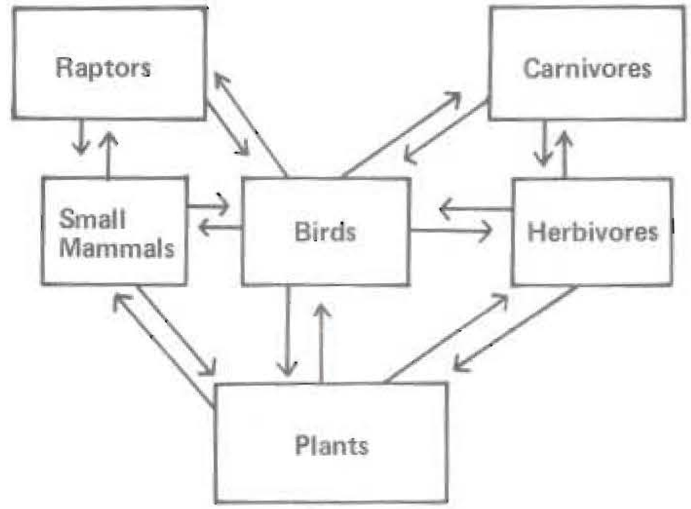

Figure 2. Schematic representation of potential plant-animal relationships on revegetated surface mines. Arrows indicate direct relationships.

The postmining investigation of an area reclaimed by natural plant succession is taking place at the B & R Mine site west of Healy. This mine was excavated and abandoned in 1945, and an additional area was reopened and mined until 1958. The same sampling that was described for the Usibelli Mine is also being done at the B & R site.

The value of reclaimed surface-mined lands as wildlife habitat has been reported for several regions of the conterminous United States (Verts, 1957; Sly, 1976; Suchecki and Evans, 1978; Whitmore, 1980), but such data are lacking for Alaska. The coal-development possibilities for Alaska are tremendous, but the impact on Alaska's wildlife is also potentially great. Without an adequate understanding of the plant-animal relationships that exist on a reclaimed surface mine (Figure 2), our ability to provide an environment capable of sustaining wildlife populations is severely hampered. With such data, reclamation can be directed to enhance habitats for game and nongame species alike. The study and examination of mine sites in Alaska will help provide information with which land managers can design reclamation programs that will benefit wildlife and maintain the integrity of Alaska's biological resources.

Funding for this research was provided by the U. S. Department of Energy, the Usibelli Coal Mining Company, Inc., and the State of Alaska through its legislative appropriation to the University of Alaska's Agricultural Experiment Station.

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Project Agriculture

An Experience in the Southern Hemisphere

by

Wayne C. Thomas*

INTRODUCTION

Australia has had numerous agricultural development efforts in its history. Some have worked, some have not; but taken in the aggregate, the process of agricultural development in Australia has been very successful. It is now one of the leading agricultural nations in the world.

New development efforts are now more rare but they still occur. One area that deserves further study for such development is the Northern Territory which is geographically isolated from mainstream Australia. It is in the center north of the continent (Figure 1), far from the main population centers of Sydney and Melbourne which lie to the south and east, respectively. There is no railroad connection between Darwin, the capital of the Northern Territory, and southern Australia markets. Surface connection is by unimproved roads, although within the territory most major roads are paved. Commercial air service to the rest of the country is good but expensive.

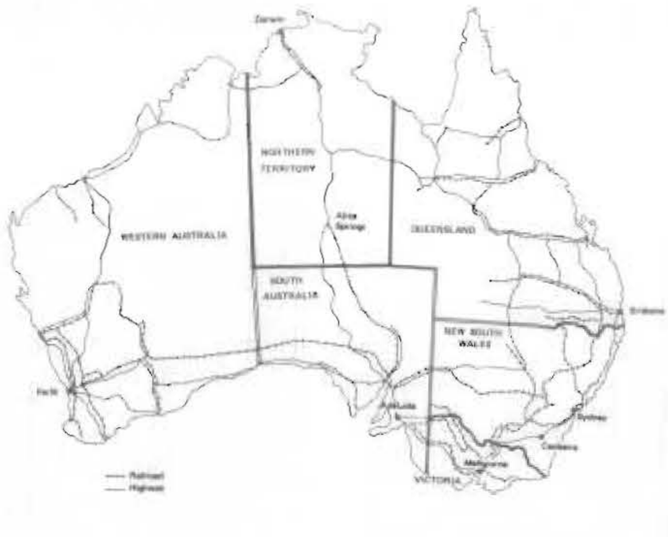

Figure 1. Map of Australia showing Northern Territory.

The Northern Territory became self-governing in 1978, with all powers granted to other Australian states except a minor few. (Federal Parliament in Canberra can veto any legislation enacted by the Northern Territory Legislative Assembly. The Territorial Government also receives special grants from the Australian Government which are not available to other states.) One of the aims of the territory's first government was to expand agriculture in the territory. Range-cattle operations have existed in the region since the 1880s, but field-crop agriculture has largely been a failure. In the past 25 years, three major attempts have been made by private interests to create large agricultural projects with primary crops of rice, sorghum, and peanuts. All involved several thousands of acres whereon the clearing, planting, and harvesting were under one management. Two factors were associated with the failure of these three agricultural development schemes: poor management (Figure 2), and inadequate agricultural research (Fisher et al., 1977). This form of agricultural development has provided one major opportunity — to lose large amounts of money.

AGRICULTURAL DEVELOPMENT

In 1979, the territorial government requested that the Department of Primary Industries in Queensland undertake a study which would propose economically viable agricultural-development possibilities for the Northern Territory. Initially, investigators reported that horticultural crops, that is fruits and vegetables, for the local market appeared feasible. In a second report, field crops, including rice, sorghum, corn, peanuts, and soybeans, were indicated for export and local markets. Government project management and individual family unit sizes of operation were also recommended. This study was acted on by the Northern Territory Legislative Assembly and legislation creating a project authority was passed in April 1980.

The Agricultural Development and Marketing Authority (ADMA) was created to bring agriculture back to the family-farm concept. This translates into farm sizes with arable land of around 2,500 acres. The big difference from the three earlier failures was that the territorial government would directly support individuals, not large investment groups, in farming.

ADMA has several functions: 1) purchase land necessary for the agricultural project, through eminent domain if necessary, from cattle operators with long-term leases on government land; 2) develop overall project plan and farm tract layout; 3) select farmers; 4) provide low-interest loans to aid farm development; 5) establish an agricultural infrastructure through direct investment of public funds, subsidies, or loans; and 6) operate the marketing system for the farmers until they decide that an alternative marketing organization is more desirable.

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Figure 2. Erosion problems associated with a large agricultural development under private management in the Northern Territory.

Figure 5. Baden Cameron, Chairman of ADMA, A. D. Hopper, Coordinator of ADMA and Bob Palmer, Chairman of Alaska Agricultural Action Council surveying the Douglas/Daly project area.

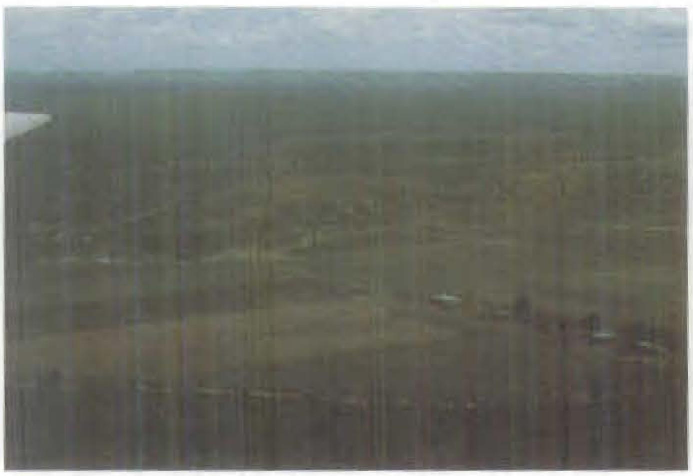

Figure 3. Rice farm in Adelaide River project area.

Figure 6. Normal vegetation before land clearing in Douglas/Daly. Note anthills in the foreground and a wild horse.

Figure 4. Land clearing in Douglas/Daly project area.

The development proposed for ADMA has been divided into two phases. Phase I is expected to require financial resources of A$4,000,000 from the Northern Territory Government and four years beginning in 1980. Total land involved will be approximately 15,000 acres in the Adelaide River and Douglas/Daly areas (Figs. 3, 4, 5, and 6). Six model farms will be used to establish efficient farm organization and typical crop rotations that have potential for good economic returns to individual farmers. This approach is useful for several reasons: 1) when planting can occur is limited by wet-season climatic conditions, so the model farms will provide agronomic benchmarks for future farmers using conventional technology; 2) cultural practices and harvesting can be assessed and alternatives recommended; 3) marketing can be organized for specific crops; and 4) Northern Territory Government funding can be kept to a minimum.

If the first phase is deemed a success, then the second phase will be undertaken. This will include up to 165 new farms with a total arable land area in excess of 408,000 acres. Phase I success depends primarily on obtaining reasonable crop yields which are consistent over several years. The transition to Phase II also depends on the Australian Government for financial support. The Northern Territory Government has plans to request A$63,000,000 (1980 dollars) to fund the second phase. The federal government will require an economic evaluation by the Australian Bureau of Agricultural Economics before it considers this request. This evaluation will probably not occur until Phase I is well underway.

ADMA will be heavily involved in marketing. It plans to function as a marketing board, buying rice, corn, sorghum, peanuts, and possibly other crops from the farmers; marketing these commodities; and operating interior and export elevators. The Northern Territory, with a population of only 125,000, has too small a local market to support a regional agriculture of more than a few farms. Development of an export market is essential to obtaining the critical mass that allows efficient farm sizes and organized markets. This will require that a multi-crop export elevator be built by ADMA. Until Phase II is well underway, volumes through the export and interior elevators will be insufficient to cover all costs of operation and debt service. A declining subsidy through ADMA is planned; as volume increases, the subsidy decreases, until it disappears.

Crops exported from the Northern Territory are expected to be sold in Asia. Overseas agricultural trade is the hallmark of mainstream Australian agriculture. Great Britain was the first major, nondomestic market; but in the period following World War II, the United States and then Japan superseded Britain in this regard. Now, expanding markets are found in South Korea, Taiwan, the Peoples Republic of China, and the developing nations of South Asia. It is to this group that ADMA will direct its primary market-development efforts. A trade mission sponsored by the territorial government has been sent to South Asia. Small shipments of agricultural commodities to Singapore have already occurred. Northern Territory agriculture can expand only if Asian markets are penetrated. Therefore, without aggressive marketing by ADMA and associated groups, particularly in Phase II, the agricultural project may not succeed for this reason alone.

FINAL THOUGHTS

Agriculture in the Northern Territory must have an expanded applied research base to provide insight into the agronomic problems that will occur as Phase I and then Phase II are implemented. The Territorial Government has supported research through its Department of Primary Production for many years but the effort must be increased. Since earlier large-scale agricultural projects undertaken by the private sector were failures due, in part, to insufficient or inadequate use of agricultural research, emphasis on this activity will be pivotal to the success of this agricultural project.

The cornerstone of Phase II is economic feasibility. Financial participation by the federal government will depend on adequate progress in farm development and marketing through Phase I. The Northern Territory is trying to create attractive investment opportunities through lowered farmland prices, reduced interest rates on farm loans, and government subsidies in marketing. This may appear as "forced" development brought about through manipulation of the market system. Alternatively, it can be viewed as a way to get agriculture started. This approach, the success of Phase I, and the funding and development of Phase II will be events worth observing. Alaska and its agriculture could obviously benefit from information gained from events in the Northern Territory. It is also likely that these benefits are reciprocal. Contact between the two regions should continue.

Editor's Note: The author was, during his visit to the Northern Territory in November 1980, a Senior Fulbright Scholar on sabbatical leave from the University of Alaska, and was a visiting professor in the Department of Agricultural Economics and Business Management, University of New England, Armidale, N. S. W. Australia. Funding for the Fulbright award, was provided by the Australian-American Educational Foundation, Canberra, A. C. T., Australia. Funding for the visit for the Northern Territory was provided by the Office of the Governor, State of Alaska.

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Climatic Trends in the Interior of Alaska

Moving Toward a High CO_2 World?

By

Glenn Juday*

A notable feature of the Industrial Revolution of the past two centuries has been the extensive and increasing combustion of fossil fuels. The energy and raw materials produced from these fuels have, of course, made the modern world as we know it. But as an inescapable consequence, a significant amount of CO_2 has been placed into the atmosphere.

Precise measurements of atmospheric CO_2 began at Mauna Loa volcano in Hawaii in 1958 and shortly thereafter at the south pole and at Point Barrow, Alaska. The initial concentration in these measurements was about 315 parts per million (ppm) or .0315%. The latest readings are approximately 338 ppm, an increase of over 7% in that short time (Machta, 1979; Keeling, 1981). Current climate models and, in fact, a neighboring planet, Venus, show us that a high CO_2 atmospheric content produces the "greenhouse effect." High-energy, short-wave, solar radiation is transmitted into the atmosphere relatively unaffected by CO_2; but once it strikes a surface and is converted to long-wave radiation (heat), it rises and is partly absorbed by CO_2 rather than radiated freely back into outer space. (Greenhouses warm primarily by reducing convection losses.)

Just how likely is it that at CO_2-induced warming will occur? Is it possible that a natural cooling trend could counteract this warming? What challenges and opportunities would we face in a warmer Alaska? How has the climate been changing over the last several hundred years, particularly the last 75 years, in which weather observations have been recorded in the interior of the state?

CO_2 AND CLIMATE-WARMING PREDICTIONS

The CO_2 climate-warming problem is of particular importance to Alaska because of a key result from climate-simulation models of a high-CO_2 world. If the atmospheric-CO_2 content were to double, the climate models indicate that the global, average, surface temperature would increase between 1.5° and 4.5°C (2.7° and 8.1°F) (Budyko, 1969; Manabe and Wetherald, 1980). But this projected warming is not expected to be distributed uniformly over the planet. In the high latitudes, especially in the northern hemisphere above 60° north latitude, some estimates of warming range between 8° and 12°C.

These estimates of the amount of CO_2-induced climatic warming cannot be taken as exact predictions of the amount, timing, or even perhaps the reality of warming. The current generation of climate models have had problems in modeling ocean-heat transport, cloud-temperature feedback, and atmospheric interaction with the real geography of the earth.

Despite these modeling limitations and some dispute over the magnitude of the warming to be expected, there is an emerging consensus that, other factors remaining constant, the earth and the high latitudes in particular will warm significantly as the result of an expected doubling of atmospheric CO_2 over the next several decades to century (National Academy of Sciences, 1979; Manabe and Wetherald, 1980; Watts, 1980; Bayes et al., 1976; Augustsson and Ramanathan, 1977). All one has to do is assume a large-enough CO_2 increase and allow enough time for it to have its full effect. The National Academy of Sciences study concludes, "To summarize, we have tried but have been unable to find any overlooked or underestimated physical effects that could reduce the current estimated global warmings to a doubling of atmospheric CO_2 to negligible proportions or to reverse them altogether. . . . It appears that the warming will eventually occur . . . ."

For the immediate future, however, the qualifier, "other factors remaining the same" becomes quite important. We now know that in the past the earth's climate has done anything but remain the same. The problem is to detect the "signal" of CO_2 in the "noise" of climatic fluctuation.

THE NATURE OF SOME CLIMATIC FLUCTUATIONS IN THE HIGH LATITUDES

It is possible that the backdrop of natural variability within which any CO_2-induced warming will be operating may be trending toward cooling, producing a net cancelling effect. For example, during the period of the greatest outpouring of CO_2 in history, 1940-75, the average global temperature was actually declining erratically; the decline was especially apparent in the northern hemisphere (Mitchell, 1979). Both long-term and short-term factors produce natural climatic variability.

Large volcanoes which inject great amounts of sulfur gases into the upper atmosphere appear to produce a short-term cooling of the earth's climate. Hammer et al. (1980) cite evidence that these sulfate aerosols cause cooling because they are particularly effective in reflecting incoming solar radiation in the troposphere. As the sulfates settle out of the atmosphere and are deposited with precipitation on ice sheets, they leave a zone of high acidity which can be dated. A rough correlation exists between dates of high ice acidity in cores taken from the

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Greenland ice cap and periods of cooling over the last 1400 years. The period after the 1912 Mt. Katmai eruption in southwest Alaska to the 1940s, a period of warming, was low in major volcanic eruptions. The 1950s and '60s (cooling) had a more nearly normal number. (The Mt. St. Helens eruption of May, 1980, was notable for the low amount of sulfur it produced).

Variation in energy output by the sun is another source of natural climatic variability. It is thought that sunspots may represent convective storms on the sun, which throw off more energy than would a smooth, undisturbed sun surface (Hoyt, 1979a). These sunspots occur in 11-year cycles. Hoyt (1979b) found a good correlation between average northern hemisphere temperature anomolies and an index of solar activity based upon sunspots for the period 1880-1970. Berri et al. (1979) found that the growth of Siberian larch near the tundra (dependent upon summer warmth primarily) correlated well with solar activity. However, northern-hemisphere temperatures in this century have become steadily warmer than the sunspot index (representative of natural climatic variability) alone would predict. Hoyt (1979b) takes this as evidence of CO_2-induced climatic warming of between 0.3° and 0.4°C over the period 1880-1970.

In addition to short-term climatic fluctuations, there are sustained long-term movements in overall climate. Basically, the sequence of climates dating back about 500,000 years correlates quite well with a simple model of the earth's orbital variation (Imbrie and Imbrie, 1980).

The earth's axis of its daily rotation is tilted off the plane of its orbit around the sun by 23.5°. This means that during the course of one orbit (one year) the northern hemisphere is inclined toward the sun (northern-hemisphere summer) and then halfway through the orbit six months later it is inclined away from the sun by the same amount (northern-hemisphere winter). The angle of the tilt has changed slightly over time, and since it follows the laws of orbital mechanics, it can be predicted for the future. Obviously, the more the northern hemisphere is tilted toward the sun in the summer, the more radiant energy can be absorbed in the ice-producing far north. The earth's orbit around the sun is another source of variability. The orbit is not circular but eliptic. This means that at certain times of the year the planet is closer to the sun, receiving more energy, than at others. If this close solar approach corresponds with the northern hemisphere summer, again as an example, then there will again be a warming response — and, under opposite conditions, a cooling.

The northern-hemisphere high latitudes are particularly important in this control of the planetary climate system because these regions are the great land masses of the world which, unlike the mostly oceanic southern hemisphere, can accumulate great areas of permanent ice and snow. If there is enough summer cooling there (low snow and ice melt) and warm, moist winters (high snowfall), then the planet enters a glacial era. If there is sufficient warming, then glaciers recede, sea level rises, and the whole hemisphere warms markedly (Ruddiman and McIntyre, 1981).

The prediction of orbital models is that the decline from the peak of warming that occurred about 6,000 years ago should continue for about 4,000 more years. A strong amelioration is not expected until about 15,000 years from now (Kukla et. al., 1981). So it does appear that the general climatic background will be one of cooling, although short-term variations of natural factors will continue to amplify or counter this trend.

What have these major fluctuations of climate over the last several thousand years been? How does the Fairbanks climate record fit into this? Where does it stand now in relation to these changes?

THE CHANGING CLIMATE AND THE FAIRBANKS CLIMATE RECORD

The most convenient starting point for an analysis of climatic changes over the last several millennia is the peak of the cooling of the last glacial period about 14,000 years ago.

Heusser et al. (1980) note that the change from full glacial to modern climate was very rapid in northwestern North America, being essentially completed in 1,000 years. This area, under full glacial ice conditions 14,000 years ago, shows evidence of vegetation characteristic of warmer and drier conditions than now prevail at several locations 8,000 years ago.

The forest-tundra treeline in the central Canadian Arctic has been an important marker for the shifting of climate in the past several thousand years. During the major warm interval between 5,500 and 3,500 years ago, trees grew 240 km north of the current treeline. Then, during a climatic regression, trees failed to regenerate in this zone after forest fires and were eliminated. Between 800 and 1000 A.D., the climate was again warm and trees grew 110 km north of modern limits. The cooling of the "Little Ice Age" set in and again trees failed to regenerate after fires (Bryson et al., 1965).

In Alaska, evidence for shifts in treeline during these time periods is very sparse. There is, however, a noticeable advance of seedling trees into alpine tundra in the interior of the state dating from the recent warm interval in the 1940s (Viereck, 1979).

It is interesting to note that the great expansion and colonization of northern lands by Scandinavian people during the Viking Age was coincident with the most recent, major, warm interval, from about 800 to 1200 A.D. During this period, the colonization of Iceland and then Greenland took place, and North America was "discovered" about 1000 A.D. The disappearance of the Greenland Norse colony took place with the onset of the Little Ice Age. Its place in Greenland was taken by Inuit people of the Thule culture who abandoned Baffin Island (further north) at this time.

The climatic record for most Alaska weather stations began only in the early part of the present century. Hamilton, (1965) has analyzed temperature records through 1959 of several Alaska stations in five regions of the state. He found that there was an overall warming from the late 1800s to the late 1950s of 0.6 to 0.8°C. This came about in a gradual warming from 1910 to 1935, then a pronounced peak of warmth at about 1941, followed by a sharp cooling to 1947 with little change thereafter. All stations agreed closely in these major features and matched the overal trends of the northern hemisphere well. The Fairbanks Airport Station was not used in Hamilton's study but is representative of climatic conditions in the interior of the state. Its first year of record is 1905. Figure 1 shows the mean annual temperatures for this station for the length of record. Four features in it are of particular relevance.

A warming trend, starting from a very low base in the earliest years, is evident up to 1929. It was followed by a subse-

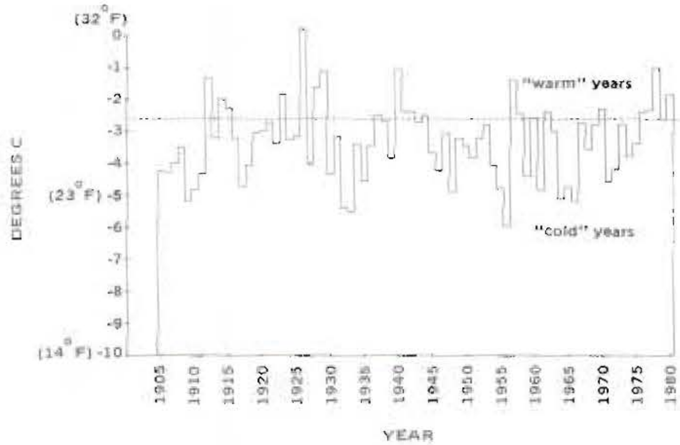

Figure 1. Mean annual temperatures, Fairbanks Airport Station, 1905-80.

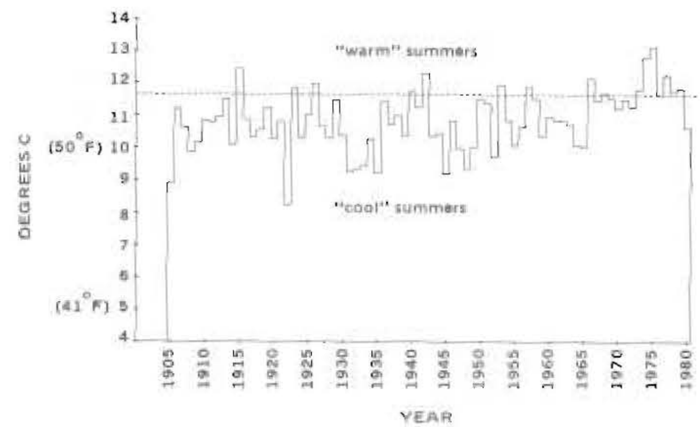

Figure 2. Averages of mean monthly summer temperatures (May - Sept.), Fairbanks Airport Station, 1905-80.

quent cold period until a sustained warm interval from 1940 through 1945 developed. Then came a severe regression to quite cold years relieved only by irregularly distributed years of moderate warmth in the late '50s. Finally, the years from 1976 to the present have been nearly unprecedented for sustained warmth and include the second warmest year on record, 1978. Figure 2 illustrates the trends of the mean monthly summer temperatures. Although the basic patterns of the annual temperatures hold up, there are some noteworthy differences.

The coolness of the earliest part of the century is evident, along with a trend toward warmth in the 1920s. A sustained warming of summer temperatures began in 1966, peaked in 1974 and 1975 in the warmest summers of the entire record, and has been broken only by the coolness of the summers of 1980 and 1981.

Figure 3 represents the course of averaged mean monthly winter temperatures for the length of record. The basic features of the annual and summer temperature records are found in the winter temperature record as well, but again with a few notable differences. The recent warming of winter temperatures has, in contrast to the record of summer temperatures, begun only in the last 5 years. But that warming has been strongest in the last 2 years.

Figure 4 shows the trend in the length of growing season measured as both number of days between 0°C (32°F) and -2.2°C (28°F). The trend is clearly toward an increase; this is about as clear as climatic trends can be in this length of time.

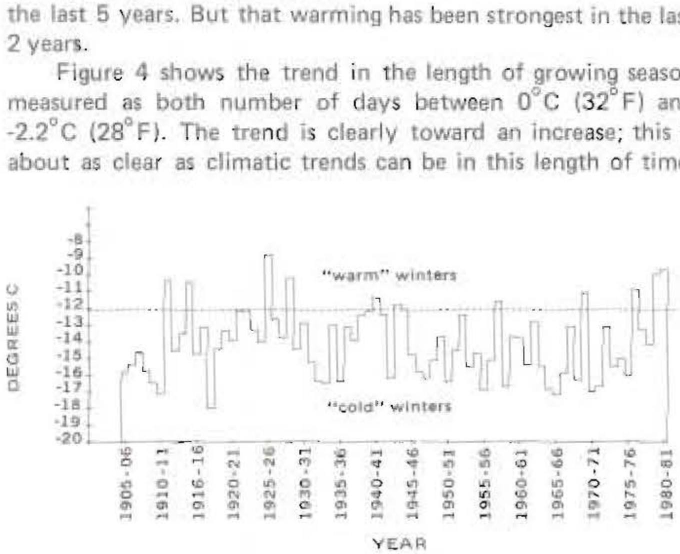

Figure 3. Averages of mean monthly winter temperatures (Oct. - April), Fairbanks Airport Station, 1905-06 - 1980-81.

Growing-season length still fluctuates and relatively short seasons still ocurr, as the 87-day, 1981 season (above freezing) recently reminded Fairbanksans. However the length of season above the -2.2°C threshold in 1981 was a considerably extended 146 days. In general even the low spots on the curve in recent years are higher than the short seasons of previous years. This recent and strong warming is generally unappreciated in much of the literature because the cooling of the '50s and '60s was so abrupt and widespread. But does this represent the peak of a trend, or simply a return to a norm that prevailed before the measurements were taken in the interior of Alaska? Garfinkel and Brubaker (1980) have matched the Fairbanks station record of May-July temperature with the tree ring width record of white spruce (*Picea glauca* [Moench] Voss) growing at treeline in the Brooks Range 250 miles from Fairbanks. The correlation during this calibration period was good enough to enable them to accept the record of conditions revealed by the trees alone from 1829 to 1905. Tree growth indicated a warming more or less steadily from 1829. They calculated that the twentieth century has been approximately 2.1°C warmer in those months than was the nineteenth.

Jacoby and Ulan (1980) have obtained tree-ring series from the northern Yukon dating back over 400 years. The Yukon chronology has been correlated to the available weather record

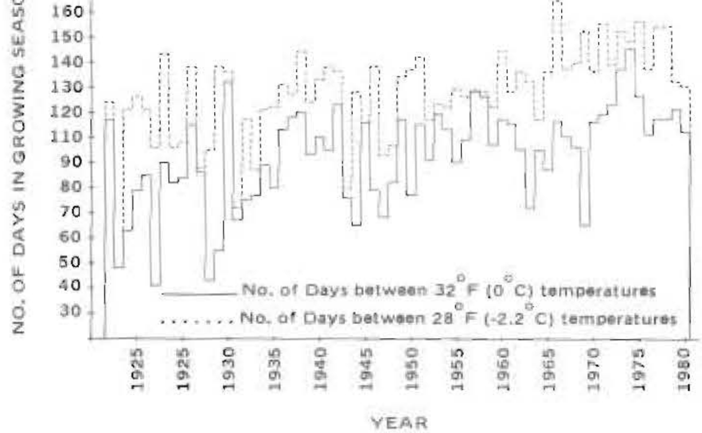

Figure 4. Length of growing season, Fairbanks Airport Station, 1931-80.

(Jacoby and Cook, 1981). This chronology reveals a climate slightly cooler than that at the beginning of the twentieth century near 1550, followed by an erratic but general decline of nearly .4°C to a distinct low near 1700. The years from 1700 to nearly 1800 were recorded as being milder than the beginning of the Fairbanks record by just over .1°C. A cooling by as much as .5°C to the modern minimum followed to the 1830s or '40s. Thereafter the record is in excellent accord with the Garfinkel and Brubaker reconstruction and the Fairbanks station record.

In looking at these trends, it is interesting to note that the end of the Little Ice Age and the beginning of the modern era of high CO_2 production, the Industrial Revolution, both date from about 200 years ago. It is tempting to assume, at least tentatively, a cause-and-effect relationship there. The erratic nature of the climate trend, such as the cooling of the '50s and '60s, could be accounted for by local and regional variability, solar cycles, and volcanic effects. The warming that has taken place to date would be all the more impressive when the cooling that the orbital variation model indicates should have been happening for the last 6,000 years is considered also. But such a conclusion would be premature. A better understanding of the causes of climate variability, one that deals more effectively with short-term fluctuations in particular, is needed. The solar sunspot record, for example, also correlates with the modern warming of all but the last few decades. A few more years of observations of world climate and atmospheric CO_2 levels may be very significant too.

If no natural background cooling is taking place, the CO_2-induced warming should be observable sometime between now and the year 2000 (Madden and Ramanathan, 1980). One of the most important factors that might be responsible for the lack of a pronounced CO_2-induced warming in the last few decades is the thermal inertia of the oceans. The heat storage capacity of the oceans is enormous; we may not yet have reached the threshold at which the stored heat makes a difference in the global climate. However, if no real warming is evident in the next 20 years, then the CO_2-induced climate-warming hypothesis will have to be seriously questioned.

What have the effects been of the warming that has taken place to date? What would an even warmer Alaska be like?

THE EFFECTS OF WARMING IN ALASKA

Since the ground "remembers" the temperatures to which it has been exposed by storing the heat (or cold depending upon your point of reference), ground and soil temperatures are an excellent place to look for the effects of warming.

Thie (1974) has shown that, in central Manitoba at the southern edge of the permafrost region, there is extensive melting of permafrost. He estimates that this began about 150 years ago, which would correlate well with the onset of the pronounced warming at higher latitudes that began between 1820 and 1830. In the Manitoba study area, 60% of the land once contained permafrost; it has been reduced to 15% today. Land collapse and vegetation changes are widespread. Lachenbruch et al. (1966) show that the equilibrium temperature profile for the permafrost at Cape Thompson in northwest Alaska has warmed about 2°C (from -7 to -5°C) and that this pulse of warmth has migrated down about 140 meters toward the base of the permafrost at 395 meters, indicating that it is recent and continuing. The permafrost situtation has particular relevance to most of central and eastern Alaska south of the Brooks Range and especially to the Fairbanks area because permafrost is discontinuous here; much of that which is present is "warm" permafrost. It now appears that, even without disturbance, some of the warmest permafrost bodies in the Fairbanks area are near surface melting; because of buried ice lenses and ice-rich silts, this would lead to ground subsidence. Everything from an altered hydrology to damage to engineering structures could result.

If the recent warming continues, then the treeline advances seen in Alaska in the 1930s and '40s should be exceeded. The northern limit of silviculture might be advanced as it was in Scandinavia in the 1930s and '40s (Mikola, 1962). The timing and vigor of tree seed production could be affected in the taiga forest as well as tree growth, nutrient cycling, insect outbreaks, extent of wildfires, and big game and bird survival. But the effects are not always likely to be straightforward. For example, the recent series of warm winters in Alaska has been caused by steady southerly winds off the north Pacific. The first mountain barriers to intercept these winds have received a much greater-than-normal snowpack. Game survival in these areas could be reduced by heavy snows. In the interior, there have been short periods of above-freezing weather all through the recent mild winters. This has caused a coating of ice over important animal forage plants in some cases, and a dense, crusted snow of lowered insulation value in others.

Differential effects in Alaska glaciers are likely also. The southerly moist winds of the last 5 years have caused a tremendous increase in the winter snowpack south of the crests of the Chugach and Alaska Ranges. Terrestrial valley glaciers, such as the wolverine glacier basin (Larry Mayo, personal communication), are thickening and might advance. Tidewater glaciers of Prince William Sound and the Kenai Peninsula that have extensive, higher-elevation, gathering areas and stable or thickening subaqueous moraines, could also be expected to advance significantly if recent weather patterns continue. Yet, if the recent warmth is sufficient to cause a net recession of the termini of these tidewater glaciers then some could be poised for catastrophic retreat. Because of the recent retreat of the terminus of the Columbia Glacier near Valdez, Meier et al. (1980) have predicted a catastrophic retreat of 20 miles or more in this glacier in the next few decades. This, if it occurs, would crowd the oil tanker shipping lanes with icebergs.

The behavior of river ice in the interior of the state, especially the dates of breakup and freezing, is another important area of response to climate changes, since commercial barge traffic on the larger rivers is an important factor in the economy of many communities. The date of the breakup of ice on the Tanana River at Nenana, southwest of Fairbanks, has been the subject of a statewide lottery every year since 1917. In only 16 of the years did the ice break up in April instead of May. Half of these early (April) breakup years are accounted for by the two major warm peaks in the Fairbanks climatic record — 1978 through 1981, 1939-40, and 1942-43; the others match scattered warm years in the record. In fact, until the last four years, which have had an unbroken succession of April breakups, there was no period longer than two years with early breakup dates in the entire record.

The behavior of sea ice is another extremely significant factor of climatic response in Alaska. Although the rate and timing of the disappearance of sea ice can be greatly influenced by physical factors, the broad trends of warming and cooling are ultimately decisive influences. Niebauer (1980) reports that while sea-surface temperatures were falling and sea-ice cover expanding in the Eastern Bering Sea from about 1973 to 1976, since 1976 there has been a precipitous decrease in ice cover and a strong surface warming there. It has been hypothesized that a significant increase in CO_2 might eventually cause the disappearance of the Arctic Ocean ice pack in the summer; however, effects far short of this could be of enormous significance to Alaska (Parkinson and Kellog, 1979). For example, the winter climate in western Alaska is greatly influenced by the seasonal winter sea-ice cover in the Bering Sea. An open ocean for a significantly greater part of the winter could be expected to cause great changes. The sedimentary basins of the Bering Sea are soon to be the subject of oil exploration and possibly developmental activities; the design and construction of offshore platforms and associated structures there must contend with storm or ice conditions that may develop. There is continuing interest in the transportation of arctic resources, especially oil and natural gas, by ship from the southern Arctic Ocean down through the Bering Sea. The Bristol Bay salmon resource in the southeastern Bering Sea is one of Alaska's richest. Any oceanographic changes associated with a changing climate in the North Pacific Ocean or Bering Sea could have far-reaching consequences for the people and economy of western Alaska and the state as whole.

But perhaps the most far-reaching consequences of CO_2-induced climatic warming would come about if the hypothesized collapse of the west Antarctic ice shelf occurred, rapidly raising world ocean levels by nearly 16.5 feet (Mercer, 1978). Much of western and northern Alaska's coastal region is flat and low lying. Most of the state's population lives in the coastal region of southcentral and southeast Alaska.

On the other hand, a real climatic warming could enhance the prospects for success of Alaska's new agricultural development projects. This could be of particular importance for the country as a whole (and the world) if warming were to be associated with drought reductions in the grain-producing ability of central North America as indicated in some recent climatic models (Hansen et al., 1981).

In a recent summary, several of the major consequences of a CO_2-induced climatic warming for Alaska and adjacent high-latitude regions were identified (Juday and McBeath, 1981):

1. Rising sea level requiring redesign or adaptation of coastal facilities and relocation of some population.
2. Melting permafrost in the warm permafrost region of the interior causing damage to roads and buildings from ground subsidence and changes in hydrology and natural vegetation.
3. Advancing glaciers and catastrophically retreating glaciers in the high precipitation regions of Southcentral and Southeast Alaska will occur as long as moist southerly winds continue to be the predominant winter weather pattern.
4. Successful agriculture brought about by warmer growing seasons and soil temperatures and extended growing seasons. These conditions would be expected to increase yields of the existing crops. If the warming is sufficient, a broader range of crops might be grown in Alaska.
5. Increased navagability of Alaska waters especially the Bering Sea and southernmost Arctic Ocean caused by shorter seasons of ice blockage; this offers the possibility (and problems) of shipping arctic resources instead of transporting them by land. A longer shipping season on interior rivers could also be expected.
6. Expanding forest and shrinking tundra especially in arctic and subarctic Canada where large shifts in treeline have occurred in the past. In Alaska, the effect might be seen primarily in altitudinal treeline shifts, forest movement into western Alaska, and in the replacement of marginal tundra woodland with full-canopied forest.
7. Changed hydrology caused by changes in density and depth of snow cover, regional increases and decreased in precipitation, and drainage network changes associated with melting permafrost.
8. New ecological circumstances for fish and wildlife populations, both positive and negative.

Will all of these effects occur? The result is by no means certain, but the experiment is running. The ultimate outcome will probably become clear within the lifetimes of most people reading this article.

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Forestry in Sweden and Finland

Its Applicability to Interior Alaska

By

Anthony Gasbarro*

INTRODUCTION

Wood products from the forests of Sweden and Finland play an important role in the economies of these nations. Each of these countries has a national forest policy which calls for a sustained annual harvest of forest products that is near or equal to the productive capability of the forest land base. In order to attain this goal, both public and private lands are managed intensively using various silvicultural practices, many of which are financed by government grants. Forest cooperatives make it possible for small-woodlot owners in each country to participate in the forest economy.

Forestry in interior Alaska is relatively undeveloped compared to Sweden or Finland, but Alaska has a similar forest-land base and is thought to have considerable development potential (Braathe, Holmen, and Nyyssonnen, 1978). Interior Alaska forests grow as rapidly as similar forests in Sweden and Finland. These forests also can be subjected to many of the same management practices, but there are some important differences. Sweden and Finland have milder climates than interior Alaska, have no permafrost in forest land areas, and enjoy favorable marketing conditions for their forest products.

CLIMATE AND SOILS OF FOREST LANDS

A major portion of the forests of Sweden and Finland grows in the same latitudes as the forests of interior Alaska (Figure 1). Productive forest lands reach further north in these

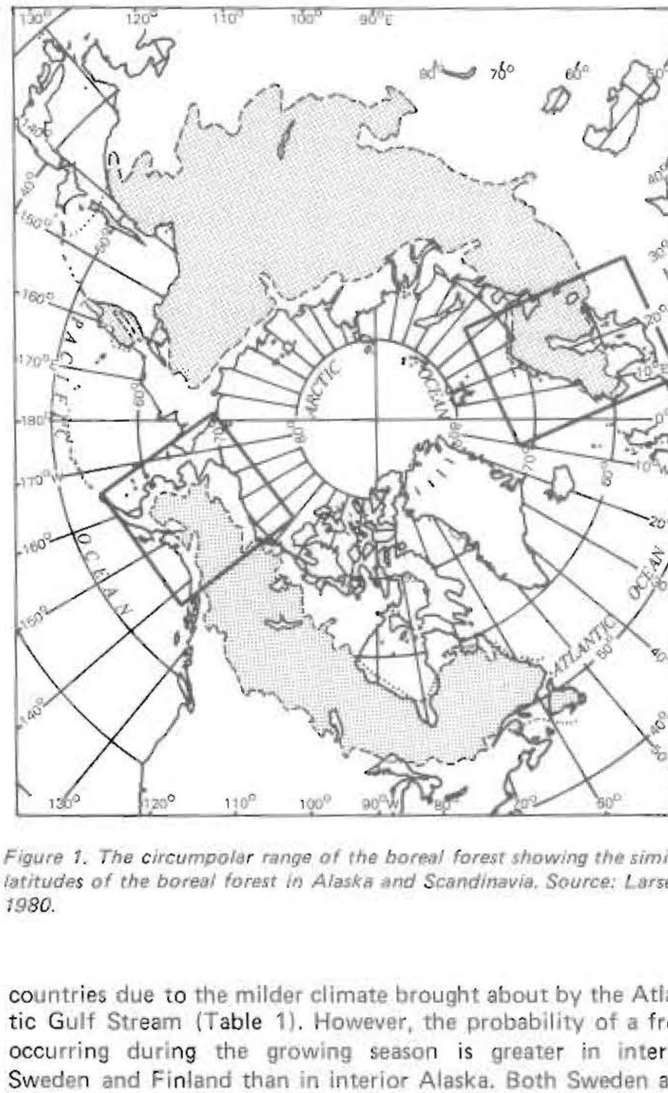

Figure 1. The circumpolar range of the boreal forest showing the similar latitudes of the boreal forest in Alaska and Scandinavia. Source: Larsen, 1980.

countries due to the milder climate brought about by the Atlantic Gulf Stream (Table 1). However, the probability of a frost occurring during the growing season is greater in interior Sweden and Finland than in interior Alaska. Both Sweden and Finland are also influenced by the continental and drier climate that originates in Russia. Most forest soils in Sweden and Finland have formed on rocky moraines or sandy sediments. In general, water infiltrates readily into these soils so that erosion from surface runoff is minimized. Both countries have wet peatland soils that are drained to support productive forest growth. Forest soils in interior Alaska range from highly erodable, wind-deposited silts to well-drained soils formed in alluvial sediments. No attempt is currently being made to drain peatland soils in Alaska for forest plantations.

Table 1. Temperature and Growing Season Comparisons.

Location	Mean Temp. Ranges (°F) July	Mean Temp. Ranges (°F) January	Length of Growing Season (days)
Sweden/ Finland	58 to 62	7 to 32	100 to 140
Interior Alaska	54 to 59	-15 to 10	90 to 120

Sources: Swedish Institute, 1979; Zasada et al., 1978; Selkregg, 1974, 1975.

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FOREST RESOURCES AND THEIR OWNERSHIP

Relative to their total land area, both Sweden and Finland have significant acreages of forest land (Table 2). Productive forest land covers 57 per cent of Sweden and 65 per cent of Finland. For land to be considered productive it must be able to grow annually approximately 15 cubic feet per acre of usable wood (Braathe, Holman, Nyyssonen, 1978).

Table 2. Forest Resource Statistics.

	Sweden	Finland
Total land area	173,700 mi^2	130,082 mi^2
Forest land area (acres)	60.4 million	48.7 million
Forest land (%)	57	65
Tree species by volume (%)		
Pine (*Pinus silvestris* L.)	38	45
Spruce (*Picea abies* L. Karst)	45	37
Birch (*Betula verucosa Ehrh.*)	10	15
Other	7	3
Annual growth (cu. ft.)		
Total	2.5 billion	2.0 billion
Growth/acre/yr.	42.9	41.4
Forest land ownership (%)		
Public	25	28
Private	75	72
Company	25	8
Other	50	64

Sources: The Swedish Institute, 1979; National Board of Forestry (Sweden) 1977; Finnish Forestry Association, 1980; Union Bank of Finland, 1980.

Annual forest growth in Sweden and Finland amounts to 2.5 and 2.0 billion cubic feet respectively. On the average each acre of forest land in each country produces about 42 cubic feet of wood per acre per year.

The principal tree species are Scotch pine, Norway spruce and European white birch. Pine and spruce account for over 80 per cent of the wood volume produced. Lodgepole pine originating in northwest Canada has been introduced into both countries.

Private ownership accounts for 3/4 of the forest land base in both Sweden and Finland. However, the two countries differ in the amount of forest land owned by large companies. Twenty-five per cent of the private forest land in Sweden is in large company holdings while large companies account for only 8 per cent of Finland's private forest land base.

Both countries have many small forest holdings, usually combined with small farms. There are 197,000 small forest/farm holdings in Sweden and 250,000 in Finland. The average-size forest in these holdings is 130 acres in Sweden and 60 acres in Finland (National Board of Forestry, 1980; Metsaliitto Group, 1980). In Finland, 80 per cent of the annual wood products harvest comes from small, private forests (Nyyssonen, 1978).

THE FOREST ECONOMY

The forest products industry is very important to the economies of both countries. Tables 3 and 4 show some pertinent economic statistics concerning forestry employment and foreign exchange earnings generated by the forestry sector. Forestry employment accounted for 254,000 jobs or 6 per cent of total Swedish employment in 1978 and 400,000 jobs or 20 per cent of the Finnish labor force in 1977. In 1978 one fifth of Sweden's foreign exchange and nearly half of Finland's came from the export of forest products. Both countries only spend between 2 and 3 per cent of their total import budget on forest products, hence the very favorable balance of trade in this sector provides financial resources to pay for the importation of energy and other materials.

Table 3. Forest Industry Employment in Sweden and Finland.

	Sweden	Finland
Full and part-time employees in forestry sector	254,000 (1978)	400,000 (1977)
Labor force in forestry sector (%)	6	20

Sources: The Swedish Institute, 1979; Nyyssonen, 1978.

Table 4. Forest Products and Foreign Exchange: Sweden and Finland, 1978.

	Sweden	Finland
Foreign exchange derived from exporting forest products (%)	20.5	44.0
Foreign exchange spent on importing forest products (%)	2.3	2.9

Sources: Skandinaviska Enskilda Banken, 1979; Finnish Forestry Association, 1980.

Both Sweden and Finland play an important role in world forest-product export markets. These countries' contribution to the world forest products trade is proportionately much larger than their share of world production (Table 5). Taken together, the countries export more than 28 per cent of the world's pulp and 29 per cent of its paperboard while they account for only 12 per cent and 7 per cent respectively of total world production. Together, Sweden and Finland produce 5 per cent of the world's fiberboard, but account for about 22 per cent of the world's trade in this commodity. Plywood production in both countries accounts for less than 2 per cent of the worlds total but their share is 9 per cent on the world export market. Swed-

Table 5. Share in Global Production (GP) and Global Exports (GE) of Forest Products – Sweden and Finland, 1978 (%).

	Sweden	Finland
Woodpulp		
Percent GP	7.2	5.1
Percent GE	20.3	8.0
Paper and Paperboard		
Percent GP	3.5	3.2
Percent GE	14.7	14.5
Fiberboard		
Percent GP	4.0	1.3
Percent GE	17.2	4.5
Plywood		
Percent GP	0.2	1.3
Percent GE	1.1	6.9
Sawn wood		
Percent GP	3.5	2.4
Percent GE	10.3	8.2

Source: FAO Yearbook of Forest Products, 1980.

ish and Finnish lumber mills produce nearly 6 per cent of the world sawnwood but account for more than 18 per cent of the world export market. Clearly these countries play a key role in keeping the world supplied with forest products.

FOREST MANAGEMENT PRACTICES IN SWEDEN AND FINLAND

Forest management practices are diligently applied in Sweden and Finland in an attempt to maximize forest productivity. The objective of Swedish foresters is to increase their country's annual allowable cut by 20 per cent by the year 2000 (Morley, 1980). Management practices include site preparation for new forest stands, a heavy reliance on artificial regeneration, cleaning and thinning, fertilizing, tree breeding, and the introduction of exotic trees. In addition, extensive areas of peatland are drained and the development of forest-access roads receive high priority. Many of these practices are possible because of the high demand for a wide variety of forest products and the willingness of government to subsidize forest practices.

Site Preparation

Scandinavian foresters recognize that cut-over forest lands will produce a crop more quickly if competing vegetation is removed and mineral soil is exposed making more water, nutrients, and light available for tree growth. Frequently, the main objectives of site preparation are to warm the soil and create a better drained microsite. Over the past two decades, techniques and machinery have been developed that prepare the site for natural or direct seeding and planting by scarifying, disking, or plowing. These means of site preparation are used on nearly 500,000 acres in Sweden and 250,000 acres in Finland each year (Appelroth, 1981; Söderström, 1981). In Finland, it is estimated that site preparation in many cases shortens the time to the next tree harvest by 5-15 years (Putkisto, 1980).

Three types of site preparation techniques and equipment used in Sweden and Finland are shown in Figure 2 (see next page). The patch scarifier has two of four, four-tooth ripping wheels which scalp a patch to mineral soil and pile the upturned sod toward the driving direction. The scarifier can be adjusted to change distance between patches. This type of a machine is now being used to a limited extent in interior Alaska. Another machine for site preparation, the disk trencher, forms either continuous or noncontinuous furrows depending upon the presence or absence of stumps or rocks, and deposits upturned sod and slash to the side. These machines also have multitoothed disks. A third machine, the scarification plow, produces a continuous furrow and is used principally on sites that are wet and have a thick peat layer (Putkisto, 1980).

Formerly, site preparation in Sweden and Finland was done using controlled burning. Relatively little controlled burning is done today because of the high cost of labor (Söderström, 1981) and difficulty in getting the right burning conditions. In some places, burned areas produce conditions favorable for a fungus (*Rhizina inflata*) which attacks young spruce seedlings (Morley, 1980).

Forest Regeneration Using Seed

Much of the forest regeneration in Sweden and Finland is accomplished through artificial regeneration rather than by natural seeding. Those forests that are established by natural means are regenerated mainly by leaving twenty to thirty seed trees per acre (Remröd, 1980). The seed-tree method is used only with pine and relies on site preparation to provide a suitable seedbed for germination. Figure 3 shows a typical stand of seed trees. In Sweden about 40 per cent of the cut-over lands are regenerated using this method of natural regeneration (Bergman, 1981, personal communication). Seed trees account for only 20 per cent of Finland's forest regeneration (Appelroth, 1981).

Figure 3. Seed tree method of natural regeneration being applied near Hällnäs, Sweden, N64°20.

Direct seeding accounts for a small percentage of the artificial regeneration done in Sweden and Finland mainly because of the lack of seed (Hagner, 1981). At high northern latitudes pine and spruce have infrequent good seed years. Both countries have established seed orchards to produce additional quantities of seed; however, these orchards are only able to supply seeds for tree nurseries and not the quantities that would be needed for widespread direct seeding.

Recently foresters in Sweden have begun to experiment with two direct-seeding methods that require relatively small amounts of seed. These methods involve using small, light, degradable-plastic cones or funnel-shaped shelters to enhance germination and the growth of the young seedling (Figure 4). Four seeds are placed within a cone shelter on mineral soil exposed during site preparation. To obtain results comparable with tree planting, about 1,100 cones are placed on each acre (Hagner, 1981).

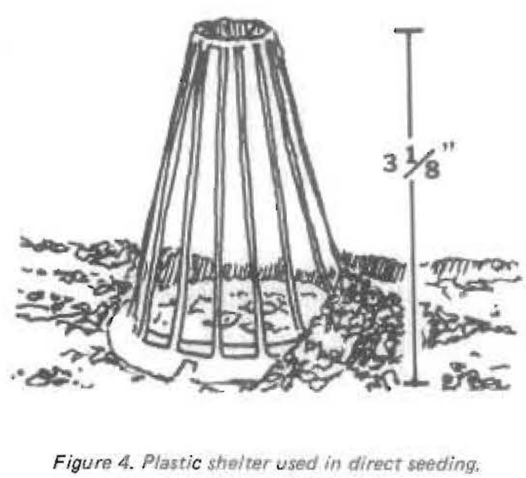
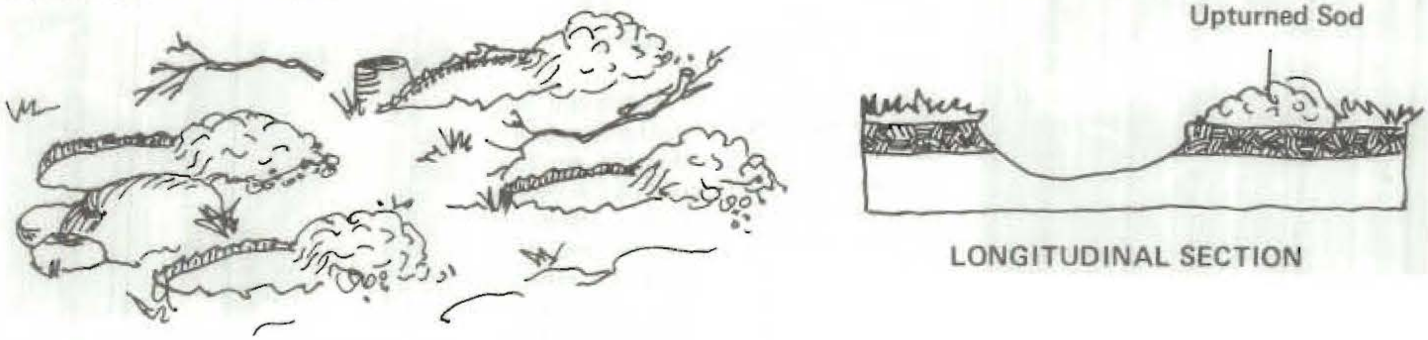


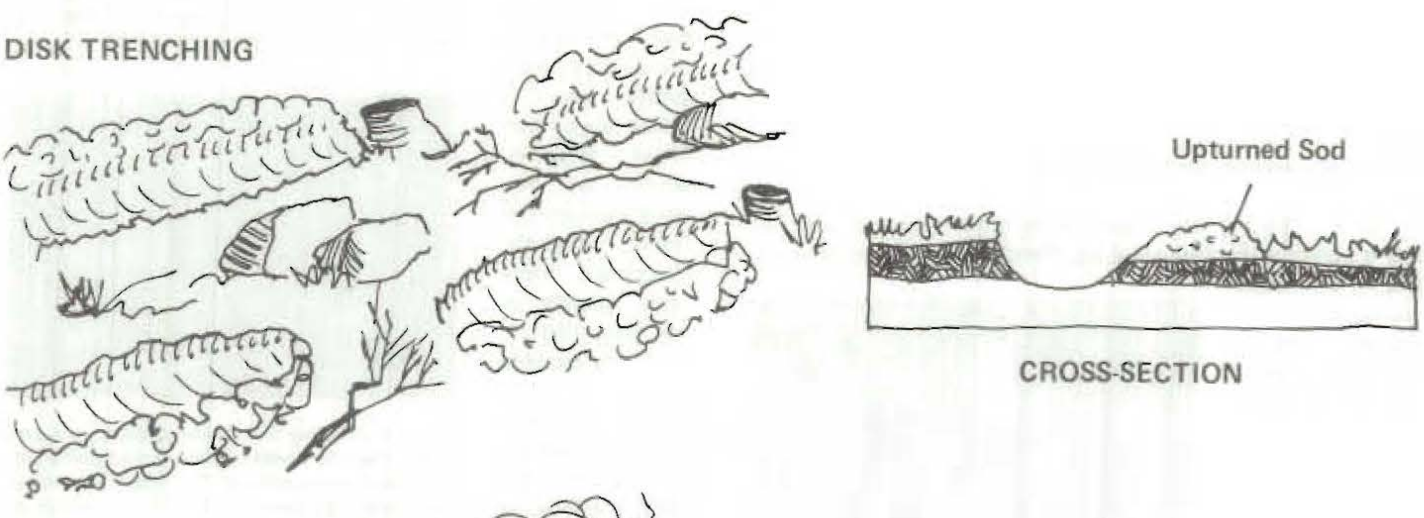
Figure 4. Plastic shelter used in direct seeding.

Figure 2. Site preparation techniques and machinery. From left to right: patch scarifier, disk trencher, and scarification plow. Sketches of the work accomplished by each are shown below. Adapted from: Logging Research Foundation, 1978.

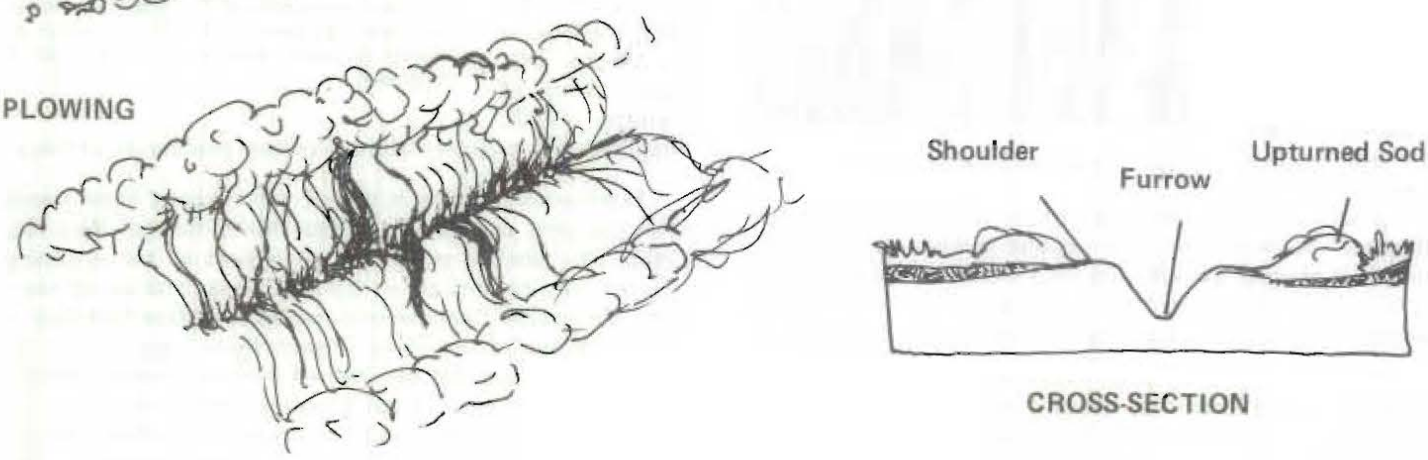
PATCH SCARIFICATION

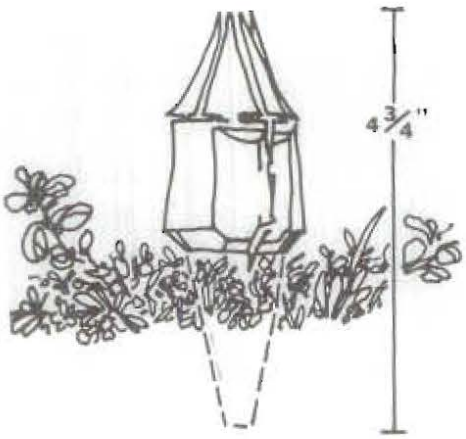


DISK TRENCHING



PLOWING





Funnel shelters do not require mineral soil; thus little or no site preparation is needed. The funnel is inserted about 2 inches into the humus and six seeds are placed within. These seeds fall to the bottom of the funnel where there is adequate moisture for germination and growth. About 1,200 funnels are placed on each acre. The device used for inserting the funnels into the forest floor is shown in Figure 5. If this method proves successful, it could revolutionize forest regeneration practices in northern latitudes as it would greatly reduce the need for site preparation. Hagner (1981) estimates that it could lower current artificial regeneration costs by half.

Figure 5. Device used for inserting the funnels into the forest floor.

Forest Regeneration through Planting

Most of the artificial regeneration done in Sweden and Finland is accomplished by planting. Planting stock is usually produced in large tree nurseries. In Finland alone, 200 million seedlings are planted yearly (Pease, 1980a). Seedlings are planted in a number of different ways. Figure 6 shows a bareroot seedling and the planting tool used to place it in the ground. Most tree seedlings planted today are containerized (Figures 7, 8, and 9). The most popular planting tools are mattocks and planting tubes (Figure 10). An experienced planter can plant between 1,300 and 1,800 seedlings per 8-hour shift (Bäckström, 1975) which on the average would plant from 1.5 to 2 acres.

Figure 6. Bare root plant and planter.

Most planting is done by hand, but steadily rising labor costs are making hand planting less economical. Efforts are now being made to develop a mechanized planter. Both Swedish and Finnish engineers have developed prototypes that have yet to be used widely. The major task is to develop a planting machine that can plant seedlings in the rocky soils of these countries. A fully mechanized planter now being tested in Finland can plant between 1,200 and 3,000 seedlings per hour, about the same number one man can plant in a day (Pease, 1980a).

Figure 7. Seedling in a paper container to be planted in ground by use of a planting tube, shown in Figure 10.

Cleaning and Thinning

Cleaning and precommercial thinning are carried out in young conifer stands in Sweden and Finland to remove the competition of the faster-growing hardwoods and to regulate the density of the future pine or spruce crop trees. These practices, which do not yield commercial forest products, encourage more rapid growth of the trees that remain. Forest land owners in Sweden, on the average, treat approximately 600,000 acres annually in this manner (National Board of Forestry, 1980). Finnish forest-land owners also utilize these practices extensively.

Figure 8. Seeding in a compressed peat block to be placed on exposed mineral soil. There is no need to prepare a hole for this seeding.

Figure 9. Seedling that has been grown in a container made by combining limestone with a volcanic rock called diabase. The resultant material has a very high pore volume and provides good support for roots. Seedling is then planted in the ground.

Commercial thinning is carried out in young forest stands when the pine or spruce are about 40-45 feet tall (Remröd, 1980). This practice stimulates the growth of the remaining trees and also permits the utilization of trees that would eventually die and rot. Commercial thinnings take place from two or three times during the life of a given forest stand. Figure 11 shows a pine forest that has received its final thinning and will undergo final harvest in about 20 years. The number of times a stand is thinned over its life span has been decreasing because of high costs. In Sweden, thinning in some areas is at best a break-

Figure 10. Inserting a containerized seedling in a planting tube.

Figure 11. Scotch pine forest after final thinning. Photo taken near Hällnäs, Sweden.

Figure 12. Pine-seed orchard, Savar, Sweden.

even proposition (Morely, 1980). Approximately 200,000 acres were thinned in Finland in 1978 (Appelroth, 1980). Thinning takes place on about 540,000 acres in Sweden annually (National Board of Forestry, 1980). In Finland nearly 50 per cent of the total wood harvest comes from thinning (Nyyssonen, 1978), while thinning only accounts for about 20 per cent of the total annual wood volume harvested in Sweden (Swedish Institute, 1979).

Fertilization

In order to increase forest productivity, pine and spruce stands are fertilized. About 130 lbs. of nitrogen are applied to each acre when trees reach about 50-60 years (Remröd, 1980). Applications are made every 6-7 years until shortly before the trees are to be harvested. Trees planted on drained peatland are fertilized with phosphorus and potash which leads to the release of growth-producing nitrogen from the organic matter (Remröd, 1980). Fertilization is regarded as an absolute precondition for the current yield level of Swedish forests. Any reduction in fertilization will mean less wood harvest (Remröd, 1980). About 450,000 acres in Sweden and 250,000 acres in Finland are fertilized annually. Fertilizer is usually applied by aircraft.

Tree Breeding and Use of Exotic Species

Tree breeding is practiced on a large scale in both countries to increase the growth and quality of forests. Seed orchards provide seed that has been produced from naturally superior trees or trees developed through special breeding programs. In Sweden, 50 per cent of the pine seed planted comes from seed orchards (Figure 12). Forests from these seeds are estimated to be 20 per cent more productive than forest from natural reproduction (Remröd, 1980). Finland alone has nearly 7,500 acres of pine-seed orchards. Both countries have developed means to induce birch to produce seed when only 2 years old through controlled conditions in plastic greenhouses (Figure 13).

Figure 13. Birch grown in plastic greenhouses for early seed production.

As early as 1754, the great Swedish naturalist Linneus suggested introducting foreign species into Sweden to raise the tree line. Lodgepole pine (*Pinus contorta* Dougl.) was first introduced into Finland in 1901. In 1978, 55 million lodgepole pine seedlings were planted in Sweden from seeds imported from northern British Columbia and Yukon Territory, Canada (Nyland, 1977). Finnish foresters are also developing plantations of this species. Lodgepole pine has a faster growth rate than the pine in Sweden and Finland particularly on poorer sites.

Figure 14. Scotch pine plantation on a drained peatland in Finland.

Drainage

Peatlands are being drained and fertilized so that they will support productive forest growth. Drainage has been practiced in Sweden for 100 years. In recent years about 74,000 acres have been drained annually (Swedish Institute, 1979). As of 1978, 12 of 17 million acres targeted for drainage in Finland had been drained (Nyyssonen, 1978). Currently about 110,000 acres are drained annually in Finland (Finnish Forestry Association, 1980). An examples of a Scotch pine plantation on a drained peatland in Finland is shown in Figure 14. When Finland reaches its target goal of 17 million acres of drained peatland, the forest land base will have increased by 20 per cent (Nyyssonen, 1978).

FORESTRY LEGISLATION AND PROGRAMS

Sweden

There are national forestry acts in both Sweden and Finland that establish and govern forest practices on both public and private land. According to the 1979 Forestry Act of Sweden, the aim of forest policy is to manage forest lands "in such a way as to provide a permanently high and valuable timber yield" (National Board of Forestry, 1979). It also states that management "should pay heed to nature conservation and other public interests." The act calls for the immediate establishment of new stands on land from which forests have been removed and on unused land (e.g. abandoned farmland). It specifies when forests can be clearcut and prohibits cutting without permission in forests difficult to regenerate. Implementation of the act falls to county forestry boards which are also vested with the responsibility of rendering assistance in planning forestry management and operations. There are 24 county forestry boards in Sweden that employ 2300 permanent and 4600 part-time employees.

The forestry boards also administer government subsidies to the forestry sector. The subsidies concentrate mainly on long-term measures and on those areas of the country where production and economic conditions are poorest (National Forestry Board, 1979). As can be seen in Table 6, the subsidies are significant, ranging from 50 to 90 per cent for most forest practices.

Forest owners in Sweden are subject to a silviculture fee. This fee is obtained by assessing a 3 mil tax on the forestry value of their property (Natural Forestry Board, 1979). The fee supports forestry research and development.

Table 6. Swedish National Government Grants for Forest Management.

		Maximum % of Costs Covered by Grants		
		Forest Development Area		Other
Measure		Inner Zone[a]	Outer Zone[b]	Areas of Sweden
Planting of forests on abandoned farmland		50	50	50
Regeneration of forests after cutting of thin stands or stands with unsuitable tree species[c]	Private	70	30	30
	Others	60		
Complete measures for establishing of stands		50	30	0
Neglected cleaning	Private	70	30	0
	Others	60		
Thinning of stands with low timber content or small sizes		Deficit from cutting		0
Draining of forests and wetlands	Private	70	50	50
	Others	60		
Supplementary planting after damage by rabbits or field mice	First	70	70	0
	Second	90	90	0
Mass invasion by insects		75	From case to case	
Construction, rebuilding and major improvement work on forest roads		75	60	60
Forest management plans for private properties		About 50		

[a] The inner zone includes coastal areas of northern Sweden and those areas of higher elevation in the central northern part of the country.

[b] The outer zone includes all of southern Sweden and the central coastal area.

[c] Any deficit from cutting is subsidized.

Source: National Forestry Board, 1979.

Finland

Forest management in Finland is guided by the Act of Private Forests and the Forest Improvement Act (Pease, 1980b.). These acts are administered by the National Board of Forestry which is 120 years old (Roget, 1980). As in Sweden, there are district forestry boards that monitor forestry activities and provide technical assistance. The boards also administer government subsidies. Subsidies up to 50 per cent or better exist for road building, thinning, stand cleaning, and drainage (Roget, 1980). Forest stand regeneration is not subsidized by the government but by the purchaser who pays a 12 per cent tax on the purchase price of the timber (Roget, 1980).

FORESTRY COOPERATIVES

No discussion of Swedish and Finnish forestry would be complete without mention of forestry cooperatives. In Sweden, there are six major forest-owner associations which together control 60 per cent of the private forest land (National Board of Forestry, 1977). The main tasks of these associations include negotiations with industry to determine the market price, selling and contracting for delivery of wood, providing tree felling and silvicultural services to members, transporting wood to the mill, and training in woodlot management (Roget, 1980). The six associations contain more than 130,000 small-woodlot owners (National Forestry Board, 1980). The associations along with government subsidies make it possible for such landowners to manage their woodlots economically.

Cooperatives are also an important part in the forest economy of Finland. The Foresty Council of the Central Union of Agricultural Producers represents 382 local forestry associations comprised of 172,000 landowners (Roget, 1980). The Council's operations include; timber business guidance, helping shape forest policy legislation and guiding the activities of the forestry associations. Another group of approximately 170,000 landowners belong to the Melsaliitto Group whose main function is to market and process the wood produced by its member's either through timber trading or through its own manufacturing plants (Metsaliitto Group, 1980).

ENHANCING THE POTENTIAL FOR FORESTRY IN INTERIOR ALASKA

There are some aspects of forestry practices in Sweden and Finland that could lead to a more substantial forest industry in interior Alaska. Several approaches toward improving interior Alaska's forestry capability are as follows:

- Establishing a stable forest-land base.
- Initiating more intensive forest-management practices.
- Developing a reforestation program.
- Expanding an information and education program for private forest-land owners and other citizens.

Establishing a Stable Forest-Land Base

In order to guarantee a sustained yield of forest products, a land base has to be dedicated for this purpose. This land must not only have the capability for growing trees but its use for forest-management purposes must be guaranteed for a long period of time. Investments of labor and capital for such practices as planting, cleaning, and thinning will not be forthcoming if it is perceived that, during the life of the tree crop, the land will be put to another use. As was discussed earlier, Sweden and Finland have stable land bases for forestry through dedicated public forest land and through laws that require private forest lands to be managed.

Interior Alaska does not have a forest land base dedicated to forest production. Much of the productive forest land in interior Alaska where timber harvesting is not already precluded or limited is in state or private ownership. Some of the state lands that have productive forest have been classified as "forest land" or "resource management land" (State of Alaska, 1978). However, these classifications have not guaranteed their being retained for wood production or their receiving adequate forest management (State of Alaska, Board of Forestry, 1981).

The establishment of multiple-use state forests would go a long way toward alleviating these problems, particularly if these forests are put under the control of a division of forestry. The state of Alaska Board of Forestry (1981), recognizing the need for lands committed to forestry, has recommended that as many as 7.7 million acres throughout the state be dedicated as state forest resource management areas. Until this is done, particularly in interior Alaska, the forest industry will not be able to count on a sustained supply of raw material.

Much uncertainty exists concerning the role private lands will play in the development of a forest industry in interior Alaska. Most of these lands will be owned by Native village and regional corporations as a result of the Alaska Native Claims Settlement Act (1971). The majority of the corporations in interior Alaska have not yet had time to assess the extent of their forest resources and or to formulate policies concerning their utilization. Furthermore much of the Native-owned forest land is in relatively inaccessible parts of interior Alaska.

The immediate task ahead for Native-corporations is to determine the quantity and quality of their forest resources and their productive capability. If the goal of a particular corporation is to utilize the forest resource to the greatest extent possible, then additional information will be needed to assess market conditions for forest products and develop forest-management plans. Native forest land owners as well as other landholders will need to become aware of the assistance available from state and Federal government agencies to help them plan for the management of their forest lands whether it be for forest products or other uses.

Initiating More Intensive Forest Management Practices To Enhance Productivity

Intensive forestry really began in Sweden and Finland when market conditions for forest products were such that it was possible to utilize small as well as large wood products from forest lands (Remröd, 1980). In these countries, the economics of forest management greatly improved with the advent of the pulp, paper, and particle-board industry which could utilize material from thinnings and residual material from logging operations. Although there is no such industry in interior Alaska, the rapidly expanding fuelwood demand (Gasbarro and Fox, 1980) has presented an opportunity to initiate on state land intensive forest-management practices such as thinning young stands and salvaging decaying birch and aspen from old growth-spruce stands (Richmond, 1981).

In some cases, individual fuelwood users are permitted for a small fee to do the salvaging or thinning in specially marked stands. In other cases commercial woodcutters have been contracted with to cut and pile the wood in the forest for the individual user who then pays a higher fee for the wood than if he had cut it himself. The revenues from these type of fuelwood sales in many cases will not entirely cover the costs of preparing and contracting the sale, so the state ends up providing a small subsidy for each cord cut. Continuation of this intensive management however, will lead to improved rates of tree growth.

Another way to increase the forest productivity in interior Alaska is to clean and thin forest stands which are too small to provide a commercial product but which are old enough to benefit from the removal of competing vegetation. Perhaps an "Alaska Forestry Corps" could be established and financed by state oil revenues. Comprised of young adults and staffed by professional land managers, such a corps would undertake, not only practices to increase forest productivity, but also projects to improve wildlife habitat, develop trails, and control erosion. The experience gained through work such as this would be invaluable to the youth of the state of Alaska.

Developing a Reforestation Program

A problem common to the forests of high-latitude countries is the difficulty in getting stands of conifers established after cutting. This is due to the infrequency of good seed years and the poor seedbed conditions created by the heavy organic mat of the forest floor. We have seen that Sweden and Finland address this problem through site preparation coupled with direct seeding and planting. Alaska needs to direct more effort toward its reforestation problem. It is estimated that there are 14,000 acres of previously harvested land in state ownership that are in need of reforestation. The State Board of Forestry (1981) has estimated that it would cost $2 million to accomplish this task. Manpower for such a project could also come from the suggested forestry corps. A successful reforestation program would also depend upon expanding the state's forest nursery and undertaking a extended program of seed collection. Money for financing reforestation could come from a fund created with revenues from timber sale receipts.

Forestry research organizations of the University of Alaska and the U. S. Forest Service should immediately begin research on the feasibility of using the light, degradable-plastic, funnel-shaped seed shelters that are now being tested in Sweden. If these prove to be successful in Alaska, it could significantly reduce forest-management costs. Further research is also needed to evaluate fully the use of tree species that are not native to interior Alaska, such as lodgepole pine. A program to test the practicality of establishing seed orchards of high-quality native conifers and hardwoods would also be desirable.

Expanding an Information and Education Program For Private Forest Land Owners and Other Citizens

State-supported forestry extension programs through forestry boards and the advice provided to members by private cooperatives are important parts of a nationwide effort in both Sweden and Finland to keep wood products flowing from private holdings. The state of Alaska should expand the current forestry extension program in interior Alaska so as to create more of an awareness of forestry opportunities. An extension forestry program should make private landowners aware of forest-management practices essential to sustained-yield forestry. Such a program would provide information concerning the potential productivity and value of forested lands, opportunities for specific management investments in timber production, values and markets of timber products, and multiple-use forest-land management. Local wood processors and Native corporation land owners should be provided with information about new timber harvesting and production methods, lumber drying, and storage and wood-processing techniques (Extension Committee on Organization and Policy, 1976).

One of the major differences between the countries of Sweden and Finland and interior Alaska is the lack of markets in the latter. A strong forestry extension program should be aimed at alleviating this situation by encouraging an efficient local forest industry that will produce its wood construction materials competitve in price and quality with materials currently being imported. Extension programs should also aim at making small, remote villages self-sufficient in wood energy, small-dimension lumber, and houselogs.

Editor's Note: This article is based, in part, on the author's visit in the summer of 1980 to Sweden and Finland in conjunction with the Second International Workshop on Forest Regeneration sponsored by the Swedish University of Agricultural Sciences Faculty of Forestry.

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A Cultured Biological Product Provides No Beneficial Effects on Barley or Bromegrass

by

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ABSTRACT

Agrispon, a soil additive, was tested in replicated field experiments with barley and bromegrass in the Matanuska Valley during the 1980 season. The three experimental treatments were as follows: no nitrogen (N), N at recommended rate, and Agrispon.

Barley yield, bushel test weight, and straw-to-grain ratios were not influenced significantly by Agrispon application. Nitrogen application increased both straw and grain yields, but had no significant effect on bushel weight or the straw-to-grain ratio.

Bromegrass forage yield, NO_3-N, total N, phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and sulfur (S) concentrations in bromegrass herbage and N, P, K, Ca, Mg, and S uptake by both cuttings were not influenced significantly by Agrispon application. Nitrogen application increased oven-dry yield, NO_3-N, and total N concentration of both cuttings, and the N, P, K, Ca, Mg, and S uptake by bromegrass in both cuttings. Nitrogen application also increased P and S concentrations in the herbage of the first cutting. However, N application lowered the concentration of Mg in the first cutting, S in the second cutting, and K and Ca in both cuttings.

INTRODUCTION

During the winter of 1979 and 1980 the product Agrispon was brought to our attention as a "cultured biological product" marketed to improve the soil and to supply N biologically for crop production. Promotional pamphlets infer that when Agrispon is used, no nitrogen need be applied. The name Agrispon is a trademark of Sn Corporation, Inc. of Dallas, Texas. The product was developed in Texas and has been promoted in the western United States by Kounty Marketing International of Big Sandy, Texas. A Washington distributor, Rare Soil Care of Colfax, Washington, advertises it as a "revolutionary new process to obtain nitrogen for all crops."

Following directions on the container and in the advertising, we evaluated Agrispon on Weal barley and bromegrass in 1980 in order to determine its effect on nutrition and yields.

EXPERIMENTAL PROCEDURE

Barley

A uniform area of Knik silt loam (Typic Cryorthent) on the Matanuska Research Farm near Palmer was chosen for a completely randomized block experiment (plots 6 by 15 feet) with eight replications. An area was chosen for the study which had grown barley and oats for forage in 1979. It was rototilled, fertilized, and planted April 28, 1980. All plots received a uniform application of 40 pounds of P_2O_5 per acre as triple superphosphate and 40 pounds of K_2O per acre as sulfate of potash; these were raked into the soil prior to planting. The three experimental treatments were as follows: no N, 25 lb N per acre as ammonium nitrate, and 1 ml Agrispon per plot per application (a rate of .1 gallon per acre). The required amount of Agrispon was removed from the freshly shaken bottle and added to one gallon of water in a sprinkling can. The contents were stirred vigorously and then applied uniformly to the appropriate plots on the freshly rototilled ground. Plots that received no Agrispon received the same quantity of water to provide uniform water addition to all plots. Following application of fertilizer and Agrispon, Weal barley was planted in drilled rows one foot apart with a garden seeder.

Weeds were removed by hand until barley growth was sufficient to retard their development. On August 25, four 10-foot rows of barley were cut with a hand sickle from the center of each plot, leaving a 2-inch stubble. Harvested material was placed in a cloth sack, dried in the greenhouse for several weeks, and then threshed, after which straw and grain yields and grain test weights were determined.

Bromegrass

A uniform 8-year-old stand of bromegrass on Bodenburg silt loam (Typic Cryorthent) 3 miles south of Palmer was selected for a completely randomized block experiment with eight replications. All plots (6 by 15 feet) were top-dressed on April 17 with 100 pounds per acre of P_2O_5 and K_2O as triple superphosphate and sulfate of potash. The three treatments were as follows: no N, 120 lb N April 17, 100 lb N immediately following the first cutting as ammonium nitrate, and Agrispon April 17 and immediately following the first cutting (1 ml per plot per application). The Agrispon was applied uniformly over the appropriate plots as described for the barley. On May 30, each plot was evaluated visually and rated numerically as to general grass health as indicated by leafiness, height, and color. On June 24 and again on August 22, forage from all plots was harvested with a small sickle mower, leaving a 2-inch stubble. Green and dry weights were recorded and a representative sample from each plot was ground to pass a 40-mesh screen.

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Plant tissue was analyzed as follows: N and P simultaneously, using a Technicon Autoanalyzer (TIS, 1976); NO_3-N with the nitrate electrode (Smith, 1975); K, Ca, and Mg, using an atomic absorption spectrophotometer following a sulfuric-selenous acid digestion (TIS, 1976); and S with an automatic sulfur titrator (Tiedemann and Anderson, 1971).

RESULTS

Barley

Yield, bushel test weight, and straw-to-grain ratios were not influenced significantly by Agrispon application (Table 1). Nitrogen application increased both straw and grain yields, but had no significant effect on bushel weight or the straw-to-grain ratio. Plots receiving no N or Agrispon did not stool out as much as those receiving N.

Bromegrass

Forage yield, NO_3-N, total N, P, K, Ca, Mg, and S concentrations in bromegrass herbage and N, P, K, Ca, Mg, and S uptake by both cuttings were not influenced significantly by Agrispon application (Tables 2, 3, and 4). Nitrogen application increased oven-dry yield, NO_3-N and total N concentrations of both cuttings, and the N, P, K, Ca, Mg, and S uptake by bromegrass in both cuttings. Nitrogen application also increased P and S concentrations in the first-cutting herbage. However, N application lowered the concentrations of Mg in the first cutting, S in the second cutting, and K and Ca in both cuttings. The reduction in the various nutrient concentrations is readily explained by dilution resulting from the greatly increased yields.

DISCUSSION

Vance (1978), reporting on a greenhouse study, found soil treated with Agrispon produced green bean, radish, black-eye pea, and tomato plants which grew as well as those receiving a 10-20-10 fertilizer at 105 lb per acre. A combination of N fertilizer plus Agrispon produced results no better than either Agrispon or fertilizer alone. Our work with lettuce and other crops has shown that much larger quantities of fertilizer are required in the greenhouse than in the field to secure equal plant performance. Thus, Vance's lack of response to fertilizer compared to Agrispon may have resulted from the relatively low fertilization rate used in his study.

Agrispon is a living culture of microorganisms that includes fungi, algae, and associated bacteria. A letter we received January 31, 1980, from Dr. D. F. Bezdicek, Soil Microbiologist, Agronomy and Soils Department, Washington State University, Pullmam, Washington says: "We have a bacterial count on the product you mentioned (Agrispon) and found less than 10,000 organisms per ml of undiluted product. At the recommended rate of application, the number of organisms added to the soil would be minimal." In contrast, agricultural soils contain in excess of 10,000 algae, 100,000,000 bacteria, and 20,000 fungi per gram of soil without microbial innoculation (Alexander, 1961).

Our results imply that Agrispon should be categorized with several other soil additives and foliar sprays which have appeared on the market in recent years and whose advertised claims frequently exceed product performance. Since most of these products do not contain enough N, P, and K to be sold as fertilizer, they are marketed as "nutrient-release agents," "soil conditioners," and "soil amendments." Most of these products are recommended to be applied to the soil directly or used as a foliar spray, and their recommended use is at low application rates compared to fertilizer. The reasons for the claimed results are either unknown or a "trade secret," and accompanying testimonials are frequently based on one year's use in nonreplicated trials. Such products will not harm a crop, but replicated field experiments seldom show any beneficial effects.

CONCLUSIONS

The results of these two experiments showed no response by barley or bromegrass to Agrispon applications. They did demonstrate that both barley and bromegrass respond well to N application.

Table 1. Effect of Agrispon and Nitrogen on Barley Yield, Test Weight, and Straw-to-Grain Ratios in 1980 (Means of 8 Measurements).

Treatment	Straw (T/a)	Grain (T/a)	Total (T/a)	Test Weight (lb/bu)	Straw/Grain ratio
No N	0.80b[1]	0.66b	1.46b	38.6a	1.22a
N	1.21a	0.98a	2.19a	38.2a	1.24a
Agrispon	0.75b	0.66b	1.41b	38.6a	1.15a
C.V. (%)[2]	15.3	14.5	14.8	2.6	6.7

[1] Column values followed by the same letter are not significantly different at the 5% level, using Duncan's Multiple Range Test.
[2] Coefficient of variation (C.V.) indicates the dispersion of the individual values around the mean. The larger the value, the greater the variation within the experiment.

Table 2. Effect of Agrispon and Nitrogen on Bromegrass Visual Rating, Yield, NO_3-N and Total N Concentration in Herbage and Total N Uptake in 1980 (Means of 8 Measurements).

Treatment	Visual Rating[1]	Oven-dry Yield (T/a)			NO_3-N (%)		Total N (%)		N Uptake (lb/a)		
		1st	2nd	Total	1st	2nd	1st	2nd	1st	2nd	Total
No N	0.9b[2]	0.77b	0.27b	1.04b	.013b	.024b	1.35b	1.80b	20.8a	9.8b	30.6b
N	3.0a	3.02a	2.26a	5.28a	.035a	.054a	1.69a	2.27a	102.1a	101.8a	203.9a
Agrispon	1.0b	0.74b	0.26b	1.00b	.014b	.022b	1.34b	1.81b	19.8b	9.4b	29.2b
C. V. (%)[3]	18.0	16.2	12.8	13.1	43.5	39.3	9.4	7.7	15.3	15.2	9.5

[1] 0 Very poor; 1 Poor; 2 Good; 3 Very good.
[2] Column values followed by the same letter are not significantly different at the 5% level, using Duncan's Multiple Range Test.
[3] Coefficient of variation (C.V.) indicates the dispersion of the individual values around the mean. The larger the value, the greater the variation within the experiment.

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Editor's Note: Cooperative investigation of Science and Education Administration, Agricultural Research, U. S. Department of Agriculture; and the University of Alaska Agricultural Experiment Station. To simplify terminology, the trade name of the product (Agrispon) is used in this report. The use of this name is intended for the reader's benefit and implies neither endorsement nor criticism of this or of other products not mentioned.

Table 3. Effects of Agrispon and Nitrogen on Concentrations of P, K, Ca, Mg, and S In Two Cuttings of Bromegrass Forage in 1980 (Means of 8 Measurements).

	P (%)		K (%)		Ca (%)		Mg (%)		S (%)	
Treatment	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
No N	.26b[1]	.36a	1.87a	2.3a	.32a	.44a	.13a	.15a	.15b	.19ab
N	.28a	.36a	1.73b	1.5b	.22b	.34b	.10b	.16a	.20a	.18b
Agrispon	.26b	.37a	1.90a	2.4a	.30a	.44a	.12a	.15a	.15b	.20a
C.V. (%)[2]	6.2	7.3	4.7	6.0	6.7	7.8	10.1	10.6	8.2	5.8

[1] Column values followed by the same letter are not significantly different at the 5% level, using Duncan's Multiple Range Test.

[2] Coefficient of variation (C.V.) indicates the dispersion of the individual values around the mean. The larger the value, the greater the variation within the experiment.

Table 4. Effects of Agrispon and Nitrogen on P, K, Ca, Mg, and S Uptake by Brome Grass in Two Cuttings 1980 (Means of 8 Measurements).

	P (lb/a)		K (lb/a)		Ca (lb/a)		Mg (lb/a)		S (lb/a)	
Treatment	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
No N	3.89b[1]	1.94b	28.9b	12.8b	4.95b	2.38b	2.06b	0.82b	2.30b	1.05b
N	17.19a	16.10a	104.6a	65.9a	13.36a	15.15a	6.31a	7.40a	12.10a	8.13a
Agrispon	3.89b	1.91b	27.9b	12.4b	4.51b	2.27b	1.85b	0.78b	2.15b	1.02b
C.V. (%)[2]	19.9	11.0	16.3	18.2	11.7	18.1	11.3	21.6	16.1	13.4

[1] Column values followed by the same letter are not significantly different at the 5% level, using Duncan's Multiple Range Test.

[2] Coefficient of variation (C.V.) indicates the dispersion of the individual values around the mean. The larger the value, the greater the variation within the experiment.

Barley Whole-Wheat Quick Bread

A Potential Use for Alaska Grains

By

Ruthann B. Swanson* and Marjorie P. Penfield**

INTRODUCTION

Expansion of grain production in Alaska is continuing as new acreage is made available for crop production (Pollock, 1981) and results from locally conducted variety trials of cereal crops are compiled. Barley is the best-suited grain for production in Alaska (Wooding and McBeath, 1979). It grows well in cool climates, responding better than wheat or oats to the short growing seasons, as evidenced by the successful production of barley in other areas of the circumpolar region (Taylor, 1974).

In general, barley as a foodstuff has been overlooked in the United States where less than 6% of the barley produced in the early 1970s was used in soups, dressing, baby foods, and breakfast cereals (McCuistion, 1973). In countries where barley is included in the diet, hulless varieties rather than the hulled varieties produced for the maltsters and animal-feed producers are used. The digestibility of the hulless varieties is 94%, while the hulled varieties are 83% digestible. The grain has been found to be an excellent source of thiamin (6.5μ/g), nicotinic acid (115 μ/g), riboflavin (1.2μ/g), pantothenic acid (4.41μ/g), pyridoxin (11.5μ/g) and choline (1100 μ/g). In addition, folic acid (0.65 μ/g) and tocopherols (32-50μ/g) are present (Pomeranz, 1973). The hulls of the covered varieties are low in nutrients (Whitehouse, 1979). The proportion of the hull decreases as the latitudes at which the grain is grown nears the Arctic Circle (Pomeranz, 1973). The long photoperiod in the arctic and subarctic regions facilitates increased uptake of soil nitrogen by the plant, resulting in a high-protein, low-starch barley. The protein content of Alaskan barleys grown at Fairbanks averages 17.3%, while the United States average is 12% (Wooding and Husby, 1980).

Usually lysine and methionine are limiting amino acids of barley (Whitehouse, 1970), however new high-lysine varieties have been developed (Prentice et al., 1979). In addition, the methionine content of Alaskan barleys is significantly increased (Wooding and Husby, 1980). Many artificial mutants of barley have been developed, but no complete nutrient analyses have been conducted. Other constituents including starch have been altered, making available high-amylose and amylopectin varieties. The lipid content is approximately equal to that of wheat and the insoluble carbohydrate is found mainly in the hull (Whitehouse, 1970). The hulless varieties are recommended for human consumption (Whitehouse, 1970), although hulled varieties are suitable if the hulls are removed or are finely milled (Prentice et al., 1979).

Tibet Hulless, a naked barley introduced to Alaska in 1945 from Tibet, has adapted well to the Alaskan climate. Used for human food in the Himalayan region of Asia, Tibet Hulless matures in areas of Alaska where even the earliest-maturing varieties of wheat cannot be successfully grown. Thus, Tibet Hulless may be suitable for production, not only on a large-scale operation, but by bush residents engaged in subsistence farming as well (Wooding and McBeath, 1979). Wooding and Husby (1980) report a protein content of 18.2% for Tibet Hulless field tested at Fairbanks. Marketing of barley for human consumption, as well as for animal feed, is being considered (Lewis, 1981), which would make available a grain produced in the state that has a positive nutritional image (Moore, 1980).

Many different cereals, including barley, have been grown for centuries; and breads have become a staple in the diet. Barley flour has been used in both quick and yeast breads. Quick breads are those breads that are leavened by a chemical leavening agent such as baking powder. The leavening action occurs due to the production of CO_2. These breads range from pourable batters such as popovers and muffins to soft-dough products such as biscuits. Quick breads are usually baked immediately after mixing. Yeast breads, however, require fermentation by the yeast to produce the CO_2 necessary for leavening. The production of CO_2 results in the increase in volume that occurs during the "rising" or fermentation period. Yeast breads are usually prepared from an elastic dough that must be kneaded and shaped prior to baking. However, an alternate preparation method allows yeast breads to be made from a batter similar to quick breads. Batter yeast breads must also be allowed to rise just as are the yeast breads prepared by the conventional method. Not only do the characteristics of the two types of bread differ, but the preparation time required for yeast breads is much longer than that needed for quick breads.

The use of barley flour in breads has decreased as wheat production has increased in the western world (Pomeranz, 1973). Thus, little research has been directed toward the components of barley in relation to the bread-making process. Landenberger and Morse (1918) concluded that although gluten, the protein responsible for structural support in leavened baked products, may have some effect on the characteristics of the bread, gluten composition in barley does not differ appreciably from that of wheat. Cunningham and others (1955) found the viscoelastic properties of barley breads to be related

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to the gluten properties. Barley gluten is firm and inelastic, darkening rapidly to a brown shade, while wheat gluten is elastic and cohesive. The water-absorbing capacity of gluten is lower for barley than for wheat. Gluten also is responsible for the fine, regular crumb structure characteristic of leavened bread. Hart and coworkers (1970) produced a barley yeast bread with good texture by adding gums to the batter.

The gluten structure of quick breads is weaker than that of yeast breads. This weakness may be attributed to the increased liquid and sugar, and the decreased manipulation of the batter as well as the incorporation of less flour into the mixture. While Tibet Hulless barley grown in Alaska is known to have a higher protein content (Wooding and Husby, 1980) and, thus, a possible increase in gluten content, the characteristics of barley gluten are not conducive to good structural support in yeast breads since they are firm and inelastic (Cunningham et al., 1955).

Starch, as well as gluten, has an important function in breadmaking. During baking, starch granules imbibe water and swell. This process is called gelatinization. Thus, some of the characteristics of the bread are dependent upon the starch utilized in the bread-making process. Hoseney et al. (1971) reported that barley starch gelatinizes at temperatures slightly above those for wheat starch and produces loaves with volume nearly equal to that of wheat-starch loaves. Sollars and Rubenthaler (1971) found that both barley starch and wheat starch produce experimental cookies and cakes of acceptable quality.

Unlike yeast breads, which are dependent upon gluten for a structural network, the structure of quick breads like that of cakes and cookies relies on gelatinization of the starch during the baking process and the assistance of the protein in egg. During baking, the volume increases until the starch is gelatinized and proteins in the batter have coagulated or firmed.

The higher gelatinization temperature of barley starch also allows additional time for volume increase. Volume increase is additionally facilitated by the use of a chemical leavening agent that increases the rate of CO_2 production. The increased sugar levels in quick breads further delay the gelatinization of the starch as well as coagulation of the proteins present. Thus, barley should produce acceptable baked products in which the role of gluten is minimized, providing the flavor and appearance are acceptable to the consumer. Prentice and others (1979) found good acceptability of the texture and flavor of a 15% barley-meal bread when compared with 30% whole-wheat bread by a sensory panel.

The functionality of flours from Alaskan-produced grain in baked products has not been evaluated. Thus, the purpose of this study was to evaluate the appearance, texture, and flavor of a whole-wheat quick bread in which barley flour had been substituted for all-purpose flour.

MATERIALS AND METHODS

Barley whole-wheat quick bread was prepared using flours produced from Tibet Hulless barley and Chena red spring wheat obtained from the University of Alaska Agricultural Experiment Station, Fairbanks. Each grain was ground in a Waring Blendor to produce flour. Only the flour that passed a standard, 20-mesh seive was used (FDA, 1979). Barley flour was substituted for all-purpose flour at four levels: 0, 40, 60, and 100%. Chena red spring whole-wheat flour comprised 50% of the total flour in each lot. Thus 0, 20, 30, and 50% of the total flour used for the four variations was barley flour. The basic formula is listed in Table 1.

Table 1. Laboratory Formula for 300-g Loaves of Barley Whole-Wheat Quick Breads.

Ingredient	Grams	Source/Brand
All-purpose flour[a]	76	Gold Medal
Salt (iodized)	4	Morton
Baking powder	5.8	Calumet
Granulated sugar	66.6	Kroger
Unsifted whole-wheat flour	80	University of Alaska Agricultural Experiment Station (Chena)
Beaten egg (grade A)	33.3	Kroger
Whole milk	161.3	Kroger

[a] Tibet Hulless barley flour (source: University of Alaska Agricultural Experiment Station) was substituted for all-purpose flour on the following basis: 20% barley bread, 30.4 g barley flour for 30.4 g all-purpose flour.
30% barley bread, 45.6 g barley flour for 45.6 g all-purpose flour.
50% barley bread, 76 g barley flour for 76 g all-purpose flour.

Dry ingredients were weighed on a Harvard trip-balance scale. All dry ingredients except the whole-wheat flour were sifted together; the whole-wheat flour was stirred into the other sifted dry ingredients. One-quarter of the combined dry ingredients was added to the beaten egg, and this mixture was combined by beating 20 strokes. One-third of the milk was added to this mixture and incorporated by beating 15 strokes. An additional quarter of the dry ingredients was added and the procedure was repeated until all ingredients were combined. The batter was allowed to rest for 5 minutes prior to baking.

Three hundred grams of batter were weighed and baked at 375°F for 30 minutes in a 17.5 x 8.0 x 5.5-cm loaf pan that had been greased with 1 gram hydrogenated vegetable shortening (Crisco). The loaf pan was placed in the center of an electric oven on a rack located at the third position from the bottom. After removal from the oven, the bread was cooled for 10 minutes before it was removed from the pan. The bread loaves were frozen in sealed plastic bags after cooling an additional hour.

Specific gravity of the batter was determined as an indicator of expected volume (FSNFSA, 1976). All other objective tests were conducted on bread that had been frozen for two days and thawed at room temperature for approximately two hours prior to testing. Loaf volume was evaluated using a loaf volumeter (FSNFSA, 1976).

Figure 1 indicates the slices of each loaf of bread used for sensory and the additional objective tests. The bread slices designated for objective testing were photocopied to indicate cell dis-

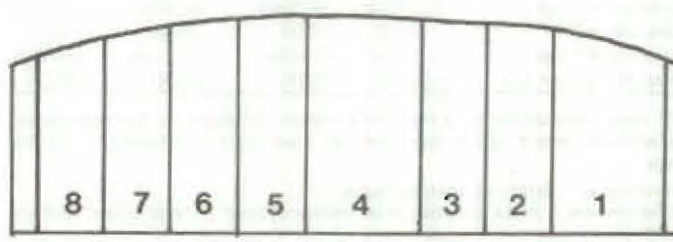

Figure 1. Schematic representation of quick-bread loaves indicating the slice position designated for objective and sensory testing. Slices 1 and 4 (2.5-cm) thick) were used for objective tests. Remaining slices (1.25-cm thick) were used for sensory tests.

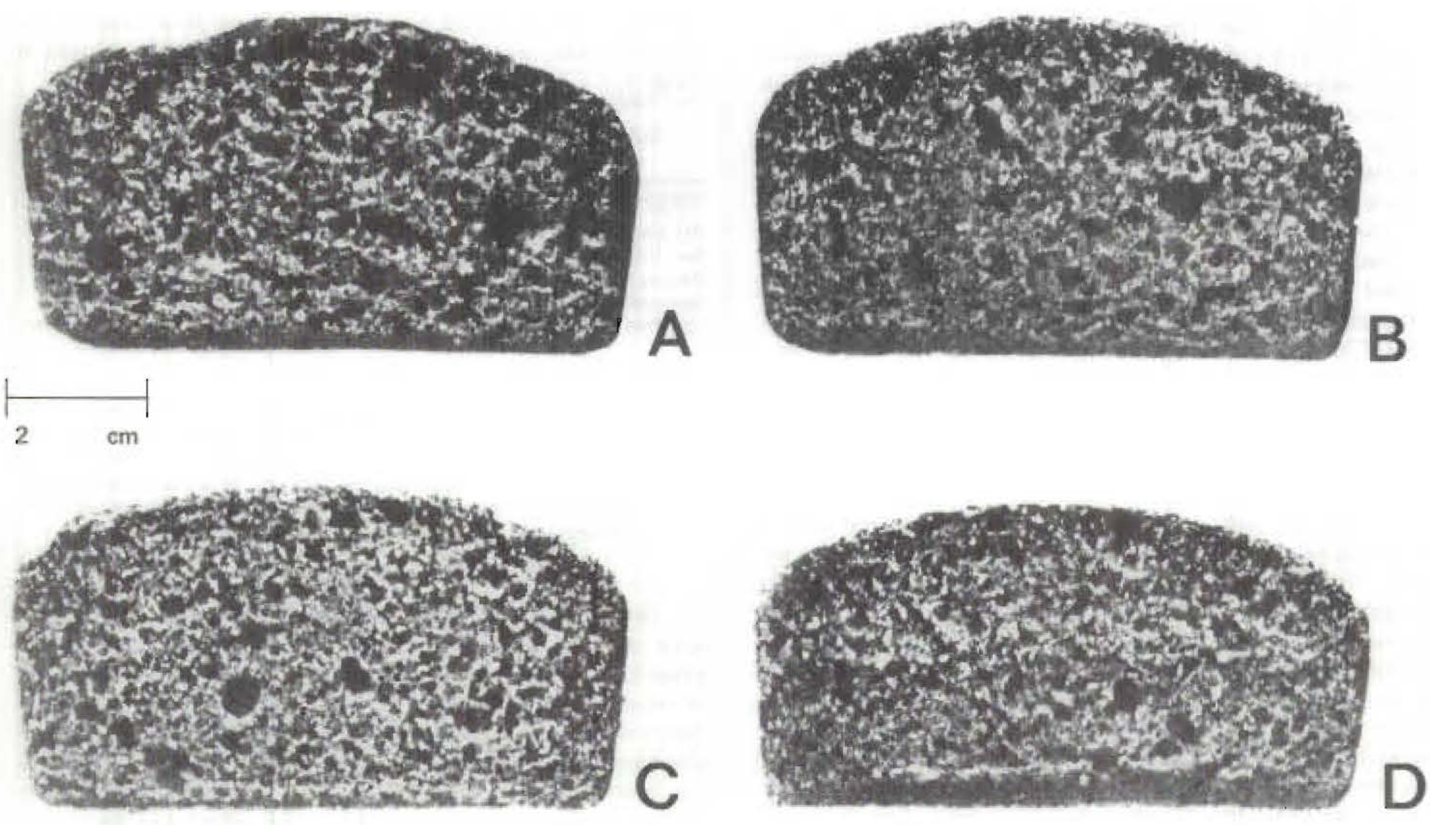

Figure 2. Photocopies of the sliced bread serve as a record of coarseness, compactness, and cell distribution of the crumb, as well as volume of the loaf. Slices are position 1. A = 0% barley, B = 20% barley, C = 30% barley, and D = 50% barley.

tribution, coarseness of crumb, and shape (Figure 2). Tenderness, cohesiveness, and gumminess (Bourne, 1978) were evaluated using the compression cage attachment to the Instron Universal testing machine (Model 1130) at a crosshead speed of 50 mm/min., chart speed of 100 mm/min., range setting of 50 and a load cell of 50 kg. Cylindrical samples, 3.9 cm in diameter and 2.5 cm high, were compressed to 20% of their original size. Moisture content was evaluated on the Sauter Moisture Tester and Toppan Balance (FSNFSA, 1976). Results for all objective tests are reported in Table 2.

Table 2. Effect of Barley Flour Substitution for All-Purpose Flour on Objective Evaluation of Whole-Wheat Quick Breads.[a]

	Variation, % barley flour			
	0%	20%	30%	50%
Specific gravity	1.23	1.19	1.19	1.20
Loaf volume (cm^3)	721.7	760.0	715.0	733.3
Tenderness[b] (kg)	25.94a	30.00ab	31.50b	38.79c
Cohesiveness[c]	0.36	0.39	0.35	0.38
Gumminess[d] (kg)	9.45a	11.43ab	11.41ab	14.30b
Moisture content (%)	37.10	39.00	39.96	40.27

[a] All values are means of 3 replicates. Means followed by the same letter or without letters within rows are not significantly different at the 5% level.

[b] Tenderness = height of Instron curve I.

[c] Cohesiveness = ratio of area under Instron curve II: area under Instron curve I.

Sensory evaluation of the product was conducted by 12 volunteers from the students and faculty at the University of Tennessee, Knoxville. Individual panelists had varied experience and varied with replication. A consumer texture profile analysis ballot (Szczesniak et al., 1975), modified to include appearance, flavor, and overall acceptability parameters as well as texture parameters, was used to report the sensory evaluation. This technique allows the panelist to mentally visualize and describe the characteristics of an "ideal" product. Characteristics evaluated are indicated in Table 3 and Figures 3, 4, and 5. The "ideal" product and each sample were rated with respect to each characteristic on a 6-point scale ranging from *not at all* (0) to *very much so* (6). Samples that had been placed on white plates were coded with three-digit random numbers and evaluated under white light in individual sensory booths. Samples evaluated by each panelist were randomly selected, however, each received samples from the same location within the loaf for each variation within a replication. All samples were served at room temperature. Water was provided for rinsing. Each sample was one half of a 1.25-cm-thick slice of bread.

The experiment was replicated three times. Analyses of variance and Tukey's range test where appropriate were used to evaluate the effect of the substitution of barley flour in the basic formula at four different levels on physical and sensory characteristics of the bread.

After data from the study were evaluated, we concluded that the 30% barley level was the highest acceptable level for inclusion in the quick-bread product. The laboratory formula was increased for production of larger loaves and tested. The formula, which yields two 1-pound loaves of barley whole-wheat quick bread, is given in Table 4.

Table 3. Effect of Barley Flour Substitution for All-Purpose Flour on Sensory Evaluation of Whole-Wheat Quick Breads.[ab]

Characteristic	Ideal	0%	20%	30%	50%
Appearance: Crust					
Rounded	4.53	4.14	4.53	4.47	4.08
Uneven shape	2.19	2.69	2.28	2.53	2.69
Browned	4.47a	3.03b	3.00b	3.11b	3.83ab
Appearance: Crumb					
Light brown	4.08	4.53	4.14	4.03	4.03
Coarse grain	3.39	3.64	3.64	3.42	3.39
Even cell distribution	4.58a	3.75b	3.16b	3.53b	3.17b
Compact	3.00	2.92	2.94	3.31	3.44
Texture					
Rough	2.84	2.94	3.17	3.19	3.58
Tender	4.58a	4.47ab	4.06bc	4.03bc	3.83c
Firm	3.72a	3.92ab	4.14ab	4.14ab	4.33b
Crumbly	2.94	2.67	2.68	2.78	3.08
Gummy	2.14	2.78	2.61	2.67	2.47
Moist	4.56a	4.58a	4.28a	4.22a	3.61b
Dry	2.14a	2.39a	2.67a	2.47a	3.31b
Good	5.56a	4.67b	4.44b	4.42b	4.14b
Flavor					
Sweet	3.64	4.69	4.42	4.42	4.11
Strong	3.05	2.75	3.08	2.89	2.97
Sour	1.58a	1.11b	1.28ab	1.39ab	1.39ab
Good	5.69a	5.03b	4.39c	4.50c	4.19c
Overall Acceptability					
Appearance	4.94	4.69	4.56	4.67	4.58
Texture	5.33a	4.86ab	4.47bc	4.36bc	4.03c
Flavor	5.58a	4.78ab	4.42b	4.53ab	3.97b

[a]0 = not all all, 6 = very much so.

[b]Means followed by the same letter within rows are not significantly different at the 5.0% level according to Tukey's range test. Least squares means of 3 replications.

Table 4. Basic Formula for 30% Barley Whole-Wheat Quick Bread.[a]

Ingredient	Amount
Barley flour	1 cup + 3 tbsp.
All-purpose flour	¾ cup + 1 tbsp.
Salt	2 tsp.
Baking powder	2 tbsp.
Granulated sugar	1½ cups
Unsifted whole-wheat flour	2 cups
Beaten eggs	2
Whole milk	2 cups

[a]Formula is designed for household or consumer use. Produces 2 1-pound loaves. Mix as indicated in Materials and Methods section. Grease 2 8½×4½×2½-inch loaf pans. Bake at 375°F for approximately 50 minutes.

RESULTS AND DISCUSSION

Barley and whole-wheat quick breads exhibited good volume and a rounded crust. Hart and coworkers (1970) reported a lack of oven spring on further rising in barley yeast bread during baking, while Landerberger and Morse (1918) indicated that lowering the pH of the dough to 5 was necessary to obtain acceptable volume. However, in this study barley whole-wheat quick breads exhibited rising during baking, as reflected in Figure 2, without the addition of gums or the manipulation of pH. Specific gravity values (Table 2) failed to indicate significant differences among the batters containing different levels of barley. Lack of difference in specific gravity values was reflected in volume measurements. As levels of barley increased from 0 to 50%, no significant differences were found in loaf volume as measured with the loaf volumeter (Table 2). Barley breads exhibited domed crusts as seen in Figure 2 and reflected in panel scores for rounded crust (Table 3). Crusts did not differ with respect to uniformity of shape (Table 3).

Brownness of the crust of barley whole-wheat quick bread was significantly different from the perceived brownness of the "ideal" quick bread at the 0, 20, and 30% levels, reflecting expectation of darker crusts than were encountered with the lower barley levels. However, the bread containing 50% barley did not differ significantly from the "ideal," indicating that it was nearer the color anticipated by the panelists. Unlike crust color, sensory scores for light brownness of the crumb did not differ among samples. The crumb of quick breads is coarser, with a more uneven cell distribution, than yeast breads, since the formation of the gluten structure and the incorporation of air during mixing is reduced. Sensory scores for whole-wheat quick breads prepared with different levels of barley flour did not differ for coarseness or roughness of the crumb grain (Table 3), although the cell distribution of each sample was not as even as anticipated by the panelists (Table 3; Figures 2 and 3). Compactness of the samples did not differ (Table 3), reflecting similarities in volumes of the samples (Table 2, Figures 2 and 3).

Satisfactory volume was achieved although starch content of the barley whole-wheat breads is lower than is normally characteristic of quick breads due to the incorporation of higher-protein lower starch wheat and barley flours.

Increasing the percentage of barley flour in the basic formula resulted in a significant decrease in tenderness, reflecting the decreased starch content. The decrease in tenderness was identified by both objective measurements (Table 2) and sensory evaluation (Figure 4, Table 3) of the products. Additionally, increase in sensory scores for firmness (Table 3, Figure 4) also is reflected in decreased tenderness. However, cohesiveness of the products was not altered significantly by incorporation of increasing amounts of barley flour (Table 2). Sensory evaluation of the quick breads indicated no significant differences in the strength of internal bonding as indicated by scores for the crumbliness parameter (Table 3). These results indicate a lack of gluten network development, even though protein content of the bread is increasing. However, the increase in the amount of protein that is hydrated in the mixing process and then coagulated during baking, may result in a decrease in tenderness or increase in firmness.

While gumminess, which is related to the denseness that persists throughout chewing, is a characteristic associated with breads of poor quality, it was not found to be present to a great degree by sensory panelists and no significant differences were found with increasing barley content (Table 3). Products that exhibit gumminess are characterized by a high degree of cohesiveness and tenderness (Civille and Szczesniak, 1973). Such products are usually high in starch content. The barley whole-wheat quick breads produced in this experiment have a reduced starch content and higher protein content, resulting in a product that has a low degree of cohesiveness and a correlative reduction in the level of tenderness. Therefore, the results obtained when determining gumminess by multiplying the tenderness and cohesiveness values from Instron measurements (Bourne, 1978) indicate a significant difference in gumminess as is seen in Table 3. However, this method of determining gumminess is actually reflecting the decrease in tenderness, rather than an increase in

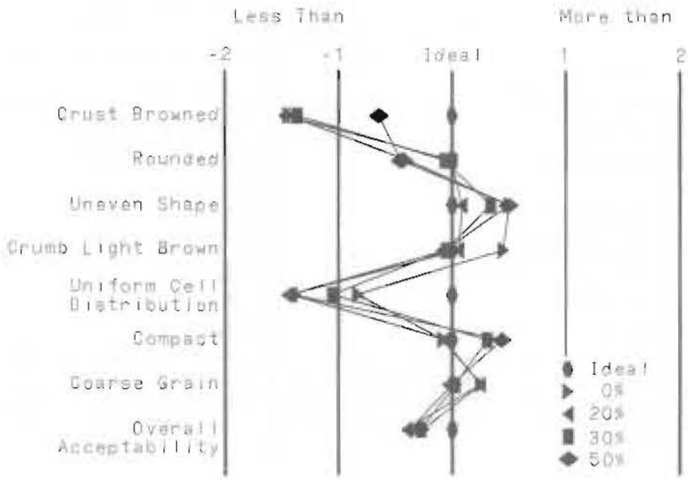

Figure 3. Consumer Appearance Profiles for barley whole-wheat quick bread and the "ideal" whole-wheat quick bread. Results are presented as deviations from the score for the "ideal" product.

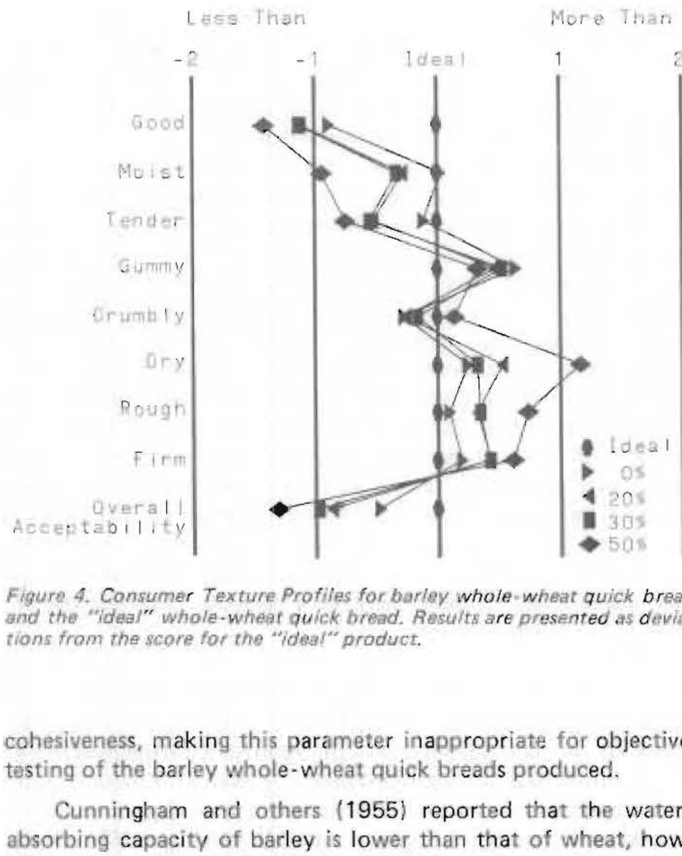

Figure 4. Consumer Texture Profiles for barley whole-wheat quick bread and the "ideal" whole-wheat quick bread. Results are presented as deviations from the score for the "ideal" product.

cohesiveness, making this parameter inappropriate for objective testing of the barley whole-wheat quick breads produced.

Cunningham and others (1955) reported that the water-absorbing capacity of barley is lower than that of wheat, however, no statistically significant differences in percent moisture content were found with increased incorporation of barley flour (Table 2). Sensory scores for moist and dry parameters decreased and increased respectively as barley increased (Table 3). Although the percent moisture content did not differ among variations, the relative proportion of the components responsible for holding the moisture did differ. Differences in release of moisture by these components may result in variations in moisture or dryness of the crumb as perceived by the sensory panelists. While texture scores for all samples were better than the

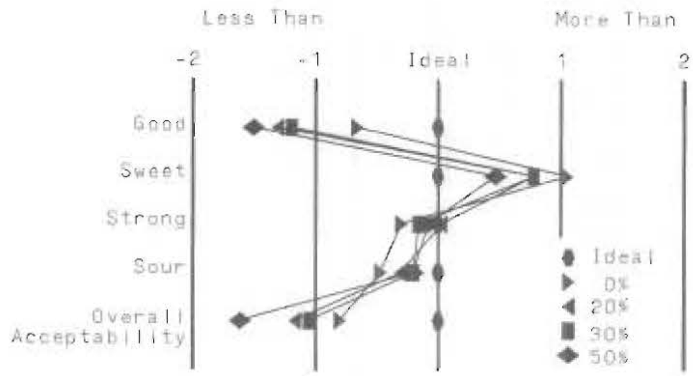

Figure 5. Consumer Flavor Profiles for barley whole-wheat quick bread and the "ideal" whole-wheat quick bread. Results are presented as deviations from the score for the "ideal" product.

midpoint on the *good* scale, they did differ from the "ideal" (Table 3, Figure 4), reflecting deviations from the "ideal" for several textural parameters.

Barley breads have been described as being sour and strong in flavor (Landenberger and Morse, 1918). Landenberger and Morse (1918) added salt to the 2% level to produce a less sour product. The formula used in this study contained less than 1% salt. However, the sugar content of quick breads is higher than that in yeast breads, and sugar also can depress sourness (Amerine et al., 1965). Sensory panelists found the degree of sourness in the breads containing barley flour to be nearer to the "ideal" than the degree of sourness found in whole-wheat quick breads. No significant differences in the sweetness or strongness of the flavor were found by the sensory judges. While the flavor of each bread was rated above the midpoint value on the scale, significant differences in goodness, i.e. the judge's overall impression, of the flavor were found. None of the variations was rated as having a flavor as good as anticipated, and the flavor of bread containing no barley flour was rated higher than any of those containing barley flour (Table 3, Figure 5).

Overall acceptability of quick breads made with barley flour differed with the parameter being tested. No significant differences were found for appearance, although significant differences in the brownness of the crust and even cell distribution were found when individual appearance parameters were evaluated (Table 3). Thus, the overall appearance of quick breads containing 0, 20, 30, and 50% barley flour is acceptable. The overall acceptability of the texture of the products differed with variation in barley content. All variations, except the bread containing 0% barley flour, were significantly different from the "ideal;" however no significant differences were found between the 0% level of barley flour and variations made with 20 and 30% barley. At the 50% level, significant differences in texture from the other breads containing barley were found (Table 3). These differences also were found in the objective evaluation of tenderness (Table 2). Overall acceptability of flavor at 0 and 30% was not significantly different from the "ideal." Significant differences were found at the 20 and 50% level (Table 3), indicating that a linear relationship is not found between the percent barley flour present and flavor acceptability. Perhaps the overall acceptability of flavor is related to the interrelationship of several unknown factors in addition, to that of the percentage of barley flour.

SUMMARY

The consumer texture profile analysis technique allows for graphic presentation of the data obtained from sensory evaluation of the products. By plotting the values obtained as deviations from scores assigned to an "ideal" product, it is possible to view graphically the characteristics being tested, as seen in Figures 3, 4, and 5. Negative values indicate that the specific characteristic tested was not as high as expected by the panelist when he/she mentally visualized the "ideal." Positive values indicate that the characteristic was present to a greater degree than expected. Overall deviations from the "ideal" by the characteristics tested were small, however the degree of deviation differed with the variation and the parameter evaluated.

Thus, whole-wheat quick bread in which Tibet Hulless barley flour is substituted at the 30% level (Table 4) is an acceptable product when appearance, texture, and flavor are evaluated. Substitution above that level results in decreased flavor acceptability and a decrease in moistness, therefore levels above 30% are not recommended. Further studies involving analysis of gluten content, functionality in yeast breads, keeping quality of the bread, effect of aging the flour, and village processing methods are indicated.

Editor's Note: The University of Alaska has no home economics department or other facilities for evaluating the suitability of Alaska grains for use in baked products. Mrs. Swanson was encouraged by members of the staff at the Agricultural Experiment Station to test Alaskan barley in her graduate work at the University of Tennessee. The Agricultural Experiment Station also supplied the barley used in the study reported here.

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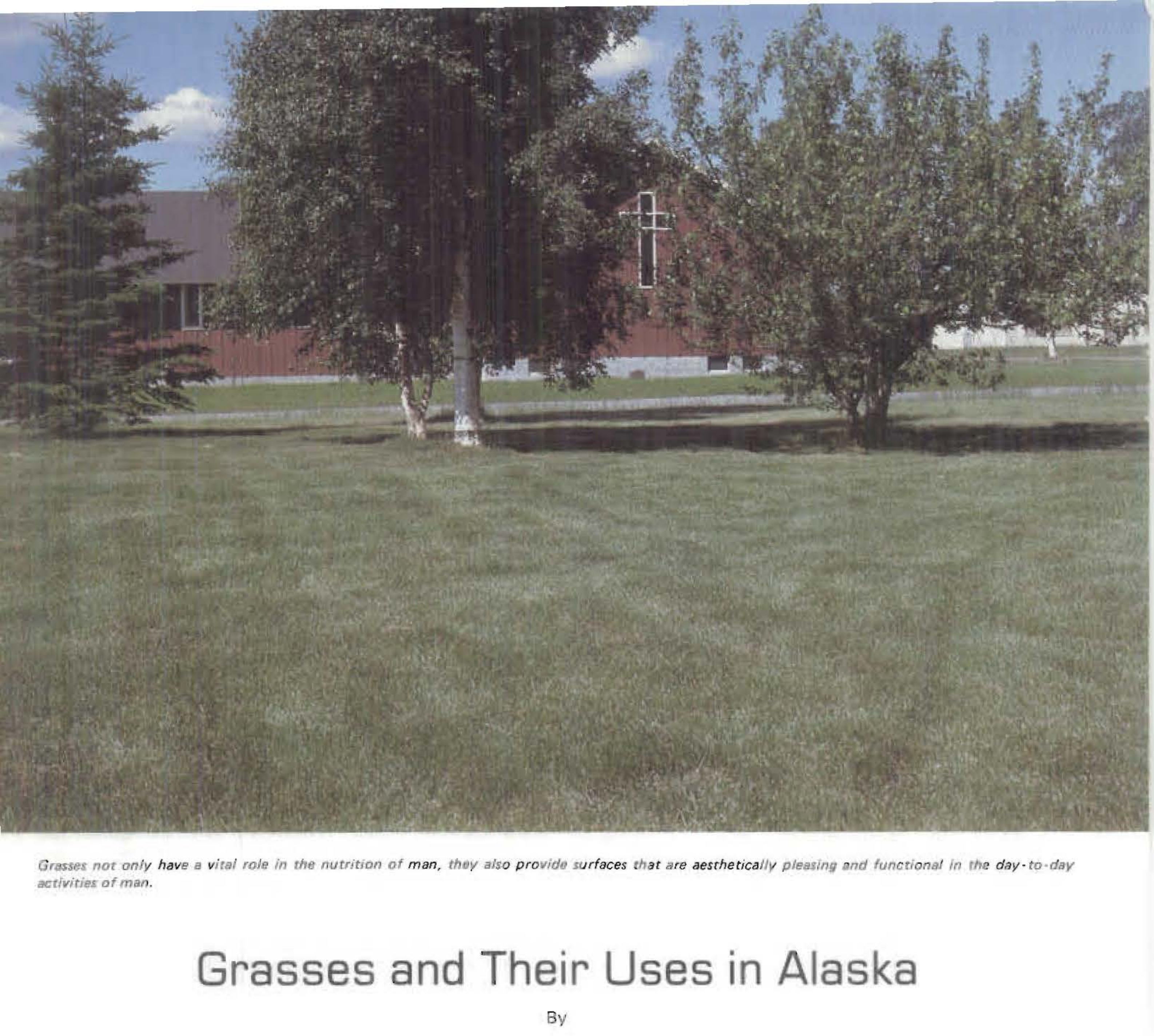

Grasses not only have a vital role in the nutrition of man, they also provide surfaces that are aesthetically pleasing and functional in the day-to-day activities of man.

Grasses and Their Uses in Alaska

By

William. W. Mitchell*

Grasses are among those things that are easily taken for granted. They are ubiquitous, sometimes commanding attention by their abundance or dominance, sometimes unobtrusively wedging their way in niches to comprise a minor portion of the flora, or springing forth when the opportunity arises to occupy an area formerly vegetated by trees or some other plant form. This versatility of grasses, with many adapted to tolerate cropping or mowing, and their ability to provide nutritious foodstuff in the seed or forage form have been critical to the development of mankind.

Mankind relies either directly or indirectly on grasses for many of the staples in his diet. All of the cereals, such as corn, wheat, rice, barley, and oats, are grasses. Animals graze grasses throughout the growing season and feed on grass hay and silage through the winter, thereby converting plant material into high-quality protein sources, such as meat, milk, eggs, etc. The future of mankind depends to a large extent on how well he manages his grasslands and grass products.

The extensive, finely ramified root systems and top-growth litter of grasses are important soil builders that have contributed to the quality of some of the world's most fertile soils. The foliage of some grasses provides an excellent healing cover on scarred land surfaces. The growth habit of certain grasses, by permitting repeated mowings that produce a manicured appearance and vegetative carpet, affords us aesthetically pleasing and functional surfaces for yards, parks, athletic fields, etc.

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Alaska is more noted for its taiga (boreal forest), tundra, and coastal forest vegetation types than it is for its grasslands. Grasses play important roles, however, within these natural systems and are assuming greater importance in cultivated and other managed systems. This paper concerns the grasses most involved in direct use by man or his animals with recommendations on the use of those judged to be best adapted to our northern latitudes. Though grasses appear to grow with ease, "it ain't always that easy" to obtain the kind of cover that is desired or required for a particular purpose. Selectivity is necessary for success and there are fewer plant materials adapted for use in the North than for the more temperate regions.

NATURAL GRASSLANDS

The natural grasslands most utilized by man in Alaska occur in the southcentral and southwestern regions, where livestock are grazed in the Matanuska-Susitna Valley region, Kenai Peninsula, Kodiak Island, and on the Aleutian Islands. Some extensive stands of native bluejoint reedgrass (*Calamagrostis canadensis*) have been the chief attraction. This is a tall grass that is both grazed and harvested for stored forage. With constant grazing, however, it is often replaced by other grasses, sedges (*Carex* sp.), and forbs. On the Aleutian Islands, bluejoint is less abundant, and other grasses, particularly Bering hairgrass (*Deschampsia beringensis*), and the grass-like sedges become more important. Various tundra regions receive considerable grazing use by herds of caribou and by reindeer (domesticated caribou) concentrated principally in the Seward Peninsula area of northwestern Alaska. Tundra types may include more sedges, forbs, and shrubs than grasses. Polargrass (*Arctagrostis latifolia*) and bluegrasses (*Poa* sp.) are some of the more important grasses affording grazing in tundra regions.

Much of Alaska's grasslands and potential grasslands (cleared shrub and forest lands and drained bogs) remain unutilized or underutilized by livestock or for forage production. Some of these areas have medium to high productive capabilities. Tall-growing bluejoint stands are indicative of sites with high productive potential. Over 2 tons of dry matter per acre have been obtained from native stands of bluejoint in early July. Persistent use by grazing or mechanical harvesting requires proper management, however, to sustain healthy growth. With good management, forage yields of 1½ tons or more per acre have been maintained.

GRASSES RECOMMENDED FOR SEEDING

The difference between success and failure for a planting often is determined in the planning stage when the seed is chosen. Making that choice generally involves a determination both of species and of particular variety, or cultivar, within a species. Named varieties have predictable characteristics because they originate from breeding material of known quality. The integrity of that breeding material is maintained by the breeder or some designated agency. For seed to be grown and sold under a variety name, it must be inspected and certified by the proper agency. Examples are 'Nugget' and 'Merion' Kentucky bluegrass and 'Manchar' bromegrass. Seed sold without a variety name, such as common Kentucky bluegrass, cannot be traced to known breeding material and therefore is without predictable characteristics. Such seed can be expected to be inferior to recommended varieties.

Experiment stations throughout the United States have continuing programs in which varieties are tested for their application for different purposes. Because of the size of our state and the few researchers available, less is known about varietal applications in Alaska than for other states. The following represents the opinions of this author about grasses that should be used for various purposes.

FORAGE GRASSES

The major forage seedings in Alaska are comprised of either smooth bromegrass (*Bromus inermis*) or timothy (*Phleum pratense*).

Bromegrass is recommended for soils in forested regions with pH 5.5 or greater. This is a generalization for which there may be exceptions, but my experience indicates brome plantings should be confined to soils above pH 5.5. Bromegrass is the principal perennial forage in the Tanana and Matanuska Valleys. The preferred varieties are 'Polar' or 'Manchar.' 'Carlton' is an alternative. Other varieties of northern origin may have application but have received little testing. Polar was developed at the Alaska Agricultural Experiment Station from material of *Bromus inermis*, an introduction, and *B. pumpellianus*, a native brome. Manchar was developed at Pullman, Washington, from material introduced from Manchuria.

Timothy is the major forage grass in the Susitna Valley, on some of the upper elevations of the Matanuska Valley, and in seeded fields of the lower Kenai Peninsula. Timothy tolerates acid soils, though liming may be necessary below pH 4.5. It is less well suited to dry sites than bromegrass. With sufficient moisture, timothy provides high first-cut yields, but regrowth is generally restricted after the first harvest, particularly on strongly acid soils. 'Engmo,' an introduction from northern Norway, is the recommended variety. If seed of that variety is not available, one may resort to 'Climax,' a Canadian cultivar. Others may become available in the future.

Other grasses used to lesser extents for forage in Alaska include meadow foxtail (*Alopecurus pratensis*), for which there are no named varieties, 'Garrison' creeping foxtail (*Alopecurus arundinaceus*), and reed canarygrass (*Phalaris arundinacea*), 'Frontier' variety, if available. Meadow foxtail will tolerate strongly acid soils but does not produce as well as timothy in the first harvest, usually June or July. It will lodge and become difficult to cut if heavy fertilization is used to promote high production. It has better regrowth capabilities than timothy. Creeping foxtail provides good growth on sufficiently deep soils that are not too acid. It should not be used on soils below pH 5.5. On soils above that, bromegrass is probably a better choice. Creeping foxtail may be better suited on sites difficult for bromegrass because of periodic inundation. Reed canarygrass can grow vigorously and tolerate acid soils but is considered too erratic in performance for recommendation here.

Grasses with good regrowth capabilities should be used for seeded pastures. These would include the turf grasses, Kentucky bluegrass (*Poa pratensis*) and red fescue (*Festuca rubra*), meadow foxtail, and bromegrass, which could be seeded in a mixture. Bromegrass could be omitted on acid soils. The recommended varieties of Kentucky bluegrass and red fescue will be discussed in the following sections on revegetation and turf grasses.

REVEGETATION GRASSES

Grasses adapted for agricultural purposes are also used in revegetation efforts. Bromegrass has wide application throughout the forested regions of Alaska on soils that are not too acidic. Brome often can be used successfully in areas with strongly acidic surface soils because seedings are conducted on the less-acidic subsoils of cutbanks and other disturbed sites. Thus, Polar or Manchar bromegrass is recommended for revegetation mixes throughout most of the boreal, forested region of interior to southcentral Alaska. They are not recommended for the North Slope region of Alaska's Arctic or other tundra habitats in alpine or coastal regions.

Red fescue is one of the most widely adapted species in North America, and is indigenous from the Arctic to Mexico. In Alaska, the species can be applied from the north coast to the southeastern coastal region. It is adapted to sites that are moist to relatively dry. The species is subject to injury by snow molds and other fungal diseases.

The variety 'Arctared' red fescue, released by the Alaska Experiment Station, is one of the hardiest grasses commercially available for use in our state. Arctared fescue is one of very few grasses recommended for the North Slope (the true Arctic) as well as for the boreal forested region and the alpine and western-to-northwestern, coastal, tundra regions. Actared fescue is a valuable grass for revegetation use. Second choices throughout the boreal forested region are the varieties 'Boreal,' a Canadian release, and 'Pennlawn,' a Pennsylvania release. Pennlawn and Boreal are first choices, however, along the southeastern and southern coastline, including the lower Kenai Peninsula, and throughout the Aleutian chain.

All of the above-named varieties are of the creeping form of red fescue and will spread by means of rhizomes to a limited extent. Seed sold as creeping red fescue without any other varietal distinction merely identifies it as being of the creeping type. It is the same as the class of seed sold as common; therefore, it cannot be traced to any particular breeding material and is probably poorly adapted. The chewings type of red fescue is a noncreeping, tufted type that is less hardy than the other recommended varieties of red fescue. 'Highlight' is a variety used in the Northwest. It may be adapted to the coastal regions of southern to southeastern Alaska.

Meadow foxtail also is widely adapted to Alaskan conditons, though it is not as hardy as Arctared red fescue. No named varieties are available at this time. It is recommended for revegetative use throughout all except the North Slope region of Alaska. Meadow foxtail can provide growth on some difficult peaty soils of the muskeg type where other grasses may fail. It also has been used with some success on difficult-to-stabilize clayey soils that are subject to solifluction. Its close relative, 'Garrison' creeping foxtail, is not as widely adapted, being strongly inhibited in growth on strongly acid soils (below ph 5.5). It can grow and spread vigorously on neutral to moderately acid soils where moisture is sufficient.

Kentucky bluegrass often is used in revegetation mixes with red fescue for roadside plantings, particularly where a low, turf-life appearance is desired. The species may be applied throughout most of the state. The preferred varieties are, first, 'Nugget,' an Alaska Experiment Station release, followed by 'Merion.' Others used in Alaska include 'Sydsport' and 'Park.' Insufficient information is available about numerous other varieties to allow for comment here. Nugget may be used on the North Slope, though it is marginal there. The other varieties are recommended only for regions south of the Brooks Range.

Timothy is adapted to acid soils but does poorly in droughty situations. It is best adapted for the more moist western, southcentral, and southeastern coastal regions and upper elevation, forested to low alpine regions. Timothy is not suited for the Arctic. 'Engmo' is the preferred variety with 'Climax' as second choice.

Other grasses that have been used for revegetation in Alaska include 'Durar' hard fescue (*Festuca longifolia*) and crested wheatgrass (*Agropyron cristatum*), varieties 'Nordan' or 'Summit.' These can be used on relatively dry sites that are not strongly acidic. They do not endure as well, however, as the bromegrass and red-fescue varieties, which also serve on dry sites. Some varieties and experimental materials of sheep fescue (*Festuca ovina*) that are currently being tested may find application in the future.

A wheatgrass that has shown some promise in revegetation trials on soils near neutral to basic in pH is 'Sodar' streambank wheatgrass (*Agropyron riparium*). It spreads by underground rhizomes, distributing stems without a lot of basal leafage throughout the occupied area. Despite its name, it appears suited for well drained, relatively dry sites in the boreal forested region.

Four varieties of grasses were recently released by the Alaska Agricultural Experiment Station that contribute to the very limited arsenal of plant materials that can be applied in the Arctic. All are based on collections of grasses that are indigenous to Alaska.

'Tundra' glaucous bluegrass (*Poa glauca*) consists of selections derived from material collected in arctic Alaska and is well adapted for arctic use on upland sites. It has afforded excellent cover on research plots for over 8 years. Tundra bluegrass is not recommended for use south of the northern treeline.

'Alyeska' polargrass (*Arctagrostis latifolia*) is based on a number of collections made throughout interior to western Alaska. It is better adapted to wet sites than Tundra bluegrass and is recommended for use in the Arctic as well as in the western to northwestern coastal tundra region and alpine tundra sites that remain snow covered through the winter.

'Sourdough' bluejoint reedgrass (*Calamagrostis canadensis*) also is based on a number of collections made through interior and western Alaska. Bluejoint reedgrass is probably the most abundant grass in Alaska, occurring in a wide range of habitats throughout the forested to coastal meadow and tundra regions of the state. There has been little seed made available of this variety because of difficulties in seed production. Once established, however, the grass performs well on a wide range of sites through the forested to arctic regions of Alaska. Both Sourdough bluejoint and Alyeska polargrass have low seedling vigor, and thus are at a disadvantage when seeded with more vigorous grasses. Seeding rates should be reduced to accommodate these grasses in mixes.

'Norcoast' Bering hairgrass (*Deschampsia beringensis*) was released in 1981, and the first planting was made by a private grower for commercial production. Components of this variety were used for revegetation of disturbances on Amchitka Island in the Aleutian Islands. They also have done well in reclamation trails on Iceland and in moist-to-wet situations at Prudhoe Bay. Norcoast is recommended for use in maritime and coastal meadow and tundra situations; it also can be used in the Arctic. It is limited in use through the forested regions of Alaska because of its susceptibility to diseases, such as snow molds, that occur there.

TURF GRASSES

The two species best adapted for turf-grass use in Alaska are Kentucky bluegrass and red fescue. Private and public research agencies of several countries have released numerous varieties of these two species for that purpose, many of which have not been tested locally.

In turf trials at Palmer and in revegetation trials, the variety 'Nugget' has proved superior to other Kentucky bluegrasses tested. It is shorter growing than most turf grasses and provides a dense, attractively dark-colored turf. It resists the incursion of dandelions and other weeds better than other grasses and performs well with short mowing. It is relatively slow to green up in the spring, possibly because of the denseness of its growth. Other varieties that may be used include 'Merion,' Pennsylvanian in origin, 'Sydsport,' a Swedish release, and 'Park,' a Minnesota release. Park has been inferior to the other two in turf trials at Palmer. The named varieties are more expensive than common Kentucky bluegrass, but produce a superior turf. For economic reasons, seed of the more expensive varieties can be blended with common Kentucky to establish a planting. Over a period of time, the better-performing grasses should assume dominance.

Red fescue is finer leaved than bluegrass and, though rhizomatous, does not spread as vigorously as bluegrass. It is better adapted to drier and lower fertility regimes than Kentucky bluegrass. 'Arctared' is the recommended variety for use throughout most of Alaska. 'Boreal' and 'Pennlawn' are second choices. The latter two are recommended over Arctared, however, for the coastal regions of southcentral to southeastern Alaska. Blends of Arctared with Pennlawn or Boreal may be advisable in some situations.

A possible rationale for mixed plantings, including different varieties of bluegrass and red fescue, would be to provide a mix of tolerances that can protect against different diseases. However, one or two well-adapted entries will produce a more uniform appearance.

Chewings fescue, a tufted form of red fescue, appears in turf mixes sold in Alaska. It has been a poor performer in turf trials at Palmer and in many revegetation trials, as it is insufficiently hardy for Alaskan conditions. It possibly may serve in plantings along the coastal forested region out to the Aleutian Islands. 'Highlight' is a variety produced in the northwestern states.

Bentgrasses (*Agrostis* sp.) also occur in lawn mixes but often do not survive Alaska's winters. Because its growth habit permits extremely low mowing, creeping bentgrass is used on golf greens, where it receives special attention. Nevertheless, bentgrass varieties frequently must be reseeded after sustaining winter injury.

CONCLUSIONS

The above recommendations are necessarily based on trial results and observations in the relatively few areas where agriculture and research efforts are currently underway. The findings of other researchers, particularly L. J. Klebesadel, R. L. Taylor, W. M. Laughlin, H. J. Hodgson, and A. C. Wilton, have been important to the formation of these recommendations which remain, however, the opinions of the author.

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A field review of selection factors for potential sites is performed by outdoor-recreation specialist, Dr. Alan Jubenville, and Dave Densmore, environmental specialist.

Using the Recreation Concept Plan Technique To Assess Public Choice

By

Jo Feyhl* and Alan Jubenville**

INTRODUCTION

For many years, portions of the Upper Susitna River have been studied as a potential source of hydroelectric power, initially by the U. S. Bureau of Reclamation in the 1940s and later by the Corps of Engineers. As a consequence of these previous assessments, the Alaska State Legislature created the Alaska Power Authority in 1976 and directed it to begin detailed feasibility studies on the development of the hydroelectric potential of the Upper Susitna River. Proposals were sought in 1979 and the overall planning and evaluation contract was awarded to Acres American, Inc. The environmental assessment portion of the contract was subcontracted to Terrestrial Environmental Specialists, Inc., who, in turn contracted the School of Agriculture and Land Resources Management of the University of Alaska, Fairbanks, to develop the Report on Recreation Resources as stipulated under the Federal Energy

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Regulatory Commission License Application Exhibit E, Subtask 7 (Acres American, Inc., 1980).

Initial planning began in the late spring and early summer of 1980. The basis for such a planning effort is the concept that recreational planning, while controlling the general nature of development and minimizing undesirable impacts, has another equally important function — controlling the type and quality of recreational opportunity to be offered to the public.[1]

Since recreational opportunities in a given area provide the foundation of such a plan, it is necessary to first identify the opportunities in this particular area and describe them. The study team developed the "concept plan technique" for this purpose. The concept plan technique involves two basic steps. First, inventorying the resource in terms of opportunity settings that can be sustained over the long run and, second, assessing public interest for a range of recreational opportunities that are within the limits determined by the resource inventory.

THE PLANNING PROCESS

Located approximately 125 air miles north of Anchorage, 150 air miles south of Fairbanks, and 70 miles northeast of Talkeetna, the proposed Susitna project study area extends from the Denali Highway, upstream, to Gold Creek, downstream. The preliminary plans for the current proposal focus on a two-dam development scheme:a 635-feet-high, concrete arch dam at Devil Canyon and a 880-foot-high, earth-filled dam between Tsusena and Deadman Creeks. If built, these two structures would create elongated reservoirs with Devil Canyon Reservoir being more than 28 miles long and Watana Reservoir greater than 50 miles in length. They would average ½ to ¾ miles in width, except at Watana Creek where the reservoir would be nearly 6 miles wide (Figure 1).

The recreation planning effort encompasses the immediate reservoir areas, the possible access corridors to the dams, and any additional lands recommended for acquisition for recreational purposes. Although the project area offers a variety of recreational opportunities, it also poses some unique recreational planning problems — the steep, narrow canyon and the isolation of the area. In addition, there are no comparable projects within the region to use as a baseline for comparison of the human and environmental factors involved. The development of access into the area will have a significant influence on recreational planning. The location and design of such access, as well as the types of recreation facilities and the level of facility development, become critical to encouraging specific types of recreation opportunities and desired levels of use for an area.

From a broader perspective, recreation planning and the resulting development become, not ends in themselves, but a means of implementing a management program that stabilizes the type of opportunity being offered. Included in such a management program are clearly defined, emphasized opportunities and experiences to be offered, the choice and location

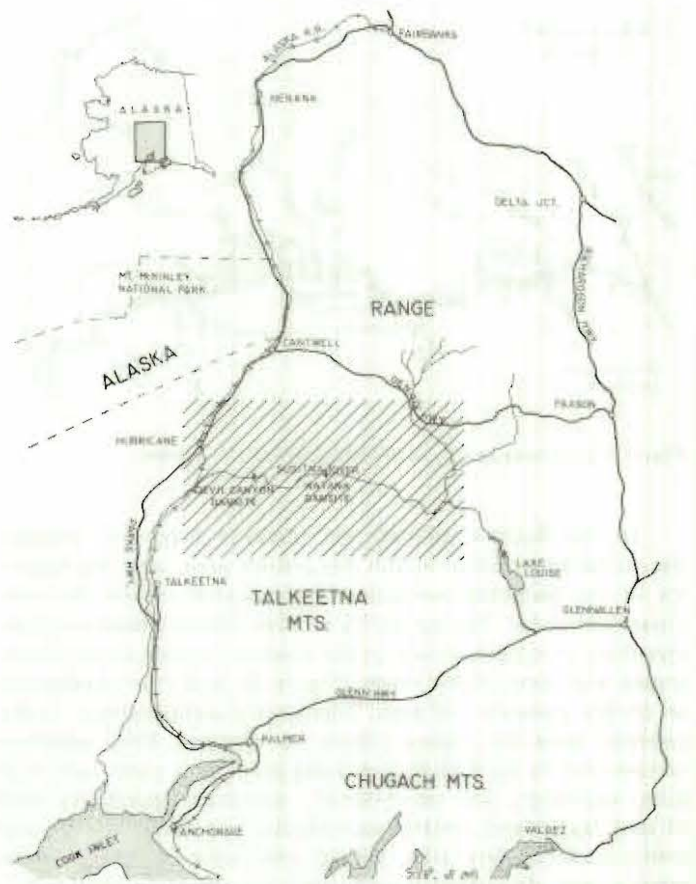

Figure 1. Location of the proposed Susitna Hydroelectric Project.

of site developments to achieve each particular opportunity with the fewest negative impacts, and the choice of management control to protect these experiences and reduce impacts that are impossible to eliminate through the planning effort.

Concept-Plan Technique

The concept-plan technique involves the development of a series of recreational concept plans that depict an array of opportunities that could be developed and managed for an area. These plans should be based on a resource inventory of possible opportunity settings in the area that would then be judged by a representative sample of possible users to determine their preferences. In theory, the final concept plan would then fit the resource and the preferences of potential users. Secondary opportunities, such as those offered by the small, natural lakes in the Susitna basin located adjacent to the proposed access roads, could also be developed, so long as they did not detract from those primary ones identified in the selected concept plan.[2]

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[1] The term, recreation opportunity, has been defined as "the availability of a real choice for a user to participate in a preferred activity, within a preferred setting for that activity, in order to realize the type of satisfying experiences which are desired." Thus, while the recreationist is mainly concerned with having a satisfactory experience, the goal of the recreation resource manager then becomes one of providing the opportunity for recreation experiences to take place (United States Department of Agriculture, Forest Service, 1980).

[2] The selected concept plan does not affect in any manner the decision to build or not build the hydroelectric project. The concept plan only reflects what is environmentally and recreationally suitable for the project area and the aggregate interest of the potential using public. If the project is approved and the decision is made to build the dams, the final recreation plan, based on this concept plan, will reflect the recreation opportunities available within the project area and the subsequent decisions on access and the design and operation of the dam facilities.

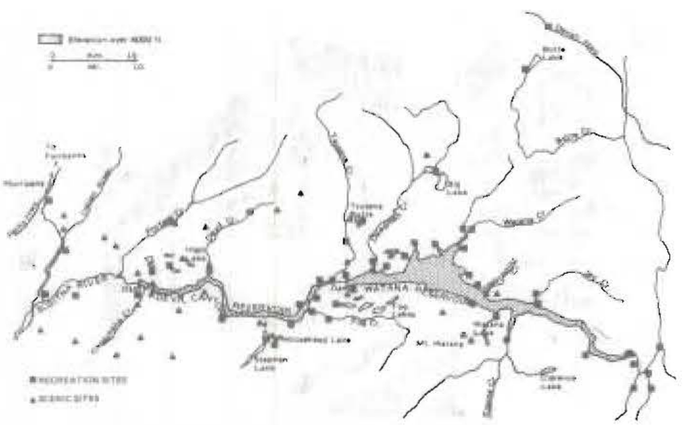

Figure 2. Locations and Type of Sites Selected for Review.

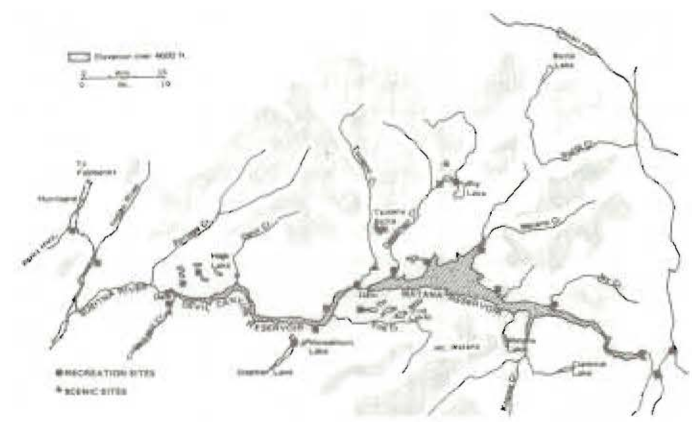

Figure 3. Sites Selected for Proposed Recreation Developments.

In the Susitna project, the resource inventory includes site-suitability studies within the project area, with the majority of the potential recreation sites located around the proposed reservoirs. The suitability studies involved developing an inventory of potential sites in the laboratory using aerial photographs and topographic maps (Figure 2), and then conducting an on-site evaluation of each. Topography and proximity to the reservoir were the original criteria for selection. Final selection factors used in the field included site stability (a combination of soils, vegetation, and topography), recreation desirability (size of area, lay of land, relative accessibility, and visitor safety), and scenic quality. Any sites judged unsuitable based on these criteria were eliminated from further consideration (Jubenville, 1980). The preliminary selection of potential sites for recreation development is shown in Figure 2 and the final selection of sites judged suitable on the basis of the field evaluation is shown in Figure 3.

Based on the results of the suitability studies, the next step was the development of a series of five concept plans that represented different scenarios of recreation opportunities, ranging from the purposeful avoidance of public facilities in combination with restricted access to the development of most of the identified potential sites (Figure 4, next page). These concept plans were then incorporated into a questionnaire that was mailed to a random sample of residents in Fairbanks, Anchorage, and the Railbelt, the locations of the majority of potential users.

The Concept-Plan Survey

The objective of this survey was to provide increased public participation in the concept plan selection process by identifing that portion of the recreation opportunity spectrum in which the majority of the public would prefer the recreation plan be focused.[3]

The questionnaire was sent to a random sample of residents of the above-named areas to determine their preferred concept and how the various types of users react to different proposals of access and facility development. This information is the essential underpinning of the total planning process since successive decisions are dependent on the nature of the selected concept plan. A follow-up postcard and a subsequent questionnaire were also mailed out in an effort to secure the desired number of responses.

A total of 502 questionnaires, 23% of the total mailed, were completed and returned; approximately the same number was returned by the postal service because the addressee had not provided a forwarding address. The total number received was considered adequate for analysis of the preferred concept plan. Chi-square analysis was performed on concept plan choice in relation to region where the respondent lived and his perceived lifestyle — urban, rural, or rural remote. There were no significant differences in choice based on region or lifestyle; therefore, the data were aggregated for analysis of the concept plan choice.

These aggregated data are shown in the following table.

Table 1. Results of Concept-Plan Survey.

Most Favored	Fairbanks	Railbelt	Anchorage	Total
Approach A	22	29	39	90 (17.9%)
Approach B	38	40	42	120 (23.9%)
Approach C	17	22	29	69 (13.6%)
Approach D	20	27	25	72 (14.3%)
Approach E	52	38	62	152 (30.3%)
Total	149	156	197	502 (100%)

INTERPRETATION OF RESULTS

Concept plan Approach A represented the purposeful avoidance of public access and facility development associated with the reservoir. This approach was favored by only 17.9% of the questionnaire respondents and for this reason it was eliminated from further consideration. This decision is also consistent with the relatively easy access to much of the area that

[3] The description of the Recreation Opportunity Spectrum or ROS has taken many forms but regardless of these descriptions, there usually exists a range of opportunity settings and conditions that stem from modern to primitive that is needed to fulfill the different needs, motivations and preferences of recreationists. The typical continuum often shows specific loci for modern, semimodern, semiprimitive and primitive opportunities (Jubenville, A., W. G. Workman, and W. C. Thomas, 1980).

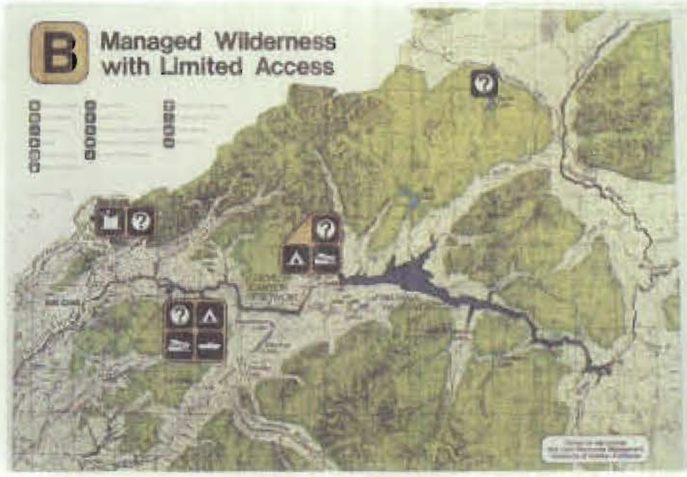

Figure 4. Concept Plans Representing the Spectrum of Recreational Opportunities for the Susitna Hydroelectric Project.

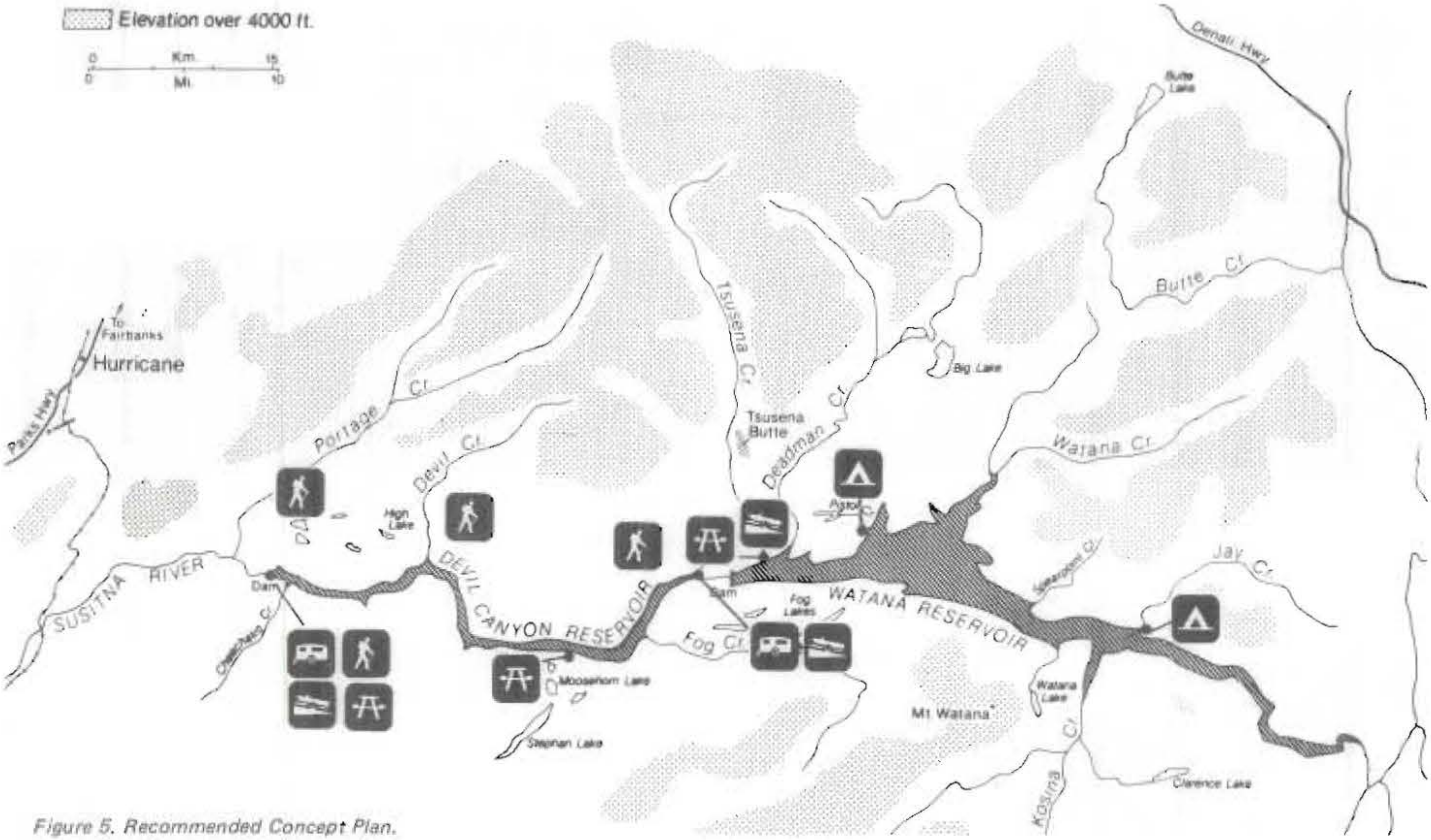

Figure 5. Recommended Concept Plan.

will probably result if access roads are built for the construction and maintenance of the dams. Any attempt to restrict access and manage the area as a primitive, recreational opportunity setting (wilderness), therefore, would be eliminated by the construction of such roads.

Approaches C and D represented compromises; in each case, one reservoir having more facility developments than the other, and Approach D being slightly more developed than Approach C. Most respondents were not interested in the mixture of low development at one reservoir and medium development at the other. As a result, approaches C and D were eliminated, even though each would have made possible the development and management of a variety of opportunity settings.

This left Approaches B and E as the primary choices to serve as the framework for the project Report on Recreation Resources. Neither choice was favored by a large proportion of the respondents. Approach E, representing the development end of the spectrum, was favored by a higher proportion of respondents, 30.3%. Approach B providing reasonable access but limited facility development associated with the reservoirs, was the second overall choice and was favored by 23.9% of the respondents.

Plans for a trail to the waterfalls on Devil Creek give visitors additional opportunities for participation.

Further analysis of the unsolicited comments from these questionnaires indicated that facilities should be developed and managed on an as-needed basis, starting with minimal facility services and expanding only when demand warrants it.

By combining the information obtained from the two steps of the concept-plan technique, a hybrid of Approaches B and E was selected as the recommended concept plan (Figure 5) that would meet the following criteria:

1. The developments proposed for the first three years will be essentially the ones shown in Approach B. Emphasis will be on rustic facilities and limited services. Primitive campgrounds located near the damsites will be designed to accomodate all types of users and permit future expansion.
2. After the first three years, long-term development will focus on the potential expansion of the campgrounds at the damsites, as well as a system of trails and boat-in campgrounds around the reservoirs. A delay in the development of the boat-in facilities will be necessary until the reservoirs are filled and the effects of shoreline stability and erosion can be evaluated.

3. In this manner, the semiprimitive opportunity setting will be maintained with an emphasis on rustic development and limited services. While initially the plan will be similar to Approach B, it could later be expanded through the development of boat-in facilities toward Approach E. This will also preserve the option of providing additional commercial services, such as a service station, camp store, or lodging. But only if such development can be shown to be economically feasible and designed to be recreationally and architecturally suitable to the opportunity setting.

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Notes

Dr. Donald E. Carling has joined the staff at the Palmer Research Center as an assistant professor of horticulture. A plant pathologist by training, Dr. Carling will be working with diseases and cultural practices for several vegetables and for potatoes. Before coming to Alaska, he was with the Virginia Truck and Ornamental Research Station, a state institution serving the ornamental and vegetable industries of eastern Virginia. Dr. Carling received a Ph. D. in plant pathology while working on mycoplasma diseases in plants and an M. S. based on his work with latent virus diseases in apples. Both degrees were received from the University of Missouri. The Carling family also includes wife Amy and the couple's two daughters, Adrienne and Silje. An outdoors enthusiast, Dr. Carling enjoys hunting, fishing and skiing, and so should feel right at home in the Matanuska Valley.

Dr. Carla Kirts has become the University of Alaska's first assistant professor of agricultural education. Dr. Kirts comes to the Alaska Agricultural Experiment Station from the University of Missouri at Columbia where she received her Ph. D. in agricultural education in 1981. She is one of only three women holding this degree nationwide. Dr. Kirts received her Bachelor of Science degree in agricultural education in 1976 and her Master of Science degree in vocational technical education in 1977, both from Virginia Polytechnic Institute and State University. While in Virginia, she taught vocational agriculture in a special program for disadvantaged students. Dr. Kirts sees her work in Alaska as threefold: she will be working with high-school and post-secondary teachers in vocational agriculture throughout the state; she will be teaching in the University of Alaska's bachelor of science program in natural resources management; and she will be assessing the need at the university for establishment of a degree program in agriculture or in agricultural education.

Dr. Stephen D. Sparrow, soil scientist with the Alaska Agricultural Experiment Station, has received a $191,000 grant from the Alaska Council on Science and Technology to conduct a three-year study entitled the "Fate of Fertilizer Nitrogen in Agricultural Soils in Interior Alaska." Cooperating with Dr. Sparrow in the study will be Charles W. Knight, Instructor of Agronomy. Work on the project will commence early in 1982.

The study was found to be necessary because increased agricultural development in Alaska has given rise to public concern that increased use of nitrogen (N) fertilizer will result in nitrate pollution of surface and ground waters. Also, with the increasing cost of fertilizer nitrogen, there is a need to find ways to minimize fertilizer N losses from soil and to maximize N-use efficiency by crops. The research will study the various transformations and fates of fertilizer N in Alaskan soils which affect loss of N from soil and utilization by plants. These include nitrification, immobilization and mineralization, leaching, and gaseous loss of N. The results wll be used to make recommendations to farmers and to policy planners on methods of management for best use of fertilizer nitrogen.

George R. Sampson, research forester, has become an affiliate assistant professor with the Alaska Agricultural Experiment Station. He is Alaska's only researcher with the USDA program, Forest Products Residue and Energy Program, and, as such, also works with the USDA's Institute of Northern Forestry, also on the University of Alaska campus.

Mr. Sampson came to Alaska from Ft. Collins, Colorado, where he was with the Rocky Mountain Forestry and Range Experiment Station. There, he conducted studies with the forest products utilization research work unit. He received his Bachelor of Science degree in 1960 in forest management from Iowa State University and a Master of Science degree in 1963 from the University of Delaware in the area of agricultural economics.

With his wife, Caroline, and children, Meg, Coleen, and Jeff, Mr. Sampson enjoys cross-country skiing, fishing, and hunting.

Dr. F. M. Husby was an invited speaker at a national seafood waste management conference titled "Seafood Waste Management in the 1980's" held at Orlando, Florida on September 24, 25, 26, 1980. The conference was sponsored by the University of Florida Sea Grant Marine Advisory Program. A paper entitled "Utilization of shellfish meals in domestic livestock rations," coauthored by Dr. A. L. Brundage and Robyn L. White, was presented.

Dr. Keith Van Cleve, Director of the Forest Soils Laboratory (AES) has returned from one year's sabbatical leave at Merlewood Research Station, Grange-over-Sands, Cumbria, United Kingdom. In his work there, he examined the techniques of nutrient analysis used at the Merlewood Research Stations Institute of Terrestrial Ecology.

Fertilizer Requirements for Barley Grown on Newly Cleared Land in Alaska's Interior

By

Gary J. Michaelson*, Frank J. Wooding**, and George A. Mitchell***

In 1978, the state of Alaska, in cooperation with private farmers, began large-scale agricultural development with the initiation of the 60,000-acre Delta Agricultural Project. This acreage will increase total land in crops by sixfold in Alaska and by eightfold in the Delta area (Brown et al., 1980).

Very little research information is available on crop-production requirements for this region. There is a need for more detailed information on the fertility of the newly cleared soils along with research on other phases of crop production. Because of the large-scale fertilizer investments which must accompany such development, information on fertilizer response is especially important. Fertilizer requirements for optimum crop yields in the first years of production are of special interest in Delta with so many acres being cleared and placed into production in a relatively short period of time.

In 1979, a 2-year study was initiated to provide farmers with basic guidelines for barley fertilizer needs on new agricultural land. The investigation involved testing the effects of the addition of the primary nutrients N, P, and K, individually and in combination, on yield and quality of barley.

Fertilizer trial plot area in spring of 1979, Tract F, Dennis Green Farm.

METHODS

Plot preparation began in May of 1979 on the Dennis Green farm, Tract F. The soil was a Beales silt loam (Typic Cryopsamment) which had been cleared in January of 1979 (Table 1). The native vegetation of this site was a mixed poplar-spruce forest. After clearing, the area was disked and rototilled and the larger roots removed by hand. The remaining organic surface litter was incorporated to a depth of approximately 4-5 inches.

Fertilizer treatments consisted of 0, 40, 80, and 120 pounds of N per acre: 0, 30, 60, 90 pounds of P per acre; and 0, 30, 60, and 90 pounds of K per acre. (All N, P and K rates are given in elemental form. To convert P to P_2O_5, multiply by 2.29, and to convert K to K_2O, multiply by 1.20.) All combinations of these N, P, and K rates gave a total of 256 plots. Nitrogen was applied as urea, P as triple superphosphate, and K as muriate of potash. To prevent possible sulfur deficiency, powdered elemental sulfur was applied to each plot at the rate of 21 pounds per acre. The fertilizer treatments were applied by hand and incorporated to a depth of 4 inches with a single pass of a rototiller.

The plots were seeded with Otra barley in five 10-ft. rows per plot with a 7-in. spacing. The seeding rate was 100 pounds per acre. Otra variety was used because it is relatively early maturing and has yielded well in long-term variety tests performed in the Delta area (Wooding et al., 1978). Each individual plot was reseeded and refertilized the same way in the 1980 field season.

In 1979, barley was planted May 26 and harvested August 21. An area 1.8 x 10 ft. was harvested by hand from the center of each plot and a mechanical thresher was used to thresh the grain. In 1980, barley planted on May 15 was harvested on August 20. An area 3.5 x 8 ft. was harvested from the center of each plot with a plot combine. Grain samples were taken from each plot for yield and protein determination. Grain subsamples

Table 1. Properties of Beales Silt Loam after Clearing and Before Fertilization.*

pH	O.M. %	N	P	K	C.E.C. Meq/100g	Sand	Silt	Clay
		– –ppm– –				– – –%– – –		
5.53	3.2	11	9.5	80	11	34	55	11

*pH determined by 1:1 soil-to-water method; O.M. by Walkley-Black; N (ammonium + nitrate - N) by 2N KC1 extraction; P by Bray P-1; K by neutral 1 N NH_4OAc extraction; C.E.C. by NaOAc method; and texture by Bouyoucos hydrometer method.

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*** Assistant Professor, Agronomy, Agricultural Research Center, Palmer.

were ground to pass through a 20-mesh screen and analyzed for protein N using a Technicon Autoanalyzer (Isaac and Johnson, 1976).

RESULTS AND DISCUSSION

High grain yields were 66 bushels per acre in 1979 and 74 bushels per acre in 1980. Figures 1 through 4 present the average responses to various N, P, and K combinations. The average overall grain yields were higher in 1980 than in 1979 (Figure 1). The rainfall during the two growing seasons was similar, with the Clearwater Station reporting 8.6 inches in 1979 and 9.3 inches for 1980 (April through September rainfall). The higher yields in 1980 may be attributed, in part, to increased soil levels of N, P, and K due to fertilizer carryover from 1979 to 1980 (Table 2). Relatively large differences in frost depth at time of planting were observed between 1979 and 1980. In 1979, with the land being newly cleared, the frost was 2 to 8 inches below the soil surface at time of planting, whereas, in 1980, a full year after clearing, the frost was more than 16 inches below the surface. The cooler, spring, soil temperatures in 1979, the year of land-clearing, may have retarded germination, root growth, and nutrient availability (Black, 1968) and contributed to lower overall yields.

Nitrogen. Grain yields were increased dramatically by the addition of nitrogen fertilizer both years (Figure 1). Approximately equal increases in yield were obtained with each 40-pound-per-acre N increment in the first year. In 1980, the second year after clearing, higher yields were obtained at each level of N fertilizer but the amount of increase in yield with more than 80 pounds per acre N applied was less.

In 1979, more fertilizer N may have been used by soil microbes in the breakdown of freshly incorporated organic matter, leaving less N available for grain production. This N immobilization process, in combination with the cooler initial soil temperatures after clearing, may have contributed to the reduced N response the first year.

Phosphorus. The native soil was deficient in P for higher levels of grain production. Thirty pounds per acre P produced relatively large increases in yield. Very little or no yield in-

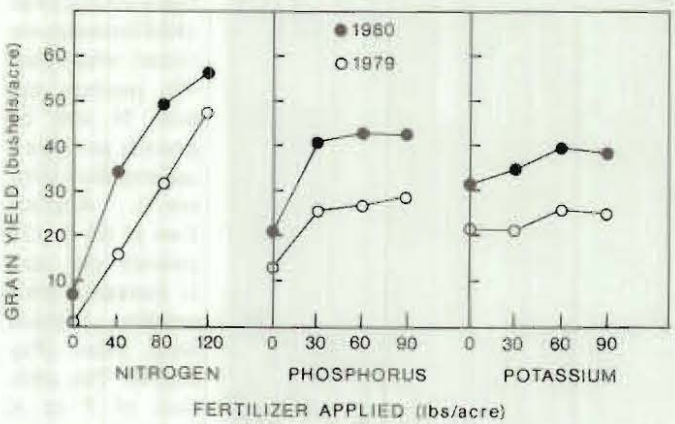

Figure 1. The effects of fertilizer N, P, and K on barley grain yields (each point represents the average of 64 observations). Least Significant Difference ($LSD_{0.5}$) = 3.1 bushels per acre.

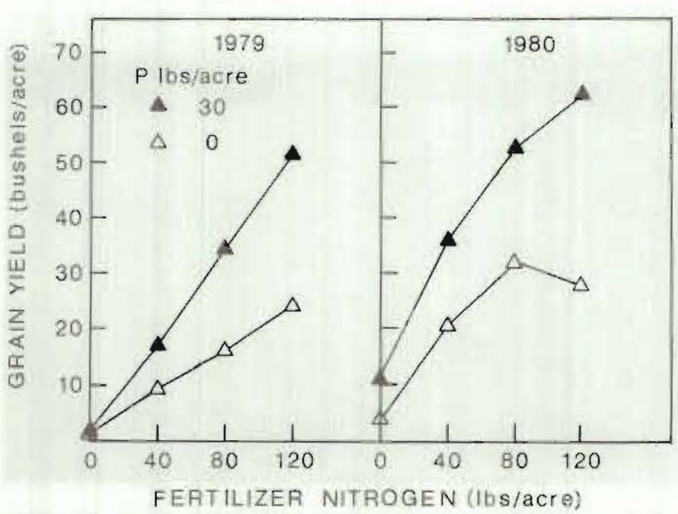

Figure 2. The effect of P on barley grain yield response to N fertilizer (each point represents the average of 16 observations). LSD = 6.1 bushels per acre.

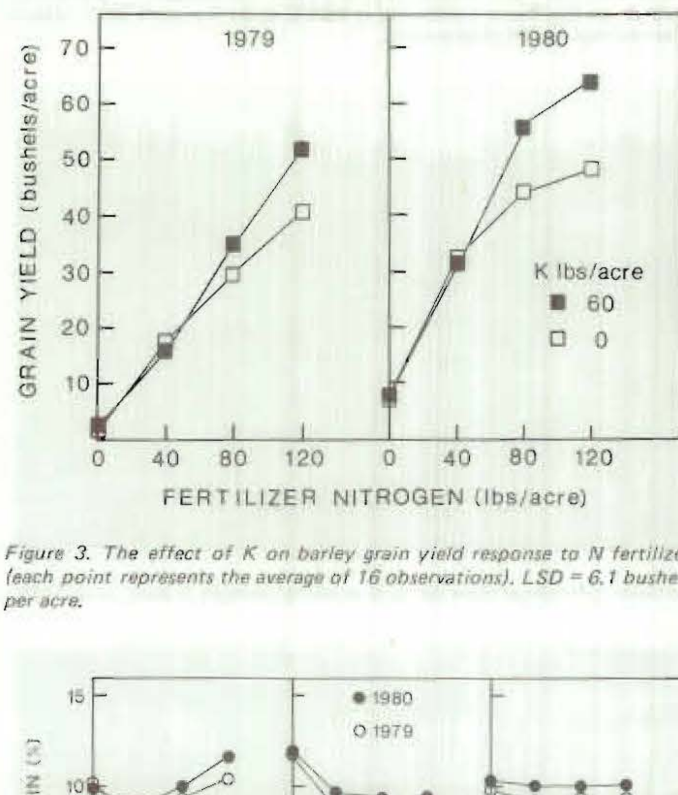

Figure 3. The effect of K on barley grain yield response to N fertilizer (each point represents the average of 16 observations). LSD = 6.1 bushels per acre.

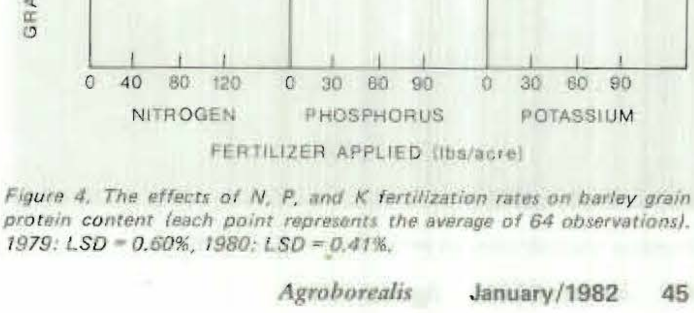

Figure 4. The effects of N, P, and K fertilization rates on barley grain protein content (each point represents the average of 64 observations). 1979: LSD = 0.60%, 1980: LSD = 0.41%.

Table 2. Initial Spring Soil-Test Levels (1979) and Spring Test Levels Prior to the Second Cropping (1980).

Plots		Soil Test Levels* (ppm)		
Fertilizer	Rate (lb/a)	1979	1980	Difference
		Nitrogen		
N	0	10 a**	16 b	6 b
	40	11 a	16 b	5 b
	80	11 a	18 a	7 a
	120	10 a	19 a	9 a
		Phosphorus		
P	0	8.8 a	3.3 c	-0.5 d
	30	9.2 a	13.9 b	4.7 c
	60	9.9 a	16.0 b	6.1 b
	90	10.2 a	23.5 a	13.3 a
		Potassium		
K	0	81 ab	64 b	-17 d
	30	74 b	70 b	- 4 c
	60	87 a	92 a	5 b
	90	79 ab	94 a	15 a

*Soil N determined by 2N KC1 extraction (values are ammonium + nitrate-N), soil P by Bray P-1 extraction, and soil K by neutral 1N NH_4-OAc extraction.

**Means within each fertilizer and each year not followed by a common letter are significantly different at 0.05 level by Duncan's MRT. Values are averages of 64 observations.

Fertilizer differences show up early as barley emerges in early June 1979.

Fertilizer trial plot area just before harvest in fall of 1979.

creases were obtained with greater P application rates (Figure 1). Phosphorus applied at 30 pounds per acre increased response to N fertilizer both years (Figure 2). Without P applied there was a drastic reduction in N fertilizer response.

Potassium. Grain yield was increased each year with the addition of K fertilizer. Potassium applied at 60 pounds per acre resulted in the highest yields (Figure 1) and was important in increasing yield responses to fertilizer N at the 80 and 120-pound-per-acre N rates. The addition of 60 pounds per acre K became even more important in the second year of production, the first year's production apparently having drawn on native soil K reserves (Table 2).

Grain Protein. There was an initial drop in protein concentration between 0 and 40 pounds per acre N and between 0 and 30 pounds per acre P applies (Figure 4). This protein drop was due to the dilution effect with the large yield increases obtained when both 40 pounds per acre N and 30 pounds per acre P were applied (Figure 1). Application of 40 to 120 pounds per acre N increased grain protein content both years (Figure 4). The addition of P or K had very little influence on grain protein.

Barley grown without fertilizer yielded very poorly, fall 1980.

Phosphorus fertilizer application affects both yield and maturity of barley. Both plots received 120 pounds per acre N but the plot on the right received no P whereas the plot on the left was fertilized with 60 pounds per acre P.

Individual heads of barley show differences in maturity and size for barley fertilized with 120 pounds per acre N and 60 pounds per acre P (left) and barley fertilized with only 120 pounds per acre N (right).

The highest yields were obtained with application of all three elements N, P, and K as in this plot which received 120 pounds per acre N, 90 pounds per acre P and 90 pounds per acre K.

Harvesting the fertilizer trial plots in August of 1980.

SUMMARY AND CONCLUSIONS

Nitrogen fertilizer increased grain yields up to the highest level applied (120 pounds per acre) both years. A greater response to the first 40-pound-per-acre increment of N and higher yield levels were obtained in the second year of production. A reduced positive response to N above 80 pounds per acre applied N was observed the second year of production. Grain protein content increased with application of 40 to 120 pounds per acre N.

Phosphorus applied at 30 pounds per acre was essential for significant grain yields and increased N responses both years. Phosphorus had very little direct effect on grain protein content. Potassium fertilization increased grain yields both years especially at higher rates of N fertilization (80-120 pounds per acre). An optimum rate of K fertilization was found to be 60 pounds per acre K. Sixty pounds per acre K was the most effective rate and was necessary to maintain native soil K levels. There was little direct effect of K on grain protein content.

The optimum fertilizer combination was 120 pounds per acre N, 30 pounds per acre P, and 60 pounds per acre K, which produced high yields with high protein contents.

As the newly cleared project soils are fertilized and cropped, soil tests will become more important in assessing optimum rates of N, P, and K fertilization. Work is currently underway to calibrate soil tests for Delta soils so they may be used in combination with fertilizer response information to more accurately predict fertilizer needs.

The Beales silt loam used in this study is only one of five major soil series occurring in the Delta Project. The natural fertility and response to fertilization may vary with location and soil. More research is needed on other project soils to assess soil variability.

ACKNOWLEDGMENTS

The authors would like to thank Dennis Green for the use of his land and his cooperation in this study. Also thanks to the Governor's Ad Hoc Committee on Agriculture and the Delta Project Administrators, Bob Pollock and Glen Franklin, for their support.

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Beefalo i

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Visitors to the University of Alaska Dairy Research Center at the Matanuska Research Farm are not surprised to see Holstein cattle in the modern dairy barn and adjacent pastures. After all, dairy research is about herd management, breeding and selection, nutrition, and other aspects of the dairy industry, and the registered Holstein herd is an important component of that research.

But, what about that small herd of cows standing on the hillside and in the lower pasture with their calves? Most are cream colored and none of them look at all like the Holsteins up at the dairy barn. Unlike the dairy herd, which spends the winter months pampered and sheltered in the barn, they spend the winter outside with a lean-to for shelter from the elements. Shelter does not seem to be a major consideration, for they do quite well outside in spite of wind and subzero cold that occurs in Southcentral Alaska. Neither do they appear to be bothered by rain or snow.

These animals are part of a small research project that started in 1975 when the first Holstein cow was artifically inseminated with frozen Beefalo semen from California. Beefalo — for some that conjures up images of a stockman's dream come true. By crossbreeding the American Bison with domestic beef cattle, the cattleman can have the hardiness under harsh conditions of the bison tempered with many of the desirable traits of domestic beef cattle.

It is a dream that started when Agriculture Canada initiated a species-crossing experiment with domestic cattle and North American bison in 1916 (Keller, 1978). That project started with sixteen cows and four bulls (all 25-75% bison) purchased from a private breeder in Ontario Province. It ended in 1964 with many questions about bison crossbreeding still unanswered. A prime question was, With high-performance purebred and crossbred domestic cattle, did the bison crossbreds provide sufficient advantage to outweigh some of the problems encountered in breeding and management? The answer was a qualified "no" if extreme hardiness is of lower priority under changing management systems and winter feeding patterns. It is also a qualified "yes" if animals are expected to fend for themselves in northerly latitudes where extreme cold and snow cover are common for long periods and where insect infestations occur. Cattalo, as they were called in Canada, exceeded Herefords in ability to withstand extremes in weather but were somewhat inferior in overall performance.

Stockmen, especially the Burton Brothers, on Kodiak Island read about similar studies being done privately in California by the Basolo family. These animals were called Beefalo and were 3/8 bison and 5/8 domestic beef — primarily Charolaise and Hereford. They were reputed to have the desirable combination of characteristics sought. The ranchers at Kodiak wondered if the Beefalo might be an answer, at least in part, to the harsh winters of Kodiak Island.

They asked Dr. Don Tomlin, the animal scientist at the Fairbanks Research Center, and me if we would help them investigate this possibility. Both Dr. Tomlin and I were skeptical about the claims made for Beefalo. He had only a small herd of beef cattle in his research program and so we agreed to breed selected Holsteins at the Dairy Research Center with Beefalo semen. Although this was expedient under our circumstances, using the Holstein in the cross did provide genetic components

Beefalo on late summer pasture at the Matanu

*Professor, Animal Science, Agricultural Research Center, Palmer.

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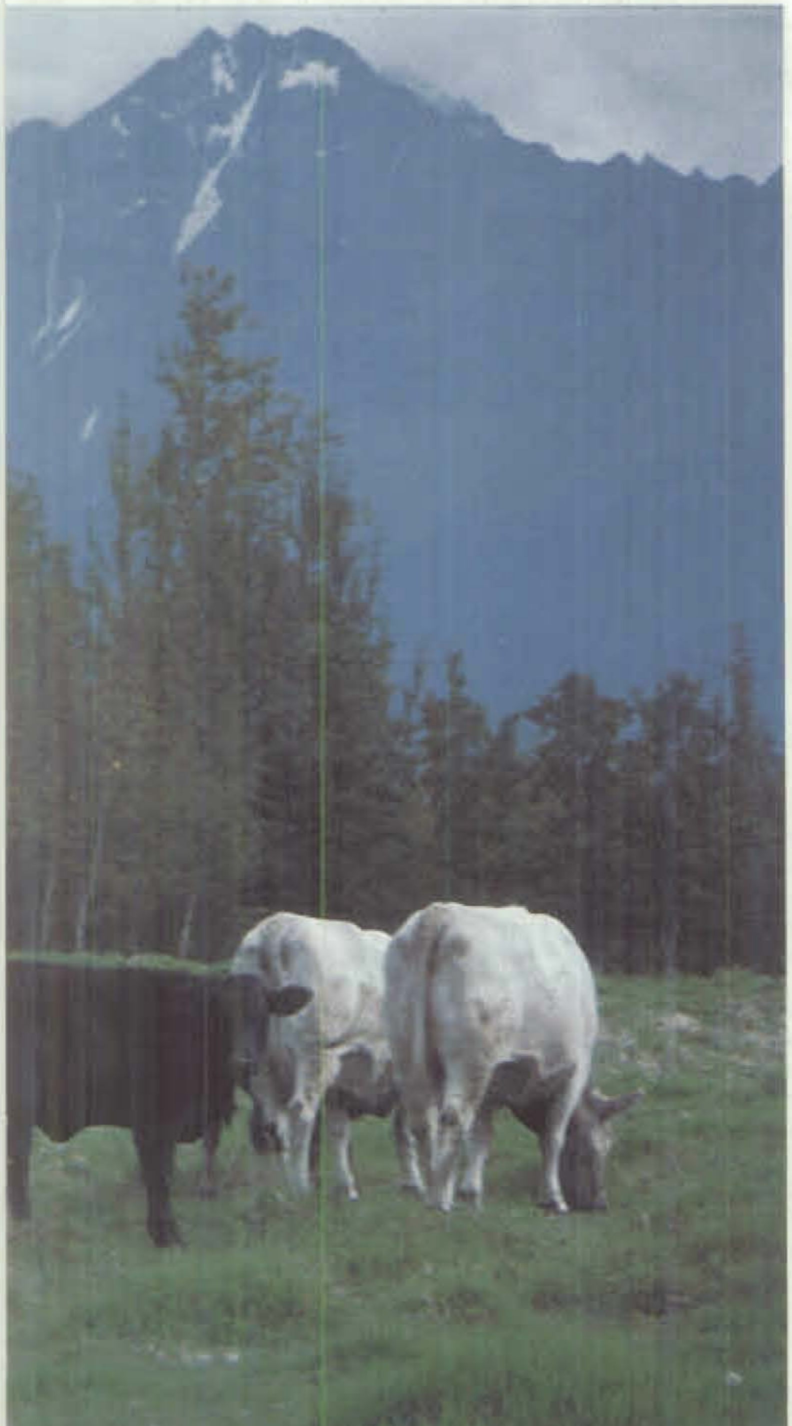

ska Research Farm. Not all are cream colored.

for size and milk production. This proved advantageous to dam and calf performance.

Our first crossbred Beefalo x Holstein was born on 7 February 1976, a bull calf. The second also was a bull calf, born 26 July 1976. Both bulls were sent to the Burton ranch on Kodiak in 1977. The first has survived the harsh Kodiak winters and has sired calves in the herd; the second was not a very desirable animal and did not live to sire offspring.

Five female Beefalo x Holstein crossbreds were born at the dairy center and formed the foundation of the present herd. Needing females to expand the herd and increase the genetic contribution of Beefalo, we instead have had seven 3/4 Beefalo bulls from mating Beefalo/Holstein back to Beefalo. Several of these have been leased to stockmen in Alaska for breeding purposes in their herds.

However, we also have one 7/8, two 3/4, and two 5/8 Beefalo females from our breeding program, making limited progress toward our original goal of developing a small herd of cattle with predominantly Beefalo breeding to be used in management and nutrition studies. The Basolo family is supporting this effort through the donation of Beefalo semen from their bulls.

Although of limited scope, our Beefalo-breeding program has several positive aspects. Interested people can observe these animals at the research farm under conditions of minimal shelter, instead of depending upon observations remote from Alaska. We have found these animals to be very hardy under our conditions and have successfully produced calves in all seasons of the year, including both wet and cold. Calves have gained in excess of two pounds daily from birth.

Heterosis, or hybrid vigor, must be considered an important factor when evaluating our results. The Beefalo is a species cross of American Bison and European breeds of beef cattle, and one would expect dominance and epistatic components of genetic variance to be significant relative to additive components. Heritability, in the narrow sense, is a function of additive effects only, and dominance and epistatic effects are not transmitted predictably from generation to generation due to random assortment and recombination of genes in the formation and union of sperm and ova to produce offspring. Therefore, one would expect that heterosis would become less important in determining Beefalo performance as lines are developed through intercross matings. However, our crossbreeding of Beefalo with Holstein reintroduces the real probability of heterosis as a significant determinant of animal performance. First-cross Holstein x Beefalo dams, having maternal heterosis for mothering ability and milk production, would support heterosis for vigor and growth performance possessed by second-generation, back-cross Beefalo calves. Heterosis, both maternal and offspring, will be of less significance as we continue to back-cross to Beefalo bulls and obtain a higher proportion of genetic material from Beefalo in our herd.

Finally, we have been able to place crossbred Beefalo/Holstein bulls at several livestock operations in Alaska. Six years is not a long time in terms of livestock breeding and we plan to continue this program with hopes of increasing Beefalo inheritance in our female population.

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Rapeseed Response

To Seeding Rate, Row Spacing, and Nitrogen Application

By

Carol E. Lewis* and Charles W. Knight**

Dr. Carol E. Lewis evaluates rapeseed fields to determine the most advantageous cultural practices for the Interior.

Since 1977, several studies have been conducted on rapeseed as a potential oilseed crop for Alaska. Results of these studies have shown that the yield and quality of rapeseed grown in Alaska is comparable to that grown in Canada (Wooding, 1978) where its value as a crop is exceeded only by wheat (Rapeseed Association of Canada, 1980). In these early Alaskan rapeseed studies, Canadian recommendations for cultural practices were followed. Recognizing the environmental differences between Alaska and Canada, further research was needed to verify that the same cultural practices were, in fact, appropriate for Alaska (Knight, Lewis, and Wooding, 1979).

Three cultural practices which are easily controlled by the farmer and which are most likely to affect yields are seeding rate, row spacing, and rate of nitrogen fertilization. Although seeding rate and row spacing could significantly affect rapeseed yields, these two variables have little effect on cost of production. Nitrogen fertilizer, on the other hand, is a major expense in crop production in Alaska. Therefore, it is to the farmer's advantage to know the application rate which will have the most effect on yield.

Superior rapeseed varieties exhibiting low concentrations of undesirable erucic acid and glucosinolates have recently been released in Canada. These varieties, marketed as Canola, are of special interest in Alaskan agriculture. The need to evaluate Canadian rapeseed cultural practices for application in Alaska is compounded by the need to reevaluate these cultural practices on the newly released Canola varieties.

Several studies have been conducted in Canada evaluating the effect of seeding rate on rapeseed yields. Researchers have considered seeding rates from 2 to 13 lb/acre with lower rates used for the smaller-seeded varieties (Lööf, 1972, Kondra, 1975). Overall, the effect of seeding rate on yield has been reported to be highly variable. At high seeding rates, rapeseed stands are thick and plants generate few lateral branches. Pods are set higher on the plant. The lower seeding rates result in fewer plants per given area but plants tend to compensate for this by branching and setting pods lower. The current Canadian recommendations for seeding are 4 to 6 lb/acre for the Canola varieties Tower, Regent, Altex, and Candle (Adolphe, 1974).

Rapeseed is sometimes grown as a row crop to provide spacing between the rows wide enough to allow mechanical cultivation. This practice is common in areas where herbicides are not widely used (Lööf, 1972). In areas where herbicides are applied as a normal practice, the crop is broadcast seeded or planted with grain drills or Brillion seeders in row spacings of 6 to 8 inches. Row spacings up to 24 inches have been compared in Canadian field trials. In research trials in 1971 and 1972, Kondra (1975) found the narrowest row spacing, 6 inches, resulted in the highest yield.

It is estimated that a 35-bushel-per-acre rapeseed crop will remove 118 lb/acre of elemental nitrogren from the soil (Bolton, 1980). Lööf (1972) reports that the crop's need for potassium and phosphorus is similar to that for cereal grains in most production areas. Based on these estimates, Bolton (1980) recommends applications of 100 to 125/lb acre of elemental nitrogen and 40 to 60 lb/acre each of P_2O_5 of K_2O for the Delta-Clearwater area in interior Alaska. The lower rates are recommended for conventional tillage and the higher rates are for minimum tillage.

METHODS

Cultural practices were compared for the Canola variety, Candle, in 1978 and 1979. The studies were conducted in the Delta-Clearwater area of interior Alaska near Delta Junction. Soils in the study area are Richardson silt-loam, and the land had been farmed for approximately 20 years prior to the study.

Study variables included all combinations of three seeding rates (3, 6 and 12 lb/a), two row spacings, (7 and 14 inches), and six nitrogen fertilizer rates (0, 50, 80, 110, 140, and 170 lb/a).

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All nitrogen was applied as urea (46-0-0). Triple super phosphate (0-45-0) and potassium sulfate (0-0-51) were uniformly applied at rates of 75 lb/a P_2O_5 and 50 lb/a K_2O respectively.

Although it is desirable to plant rapeseed on land that has been fallowed the previous year, suitable fallowed land was not available when this study was initiated. Therefore, in both 1978 and 1979, the rapeseed was seeded in a rotation following barley. All seedbed preparation and stubble incorporation was accomplished in the spring.

Herbicides to control broadleaf weeds, particularly, lambsquarter, are necessary in the Delta-Clearwater area. At present, no herbicide has been cleared in Alaska for use on rapeseed. An experimental clearance was received from the USDA Environmental Protection Agency to permit the use of the herbicide, Treflan, in this research.

Following a single disking in the spring which covered the preceding year's barley stubble, the Treflan herbicide was broadcast sprayed at a rate of 1 quart per acre (1 lb/a active ingredient). Following spraying, the plot area was disked again to incorporate the herbicide. Individual plots were then fertilized and the area was disked a third time at right angles to the prior diskings in order to incorporate herbicide and fertilizer. The area was packed with a roller packer to firm the seedbed and the plots were seeded with a Brillion seeder using seed tubes to place the seed in 7-inch rows. Fourteen-inch row spacings were obtained by plugging alternate seed tubes. Seeding in both 1978 and 1979 was done in the last week of May. In the fall, each plot was hand harvested and threshed using a stationery plot thresher.

RESULTS AND DISCUSSION

Early in the growing season in both 1978 and 1979, it became apparent that the 0 lb/ac nitrogen rate was too low and the 170 lb/a nitrogen rate was too high. Those plots receiving no nitrogen exhibited stunted, yellow vegetation and those receiving 170 lb/a nitrogen displayed very tall, green, vegetative growth. As the season progressed, the rapeseed receiving no nitrogen set very small pods and matured early. Rapeseed on plots receiving 170 lb/a nitrogen had pods of normal size, but only about 50% of the seed was mature at harvest. No visual differences were apparent for the rapeseed receiving nitrogen at the other application rates.

Average rapeseed yield response to each cultural practice is reported in Table 1. Yield responses to the three seeding rates and two row spacings were highly variable in both years. The rapeseed plants appeared to branch out and compensate for low populations or wide row spacings. Consequently, all seeding rates and row spacings resulted in similar yields. These preliminary results appear to indicate that Canadian recommendations of 4 to 6 lb/a seeding rates and 7-inch (narrow) row spacings can be used in the Delta-Clearwater area of Alaska with little effect on yield.

Table 1. Influence of Seeding Rate, Row Spacing, and Nitrogen Fertilizer Rates on Rapeseed Yield.

Main Plot Treatments	Fertilizer Rate (lb actual N/acre)					
	0	50	80	110	140	170
1978						
Seeding Rate	Yield (bu/acre)					
3 lb/acre						
7" row spacing	23.5	37.6	39.4	40.8	32.9	46.3
14" row spacing	31.2	31.2	42.1	32.7	44.5	36.9
6 lb/acre						
7" row spacing	24.4	36.6	37.2	38.6	40.4	44.9
14" row spacing	22.6	45.0	41.4	49.6	41.7	44.6
12 lb/acre						
7" row spacing	20.9	33.2	34.9	37.9	33.8	40.2
14" row spacing	22.0	41.0	41.2	52.6	38.0	43.6
Average	24.1	37.4	39.4	42.0	38.6	42.8
1979						
Seeding Rate						
3 lb/acre						
7" row spacing	30.7	30.2	31.7	35.8	38.7	35.7
14" row spacing	32.9	32.1	35.4	28.1	42.4	32.1
6 lb/acre						
7" row spacing	27.4	38.6	36.7	42.3	33.2	32.1
14" row spacing	30.2	38.8	33.2	34.1	31.6	37.1
12 lb/acre						
7" row spacing	28.1	37.2	34.6	36.5	30.0	40.5
14" row spacing	21.9	30.1	31.7	36.9	29.6	30.3
Average	28.5	34.5	33.9	35.6	34.2	34.6

Average rapeseed yields for all nitrogen rates were compared. There was a considerable yield increase from the 0 to 50 lb/a application rate. Above this rate, differences in yield were slight and variable. However, excluding the 170 lb/a nitrogen application, which did not produce mature seed, yields were highest at the 110-lb/a rate in both years.

CONCLUSIONS

These studies were conducted on Richardson soils which had been in production approximately 20 years. The soil at this site represents some of the deeper, more productive soils in the Delta-Clearwater area of interior Alaska. Current studies being conducted in this area indicate that crop responses to higher N applications might be expected on newly cleared lands or on land with shallower soils (Michaelson, 1981).

Rapeseed could be an important cash crop in Alaska. Although this study has led to some understanding of the crop's response to N application, seeding rate and row spacing, little is known about response to phosphorus, potassium, and sulfur in Alaskan soils. Studies such as that reported here could have substantial agronomic impacts on the production of rapeseed in the state.

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Vegetation Studies for the Proposed Susitna Hydroelectric Project

By

Dot Helm*

Range scientists at the Alaska Agricultural Experiment Station's Palmer Research Center have been studying vegetation for the Susitna Hydroelectric Power Project since the spring of 1980. The proposed Susitna Hydroelectric Project would involve building a dam or series of dams along the upper Susitna River in order to provide electricity to the railbelt area of Alaska. The first phase of feasibility studies is nearing completion to evaluate the proposed project for engineering, economic, and environmental considerations. One aspect of these studies is concerned with the plant ecology of the area and is aimed at determining the existing vegetation both upstream and downstream from the proposed dams, assessing the possible impacts of the project on the vegetation, and suggesting methods of mitigating such impacts. These studies will be of use both to the project and for furthering our knowledge of Alaskan vegetation.

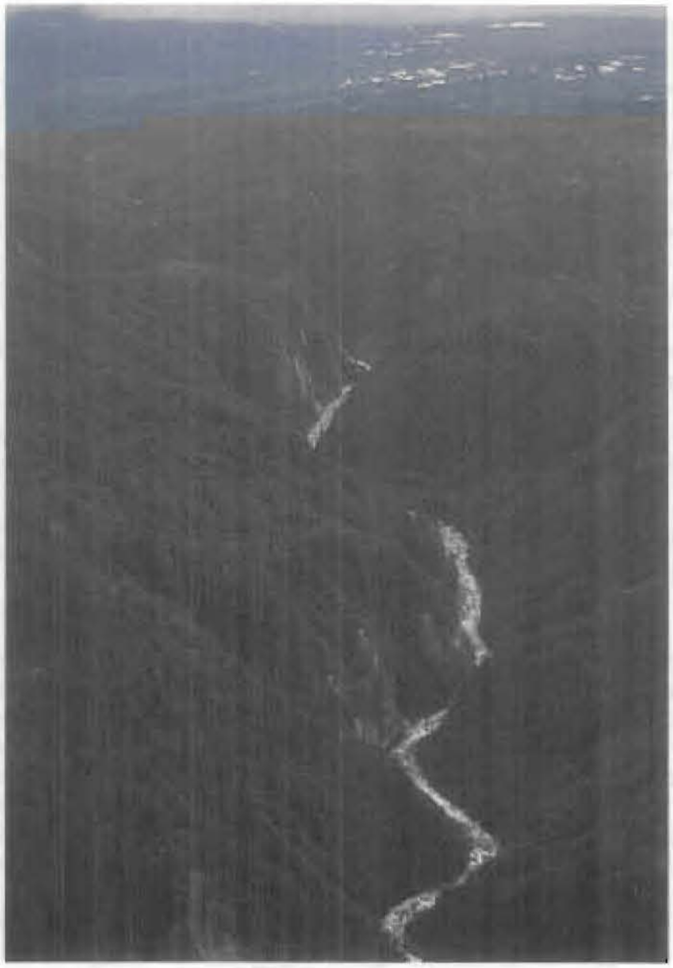

Figure 1. Closed mixed spruce and birch vegetation on steep banks of the Susitna River.

The first year's efforts concentrated on mapping the vegetation of the upper river basin, an area covering over 4 million acres, most of which is currently accessible only by aircraft or all-terrain vehicles. The proposed impoundment area is dominated by steep slopes with stands of spruce (*Picea glauca, P. mariana*), birch (*Betula papyrifera*), and alder (*Alnus sinuata*) (Figure 1). These areas have almost complete vegetation cover and a well-developed ground layer consisting mainly of herbaceous species with some shrubby plants. Benches above the river are covered with low-shrub and shrub-bog communities dominated by shrub species such as dwarf birch (*Betula glandulosa*) and blue-berry (*Vaccinium uliginosum*) (Figure 2). These areas have a less-developed ground layer which usually consists of shrubs. Sites at higher elevations contain sedgegrass tundra and mat cushion tundra vegetation (Figure 3). These well-drained areas usually contain low-growing herbaceous plants or matted shrubs. Glaciers and snow-capped mountains are the sources for many of the streams flowing into the upper Susitna River.

Previously obtained, color-infrared, aerial photography was useful in delimiting vegetation/habitat type boundaries and for interpretation of areas that were not field checked. Initially, personnel noted different textures and colors on the photographs which were believed to represent different types of vegetation. Coarse textures usually correspond to open forest types while fine textures represent herbaceous vegetation, for example (Figure 4). These areas were field checked in the early part of the season. As observers became more experienced with this vegetation, the types could be identified from helicopters. Outlines of the vegetation/habitat types were then overlain on USGS topographical maps in order to eliminate the distortion present in the photographs. Access corridors and transmission line corridors were mapped during the summer of 1981 by the same technique to provide vegetation information on these routes.

Another phase of the Plant Ecology Subtask was to evaluate the possible effects of the dams on the downstream vegeta-

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Figure 2. Low-shrub vegetation on benches above the Susitna River.

Figure 3. Sedge-grass tundra on rolling uplands of the upper Susitna River Basin.

tion as a result of changed river flows. This aspect is being addressed by studying the current vegetation and inferring what paths vegetation succession might have taken in the past. With some understanding of past vegetation dynamics, an estimate of future vegetation changes can be made for predicted flow regimes. A team of hydrologists is working on a model of the post-dam flows. Combining the two sets of information may provide an insight to possible post-dam impacts.

Many areas along the river are considered prime moose habitat which is maintained by constant reworking by the river. There is concern that a regulated river would permit the moose habitat (early-vegetation successional stages) to progress to a more advanced stage, thus reducing moose habitat. The regulated river would be expected to have lower flows in summer but higher flows in winter than the unregulated stream (Alaska Power Authority, 1980). The possibility of more ice damage

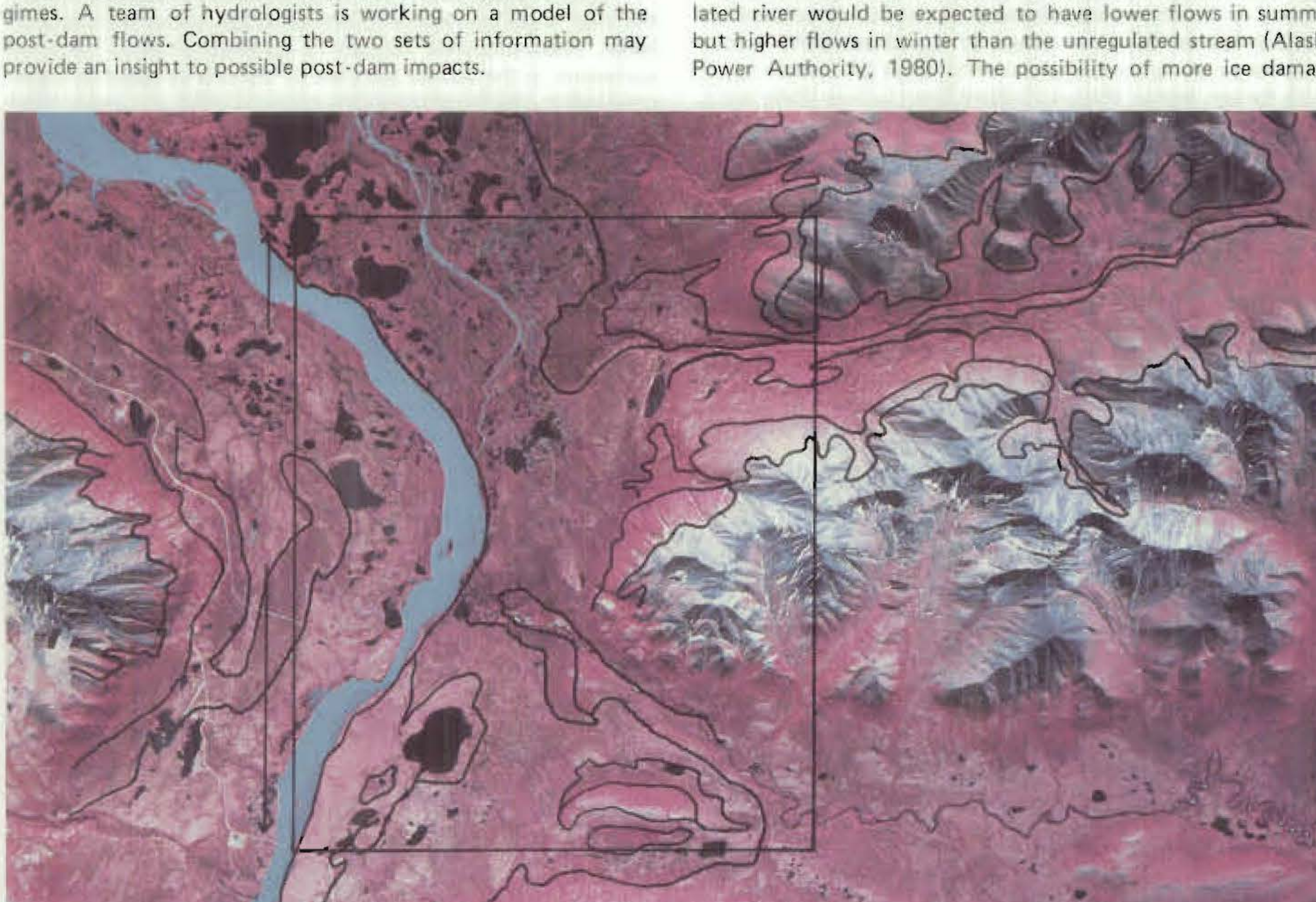

Figure 4. Color infrared U-2 image of portion of the upper Susitna River Basin. Clear water appears black while silty water shows up light blue. Spruce trees appear as small dots on an outwash fan at right of picture. Low shrubs near the river are purplish color, whereas sedge-grass tundra is the fine textured pink color in the mountains.

Figure 5. Aerial photographs taken in 1951 (left) and 1980 (right) of the lower Susitna River. Note the boxes where areas have been eroded (E) and deposited (D) between 1951 and 1980.

from higher winter flows may increase the amount of early successional areas. The down stream vegetation studies are aimed at evaluating whether the possible loss of moose habitat is a valid concern or if newly emerged areas would counterbalance the potential loss to advanced stages of vegetation. Early successional stages of vegetation consist of horsetail (*Equisetum* spp.), young balsam poplar (*Populus balsamifera*), willow (*Salix* spp.), and mixtures of these (Figure 5). More advanced vegetation includes alder (*Alnus tenuifolia* and *A. sinuata*); immature, mature, and overmature balsam poplar; birch/spruce; and shrub bog (Figures 6 and 7).

Downstream effects of the proposed dam or dams would be reduced by two unregulated streams, the Chulitna and Talkeetna Rivers, flowing into the Susitna just below Talkeetna. The Susitna River above Talkeetna accounts for 37% of the Susitna River flow just below Talkeetna and only 17% by the time it reaches Cook Inlet (Alaska Power Authority, 1980). The variability of the river flows at Gold Creek would be greatly affected by the dam while those at the Parks Highway Bridge and others farther downstream would be progressively less affected (Alaska Power Authority, 1980).

Several study sites were selected along various portions of the river from just above Talkeetna to just above the Delta Islands. These sites were selected to represent different stages of succession in the various portions of the river as based on visual observation. Aerial photographs taken in 1951 and again 1980 were compared to determine which areas had changed. Some bars had been deposited by 1980 that were not present in 1951 and some present in 1951 had been eroded by 1980 (Figure 8). Additionally, areas that were at early-vegetation successional stages in 1951 had progressed to more advanced stages in 1980. These changes were used to locate study sites on the river so that we would know how long it takes for such changes to occur.

The river above Talkeetna is incised in the valley, and islands there are fairly stable. However, ice scouring during breakup may have an effect on the vegetation here. The stream below Talkeetna is braided, and the sand and gravel bars are

Figure 6. Flooded mature balsam poplar stand upstream from Talkeetna during high water in July 1981.

Figure 7. Early successional vegetation on sandbar on the lower Susitna River above Susitna Landing, May 1981.

Figure 8. Flood-trained trees in intermediate vegetation on island above Talkeetna, June 1981. Note that the lower portions of the trunks have been bent downstream by earlier floods. Additional growth has occurred vertically.

constantly being reworked. Ice effects on vegetation in this area are negligible compared to the effects of flooding.

Vegetation and soils data were obtained from each site to analyze the vegetation and flood history of the area. Vegetation data include ground cover of plant species in several height categories, density (number of stems per unit area), and ages and dimensions of shrubs and trees. The objective was to determine how long an area would have to be flood-free or experience only minor floods before certain types of vegetation would be established. A sequence of vegetation types and length of time since the area was "stablilzed" could then be established. Comparisons of 1951 and 1980 photographs will also aid in evaluation of rate of changes in the river channel and plant succession. Even established vegetation may be flooded in wet years as we observed in some mature stands this year (Figure 8).

These vegetation studies are designed to analyze existing vegetation in the areas upstream and downstream from the proposed dam or series of dams. This information will be used to assess potential impacts of construction or to recommend areas for certain wildlife or recreational uses. Studies of the downstream vegetation dynamics will permit an assessment of possible effects of changed river flows on downstream vegetation. The results of these studies will be useful for evaluating potential impacts of the proposed hydroelectric project and for expanding our knowledge of Alaskan vegetation.

ACKNOWLEDGMENTS

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Minto: Possible location of a ducks, geese, and rabbits industry?

Potential Markets For Ducks, Geese and Rabbits in Alaska

By

Cathy Warren*

INTRODUCTION

The University of Alaska Agricultural Experiment Station was contracted by the Minto Village Council to provide estimates of the existing Alaskan consumption volumes and market prices for commercially produced ducks, geese and rabbits. The study was limited to the two major population centers within Alaska. Juneau was not considered since freight rates from Minto could not be competitive with those from Seattle.

The Minto Village Council is concerned that subsistence hunting in the future will not adequately provide all the nutritional needs of the Minto people. There is a current lack of economic development in the village, high unemployment, and few alternatives to welfare. Therefore, a small-scale agricultural project is being considered to provide an alternative to subsistence and welfare. Domestic production of ducks, geese and rabbits is of prime interest. Residents of Minto are familiar with these species and the domestic form would be acceptable as a partial substitute for traditional subsistence meat products. Raising these animals might also be an acceptable occupation in an agricultural program rather than crops or larger livestock because of this familiarity.

PRODUCTION CONSIDERATIONS

Although the people of Minto are familiar with these animals in their wild state, production factors unique to their domestic counterparts will have to be considered in a commercial operation. These factors include feed conversion ratios, basic feed information, length of time to market weight, and general production knowledge.

All breeds of duck, with the exception of the Muscovy, are believed to have originated from the wild Mallard. The Muscovy duck is a different species from all other breeds of domestic

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ducks. When crossed with other breeds of duck, their offspring are all sterile (Feltwell, 1980). The Muscovy duck is the only domestic duck that grazes grass for the bulk of their feed, as do geese. Neither the male nor female Muscovy ducks quack.

The Pekin is the breed favored by the commercial duck industry. They reach market age between 7 and 8 weeks and weigh 7 pounds before slaughtering. Feed conversions average 3.5 pounds of feed per pound of gain. Ducks require the B vitamin niacin as a food supplement to prevent leg weakness and to enhance growth (Feltwell, 1980). They should be fed starter crumbs until 3 to 4 weeks of age, then should be changed to grower pellets and grain. Domestic ducks should be given wet mash or crumbs at all stages of growth and may obtain some food requirements from grass. One acre will support up to 100 ducks.

Geese are excellent foragers, however they will grow at a slower rate if ranged rather than fed entirely on commercial feed. A number of feeding programs are available for commercial goose production. A variety of programs should be tested initially and records maintained to compare feeding costs and rates of gain. A trade-off will have to be determined between feeding cost and length of time to market weight. Commercially grown geese may be dressed between 16 and 24 weeks, depending on the feeding program. Live market weights vary, depending on age, feed program, and breed. Male Embden and Toulouse breeds average 29-32 pounds and females 21 pounds. One of the smallest breeds in the Chinese, shown in Figure 1. Live adult males average 11 pounds and females 9 pounds. The Toulouse geese were bred for their large, fatty livers, which are a popular delicacy in European countries. In 1976 these livers, weighing between 1 and 1.5 pounds, sold for almost $28 a pound in France (Kropp, 1976b). White Embden geese are one of the largest breeds and are produced primarily for meat.

Figure 1. Adult White Chinese geese and ducks raised in North Pole.

Feed-conversion ratios vary, depending on time spent on pasture and range quality. Supplemental feed for grazing geese averages 3 pounds per pound of goose, including starter, grower and finishing feed (Feedmarkets, 1975). According to Ben Kropp of Pietrus Foods, the nation's leading goose processor, all geese should be fattened with a finisher pellet feed, beginning 4 weeks prior to marketing. Geese will eat grass shoots, dandelions, and other weeds in bogs, marshlands, or creek or lake banks. They require room to graze. One acre will support between 50 and 100 geese, depending on condition of the range. Areas that are unsuitable for other poultry or livestock due to excessive moisture are ideal for geese.

Rabbits are noted for their ability to reproduce. Their average gestation period is 31 days and does may be rebred when the previous litter is 4-6 weeks old. On the average, a doe will produce between 4 and 6 litters a year. New Zealand Whites and Californians are the most common breeds raised by commercial rabbit meat producers. Young bunnies may be marketed at 8 weeks of age.

Rabbits live on grains, greens, and hay. Commercial rabbit producers usually feed pellets that are nutritionally balanced. Rabbits reingest their food. They excrete two types of feces, one hard and one soft. They will eat the soft, thus increasing their food intake.

Rabbits produce about 1 pound of meat for every 3-4 pounds of feed. Pelleted rabbit feed is 75-80% alfalfa with vitamins and minerals comprising the remainder. Most feeds contain 15-26% protein, with soybeans the best protein source (Seymour, 1977). High-quality hay and grains such as oats, wheat, barley, rye, and ground corn may be used in place of pellets. Green feeds may cause digestion problems and should be restricted (Travis et al., 1979). Salt is required in the diet along with plenty of fresh water. Rabbit hutches should be kept in a sheltered environment to keep predatory animals away. A separate area should be provided for sick rabbits. Rabbits are susceptible to several diseases and should be monitored carefully.

ANCHORAGE AND FAIRBANKS MARKETS

An estimate of the current demand in the nearby markets for ducks, geese and rabbits was necessary to indicate the potential capacity of a small-scale commercial operation . Two major population centers in Alaska were considered — Anchorage and Fairbanks. Their relationship in distance from Minto can be seen in Figure 2.

Wholesale and major retail grocers were contacted through a mail survey and a follow-up telephone survey was conducted in December, 1980. The results are shown in Table 1.

Grocers indicated rabbits and ducks are in demand year-round, whereas geese are seasonal, with the majority of sales during Thanksgiving and Christmas. Several grocers felt they could sell more rabbits if a dependable supply and consistent product were available.

Most large retail chains purchase their frozen ducks, geese, and rabbits from Seattle wholesalers and ship these items in 20,000-40,000-pound van loads with other frozen goods. Therefore, the additional freight cost per pound for these items is minimal since the vans are filled and the volumes ordered are low, compared with other frozen products shipped. A commercial producer in Minto would have to meet the Seattle wholesalers' price, minus the freight cost from Minto to the retail or wholesale store's location.

Air-freight rates from Minto to Fairbanks were $.17 per pound in December, 1980 (Alaska Central Air). Air-freight rates

Table 1. Quantity of Ducks, Geese and Rabbits Ordered Annually by Anchorage and Fairbanks Grocers from Outside Alaska.

Location	Type	Ducks	Geese	Rabbits
Anchorage	Wholesale	6,420	828	4,460
Anchorage	Retail	1,620	448	1,880
	Total	8,040	1,276	6,340
Fairbanks	Wholesale	1,430	82	0
Fairbanks	Retail	2,480	415	1,428
	Total	3,910	497	1,428
Anchorage and Fairbanks	Total	11,950	1,773	7,768

Table 2. Comparison of Production Costs[a] and Average Anchorage and Fairbanks Retail Selling Prices, 1980 Aug. ($).

	Production Costs		Anchorage & Fairbanks selling price
	Per Live wt. lb.	Per lb. of meat	
Ducks	1.17	1.67[b]	1.57
Geese - 50:50 feed/barley ration	1.30	1.86[b]	2.15
Geese-partially ranged	.91	1.30[b]	
Rabbits - pellets	2.16	3.93[c]	2.87
Rabbits - 50:50 pellet/barley ration	2.06	3.73[c]	

[a] Based on production capacity of 500 ducks, 400 geese and 750 rabbits.
[b] Dress-out of 70% for ducks and geese.
[c] Dress-out of 55% for rabbits.

from Fairbanks to Anchorage are $.24 per pound, with a minimum shipment of $18.10 or 75 pounds (Alaska Airlines, December, 1980). These products, produced in Minto for sale in Anchorage, would be subject to a $.41 per pound freight charge, if shipped by air. Truck rates were not estimated since the volumes to be shipped would not fill a truck load.

The production costs covered in the accompanying article, A Village-Based Plan for the Small-Scale Production of Ducks, Geese, and Rabbits by Dan Slaby and Carol E. Lewis, are based on facilities to accomodate 500 ducks, 400 geese, and 750 rabbits. As the market survey shows, these volumes will not supply the Anchorage and Fairbanks markets. However, they will satisfy the subsistence requirements of the Minto population. Production may be expanded to penetrate urban markets after management skills are mastered and production costs are brought into line.

Table 2 compares production costs to 1980 retail selling prices. The production costs were calculated per liveweight pound. To obtain the cost per pound of meat, a dress-out of 70% (Rabin, 1980) was assumed for ducks and geese and 55% (Travis et al., 1979) for rabbits. Since the costs of production at the levels assumed for ducks and rabbits are greater than the price per pound received by retailers, these products should not be produced for meat revenue alone. Markets for by-products such as feathers and rabbit pelts will have to be investigated. Slaughtering costs must also be given consideration.

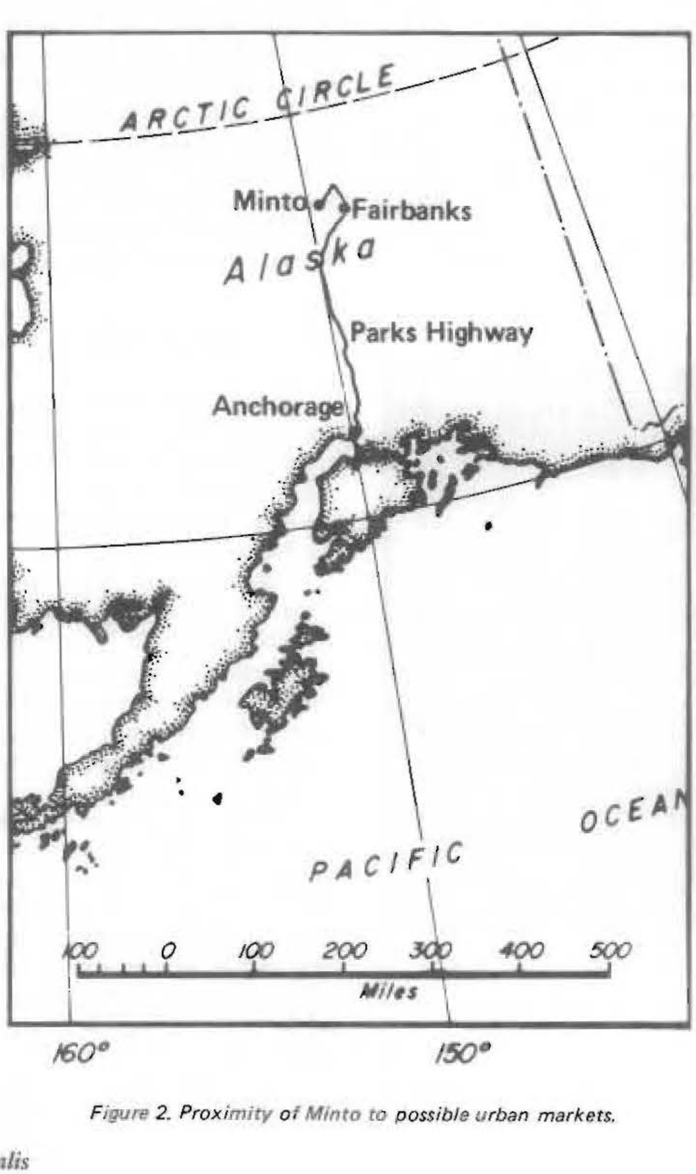

Figure 2. Proximity of Minto to possible urban markets.

PRODUCTION OUTSIDE ALASKA

National production of ducks has increased steadily from 13 million ducks in 1976 to 17.5 million in 1979 (Rabin, 1980). National goose production had dropped from 8.5 million in 1890 to around 400,000 in recent years. In 1910, Kentucky alone produced the volume the entire United States raises today (Kropp, 1975). Around the turn of the century there were many small farms raising a few geese each, as European countries do today. Presently, goose production in the United States is accomplished by only a few producers, raising much larger flocks.

The goose has been a more popular bird in European countries than in the United States. France, Poland, Hungary, West Germany, and Czechoslovakia each produce over 2 million annually (Peitrus, 1980). Russia is reported to raise over 30 million geese a year and is planning to double this amount by 1986, making use of the vast expanse of grasslands in that country (Kropp, 1976a). Manitoba and Alberta, Canada, have produced geese in flocks of 3,000 to 5,000 for the past 20 years (Kropp, 1977).

The volumes exported and imported for live ducks and geese are grouped as *baby ducks, geese, and guineas* and also with *live-poultry other than baby.* Slaughtered duck and geese exports are listed as *other poultry, fresh, chilled, or frozen.* Therefore, it is difficult to determine the number of ducks or geese exported and imported. However, Canada appears to be the leading country receiving United States produced *other frozen poultry.* It is felt most of these are ducks (Hemphill and Millmoe, 1981). The volume of other frozen poultry exported has increased dramatically from 2,033 tons in 1976 to 10,819 tons in 1979.

Export and import volumes for domestic rabbits are incomplete. However, China is a leading exporter with over 1 million pounds annually. There are no tariffs on foreign rabbit meat coming into the United States, but United States producers must pay a 20% common market tariff for rabbits sold to European countries. Belgium's rabbits average $1.25 per pound and China's $.75 a pound (Smith, 1981). Annual U. S. consumption estimates for rabbit vary from 8 (Travis et al., 1979) to 25 million pounds (Smith, 1981), which amounts to roughly 3.5 to 11 million rabbits.

SUMMARY

The volumes of ducks, geese, and rabbits currently sold by Anchorage and Fairbanks grocers are for frozen meats. A fresh product may generate an increased demand. Currently, there is little or no advertising on the state level for these products. A major marketing plan will be necessary to educate consumers as to the taste difference between wild and domestic meat of ducks, geese, and rabbits. Consumers should also be informed as to the substitutability of ducks, geese, and rabbits for more traditional meats. For example, rabbits are lower in fat (% of fresh weight) and higher in protein than primary cuts of beef and pork. Turkey is the major competition for the seasonal goose market. The high-volume production of turkeys has made it possible to market these birds at considerably lower prices than geese. A major advertising effort will be necessary to bring wholebody and cuts into the year-round market, possibly as a specialty product, eliminating the need to be price competitive with turkey during peak seasons.

As evidenced by the market survey for Anchorage and Fairbanks, the number of geese sold is considerably less than the volumes of ducks or rabbits. However, as grocers pointed out, goose sales occur primarily during Thanksgiving and Christmas. This seasonality enables a producer to operate without a year-round breeding stock. This, along with the goose's ability to obtain a substantial portion of its diet from grasslands, suggest that geese are a more attractive selection than ducks.

Although it does not appear rabbit production is profitable for meat alone, markets do exist for by-products and are necessary to ensure a successful operation. Tanned rabbit pelts can be sold to local furriers for $3 to $12 a pelt, depending on quality (Anchorage Fur Factory, 1981). Since rabbit meat is not seasonal, year round production should be considered. This will require a breeding stock which should be kept in an enclosed environment (Figure 3).

Figure 3. Breeder rabbit facility owned by Fairbanks-area grower, Debbie Wien.

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A Village-Based Plan for the Small-Scale Production of Ducks, Geese and Rabbits

By

Dan L. Slaby* and Carol E. Lewis**

Many Alaska bush villages have tenaciously maintained a subsistence-based economy dependent upon hunting, fishing, and trapping. Economic factors and a desire for consumer goods have combined to create an increasing need for cash in the village. Improved health care has increased the proportion of younger residents in the village. Improved education and employment opportunities in urban communities have resulted in a selective migration of individuals from the village. This selective migration has permitted the remaining residents to continue a subsistence lifestyle.

Recently, there appears to be a slight reversal of this trend of emigration. A variety of factors, including the desire to benefit from the Alaska Native Claims Settlement Act of 1972, underly a return of family members to the village. It is this return of village members and the increased use of modern hunting, fishing and trapping technologies that place an increasing strain on the subsistence lifestyle of the village and native animal populations.

One such community located in interior Alaska, Minto, has recognized the problems that an increase in local population would create. Having considered various options for development, the Minto Village Council has considered a plan to produce ducks, geese and rabbits to meet local food needs with an option for future commercial expansion to supply an existing Alaska market.

The factors which underly the choice of producing these particular animals include:

- Wild species of these animals occur naturally in the area, indicating the possible adaptation of domestic species to a cold climate.
- The residents are familiar with the natural biology and life cycle of these animals.
- The growth rate to marketable weight is rapid, allowing for seasonal production plans.
- Production management does not require highly specialized equipment or knowledge.
- Labor requirements for these animals are not intensive, permitting continuation of existing subsistence and social activities.

This article will summarize the production plan and financial feasibility for a scale of operation limited to 500 ducks, 400 geese, and 750 rabbits produced annually for local consumption in a village with a population between 250 and 350.

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PRODUCTION OF DUCKS AND GEESE

The production plan for ducks and geese are similar and can be described together. The following assumptions are made regarding the production of ducks and geese:

- Live hatchings will be purchased from a hatchery, eliminating the need for maintaining a year-round breeding stock.
- A minimal amount of grassy pasture will be available to permit the grazing of 50 to 100 geese per acre (Orr, 1976).
- The production plan is applicable to many breeds of ducks and geese, although the types selected for this plan are the White Pekin duck and Embden goose.
- Grain feeds will be available locally from Alaska sources (Feed prices used to derive production costs in this article are retail FOB Fairbanks).

GROWTH CHARACTERISTICS AND FEED REQUIREMENTS OF DUCKS AND GEESE

A conversion ratio of feed consumed to weight gained permits a measure of productive efficiency and can be used to determine the optimum marketable weight and age. Table 1 gives the live weight, feed consumption, and feed conversion ratios for White Pekin ducks to age 8 weeks. Weekly weight gains remain above 1 pound per week until 6 weeks of age after which the weight gain drops off substantially. Likewise, the feed conversion ratio continues to decrease until age 6 weeks, after which it increases. At 7 weeks, the average liveweight for males was 7.28 pounds, and for females 6.64 pounds with respective feed conversion ratios of 2.49 and 2.67. Changes in the weekly weight gain and feed conversion ratios indicate that the optimum age and weight of harvest is at 6 weeks. After that age, any additional weight is gained at additional cost.

Table 1. Growth Rate and Feed Conversion Efficiency for White Pekin Ducks (Orr, 1976).

Age (Wks.)	Wt. (lbs.)	Marginal Wt. Gain	Feed Wkly.	Consumption (lbs.) Cum.	Feed/lb. Wt. Gain to Age	Marginal Rate of Wkly. Change in Feed Conversion Ratio
1	.6	—	.5	.5	.83	—
2	1.68	1.08	1.64	2.14	1.27	.44
3	2.98	1.30	2.55	4.69	1.57	.30
4	4.01	1.03	2.55	7.24	1.81	.24
5	5.13	1.12	3.27	10.51	2.05	.24
6	6.19	1.06	3.57	14.08	2.27	.22
7	6.96	.77	3.87	17.95	2.58	.31
8	7.54	.58	3.39	21.34	2.83	.25

Growth data on geese presented in Table 2 indicate that goslings have a rapid rate of growth until 10 weeks of age, after which there is little weight gain (Orr, 1976). Other data indicate that management affects the growth rate and feed conversion efficiency. Table 3 presents data from a study which compares a range and confinement feeding strategy. For the first 3 weeks, goslings in the study were fed a regular pellet diet in confinement. Then half of the goslings, with equal sexes in both groups, were placed on good range and the other half in confinement. Both groups were provided with pelleted growing mash, grain (wheat and oats) and insoluble grit on a free-choice basis. Confinement-reared birds exclusively preferred pellets, but range-reared birds consumed near equal amounts of grain and pellets (Orr, 1976). The data indicate that confinement-reared birds gain weight more rapidly than range-reared, but require considerably more feed per pound of weight gained.

Table 2. Growth Rate for Embden Geese by Sex.

Age (Wks.)	Average Weight Male	Female	Both Sex Average	Marginal Weight Gain
2	1.9	1.8	1.85	
4	5.0	4.5	4.75	2.90
6	8.2	7.1	7.65	2.90
8	10.1	8.8	9.45	1.80
10	11.1	9.7	10.40	.95
12	11.8	10.3	11.05	.65
14	12.3	10.9	11.60	.55
16	12.6	11.1	11.85	.25
18	13.5	11.9	12.70	.85
20	13.8	12.3	13.05	.35

Table 3. Growth Rate and Feed Conversion Efficiencies of White Chinese X Embden Goslings (Orr, 1976).

	Confinement Reared (lbs.)			Range Reared (lbs.)		
Age Wks.	Avg. Wt.	Cum. Feed Consumption	Feed/lb. to Date	Avg. Wt.	Cum. Feed Consumption	Feed/lb. to Date
3	3.3	5.25	1.75	3.3	5.25	1.75
6	8.1	17.32	2.22	7.8	12.60	1.68
9	10.8	34.92	3.32	10.1	19.97	2.03
12	12.3	47.54	3.96	11.6	30.62	2.71
14	12.8	56.09	4.48	11.8	38.10	3.31

Feed for ducks and geese is usually available in the form of crumbles or pellets, but if these are not available, then unmedicated chicken or turkey feed can be substituted (USDA, 1972, 1974). For the first 2 weeks, ducks should have free choice of starter feed, and afterwards they can be maintained on a grower ration. Ducks can have access to pasture at 3 or 4 weeks, but are not as good foragers as geese. Water should be available upon demand.

Geese are likewise provided with starter feed for the first 2 to 4 weeks and then are switched gradually to a grower ration. Geese should be encouraged to forage as soon as possible. The supply of feed can be restricted until they are consuming an average of 1/4 to 1/3 pound of feed per evening. The availability of ration can be adjusted according to the condition and supply of forage. Geese prefer the bladed grasses, and pastures must be mowed regularly to maintain palatable, young, and tender grasses. Water should also be available upon demand.

Insoluble grit should be available for consumption upon demand for both ducks and geese.

Approximately 50 geese can be pastured on 1 acre of good forage, but a planted pasture maintained by mowing can support 100 geese (Shiltz, 1975). Geese can be used as weeders in some planted crops and gardens. Goslings used as weeders should be under 6 weeks of age because older birds can damage the plants and fruit. For example, six to eight goslings can control the weed growth on 1 to 2 acres of strawberries (Orr, 1976). Shade is essential for geese on pasture to prevent sunstroke.

On the average, a duck will consume 21 lbs. of feed to attain a live weight of 7.5 lbs. at age 8 weeks. The average range-reared goose will consume 30.62 lbs. of feed to reach a live weight of 11.6 lbs. at age 12 weeks. The average goose reared in confinement on pellets will consume 47.54 lbs. of feed to reach 12.3 lbs. at 12 weeks of age.

Alaska-grown barley can be substituted for grower ration on a 50:50 ratio without affecting the protein supply, and geese with good pasture can be fed barley as the only feed supplement.

HOUSING AND SPACE REQUIREMENTS FOR DUCKS AND GEESE

Ducks and geese do not require as elaborate housing as other poultry. A building for housing ducks and geese needs to be well lighted, ventilated, and dry.

Each adult duck requires 4 square ft. of facility space. Ducks require 1/2 square ft. of space during the first week, 3/4 square ft. the second, 1 square ft. the third, and 2 1/2 square ft. by the seventh week. At least 1/2 linear in. per duckling should be available for feeding and watering during the first 2 weeks, increasing to 3/4 in. during the third week and 1 1/4 after the seventh week.

If fed in confinement, each adult goose should have 5 square ft. of facility space available. Geese require 3/4 square ft. during the first week, and 1 - 1 1/2 square ft. during the second. After the second week, depending upon the weather, geese may be placed on range or pasture. At least 3/4 linear in. per gosling should be available for feeding and watering during the first 2 weeks.

The proposed facility design meets these requirements of space and environment for ducks and geese (see Figure 1). A facility 26 ft. by 40 ft. will provide adequate space for 50 ducks or 400 geese. A center waterway provides drainage with a constant source of water. Three 8-foot sections of an automatic-feed water trough will provide sufficient capacity. Six range feeders will provide an adequate supply of feed. The water trays are placed on a 3/4-in. mesh supported by a 2 in. x 4 in. pressure-treated wood frame. A gravel fill permits waste water to percolate into a 4-in. drain line emptying into a leach pit. A collection tank can be installed for recovery of liquid waste for garden fertilizer. A 500-gallon stock tank provides water storage. Light is provided by 2-in. x 6-in. visqueen-covered windows which can be opened to provide ventilation. Additional ventilation is provided by two roof-mounted, barn-style ventilators. The floor, other than the waterway which is covered by the 3/4-in. mesh, is covered with straw bedding.

Two infrared LPN brooders provide adequate space for 400 goslings or 500 ducklings. Regular 36-in. tray feeders and plastic 1-gallon waterers arranged in the configuration provided will suffice. An alternative brooder consists of four heat lamps suspended from the rafters with an adjustable chain to regulate heat.

One person, working on an average of 5 hours per week, should be able to manage the administrative functions such as

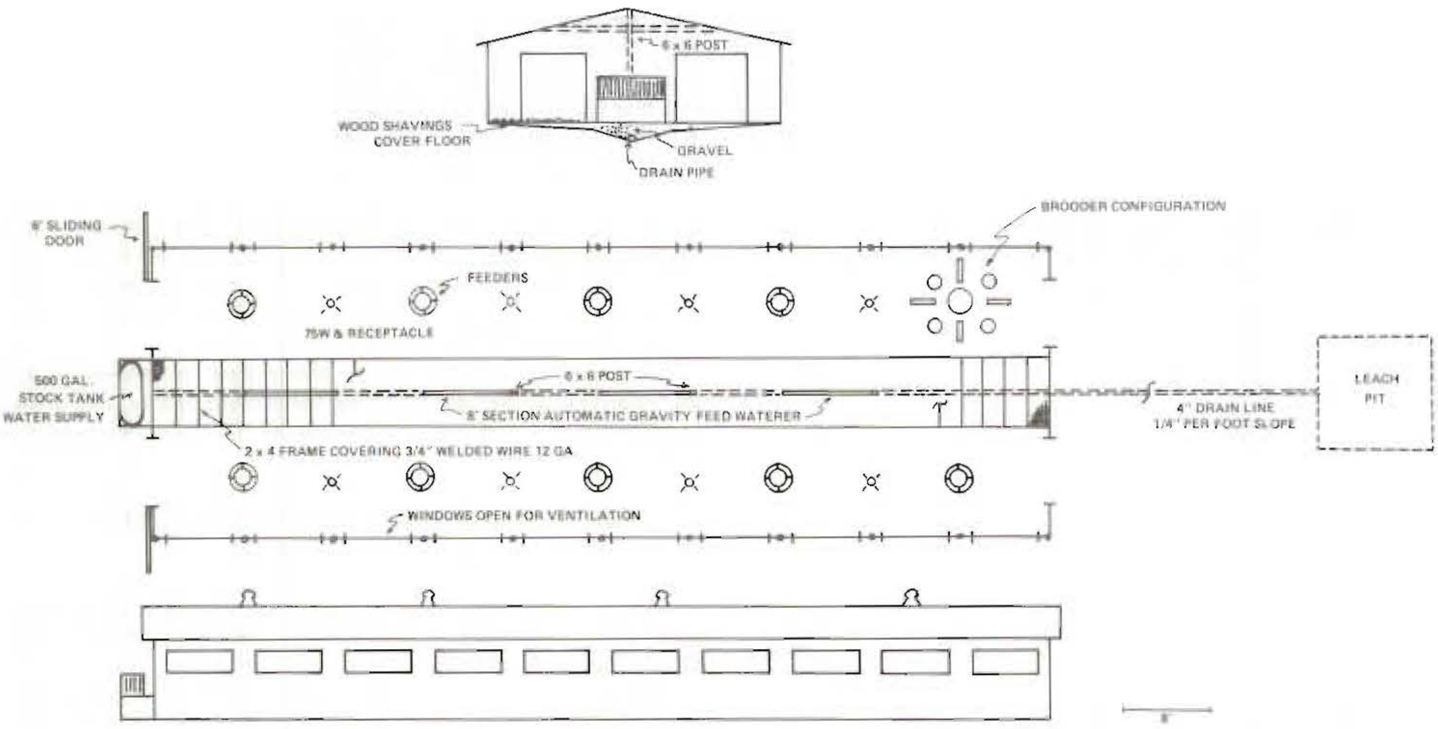

Figure 1. Proposed facility designed to accomodate 1000 ducks and 500 geese at Minto Village (Alaska Management and Planning, 1980).

purchasing, supervising the project, and marketing to the local community. Supplemental labor for watering, feeding, cleaning, and other maintenance activities is planned to be provided with the assistance of a CETA summer youth-employment program.

In order to avoid complicated regulations regarding processing, the ducks and geese will be marketed live weight locally. On a larger, commercial scale, the recovery and marketing of by-products adds considerably to revenue, indicating consideration of a processing plant.

PRODUCTION COSTS FOR DUCKS AND GEESE

Facilities: The fixed costs of operation include the land, fill, facility, and equipment. Land and fill costs for the purposes of this village plan are measured in terms of its opportunity costs, but require no capital outlay. Since local food production is a priority, the opportunity cost of land is not considered in the development of production costs. Land is not depreciated by convention, and is not considered an annual cost.

Based on 1981 prices FOB Fairbanks, the material costs of the 26-ft. x 40-ft. building and equipment is $3,843.12. Construction labor is estimated at $2,700; and transportation of materials by a local truck at $.30 per mile is $82.80. A 1,200-bushel feed-storage bin would cost approximately $1,200. Fencing includes enclosing 6 acres with 47-in. high hog wire supported by 6-ft. steel posts placed 12-ft. apart at a cost of $1,393 for materials and $360 for labor. Ducks do not utilize pasture as well as geese and fencing costs could be reduced by half. Other annual costs include insurance at $45.45, repair and maintenance costs at $130, and electricity estimated at $35 from a local supplier at 42.5 cents per KwH.

The facility would have a minimum useful life span of 15 years. For purposes of this project, the fixed costs are depreciated over 15 years on a straight-line basis. A total capital cost of $9,578.92, depreciated over a 15-year period results in an annual per-goose cost of $1.60. A total capital cost of $8,702.42 depreciated over 15 years results in an annual per-duck cost of $1.16. Other fixed annual operating expenses results in an expense of $.53 per goose and $.42 per duck.

Purchase of Hatchlings: The initial cost per duckling FOB Fairbanks in 1981 was $1.75 and $2.25 per gosling including a 5% mortality loss factor and transportation costs. Cost for transport and 5% mortality loss to Minto are $.26 per duck and $.32 per goose. Initial cost per duckling is $2.01 and $2.57 per gosling.

Labor: Assuming 5 hours per week labor for 9 weeks for ducks and 13 weeks for geese at a wage rate of $7.50 per hour gives a labor cost of $.68 per duck and $1.22 per goose. The per-unit labor cost can be reduced somewhat by increasing the size of the operation because many of the tasks are semifixed and do not increase proportionately with the size of the operation.

Feed Costs: Feed costs, using 50:50 prepared feed and Alaska barley, result in a per-duck cost of $4.31. The same feed mix results in a per-goose cost of $9.75 for geese reared in confinement. For geese on pasture provided a barley supplement, the per-goose feed cost is reduced to $4.29. For a confinement-reared goose, it costs an additional $3.34 to provide 1.4 more pounds of gain, which suggests that the most economical age of marketing geese is between 10 and 12 weeks. It is more economical to produce geese on range than in confinement.

Transportation Costs: Estimated transportation costs are dominated by the weight of feed. A 500-duck operation will require 10,500 lbs. of feed transported at $.11 per lb. for a total of $1,155, or $2.31 per duck. A 400-goose operation will require 12,248 lbs. of feed transported at $.11 per lb. for a total of $1,347, or $3.37 per goose.

Table 4 summarizes production costs for ducks and geese.

Table 4. Production Cost Summary for Ducks and Geese ($).

	Ducks	Geese
Fixed Cost		
Capital	1.16	1.60
Operating Expense	.42	.53
Variable Cost		
Duckling, Gosling	2.01	2.57
Feeding		
50:50 Ration	4.31	9.75
Range plus Barley		4.29
Labor	.68	1.22
Straw Bedding	.21	.31
Unit Cost	8.79	15.98[a]/10.52[b]
Average Live Weight to Market[c] (lbs.)	7.5	12.3[a]/11.6[b]
Cost per Pound Live Weight	1.17	1.30[a]/.91[b]

Note: Total standard production costs for 500 ducks is $4,395 and $6,392/$4,208 for 400 Geese.

[a] Costs for geese on 50:50 feed/barley ration.

[b] Costs for geese on range plus barley.

[c] From Table 3 (12 weeks) and Table 1.

PRODUCTION OF RABBITS

The production plan for rabbits is based on the following assumptions:

- An initial purchase of stock will result in establishing a breeding stock. To prevent inbreeding, male breeders will be purchased every two years.
- Feed will be manufactured pellets purchased FOB Fairbanks.
- The production plan is applicable to any breed, although New Zealand White has been selected for this report.

GROWTH CHARACTERISTICS OF RABBITS

Table 5 gives the live-weight feed consumption and feed efficiency of litters with doe and post-weaning. After the age of 8 weeks, females begin to gain weight faster than males, and a mature female weighs an average of 11 lbs. and a male 10 lbs. Feed efficiency for rabbits refers to the amount of feed required to produce fryer-aged animals. Since the young generally remain with the doe until market at age 8 weeks, the feed-efficiency ratio is calculated with the doe, and includes an average litter size of 5.7 young. The overall feed efficiency for the production of fryer rabbits should average 3.5 to 4.0 lbs. of feed per pound of live market weight at weaning (8 weeks). A New Zealand White doe with an average litter will consume about 67 lbs. of feed during the 8 weeks from breeding to weaning, an average of 1.2 lbs. of feed per day. The average weight at weaning is about 4 lbs., less than half the adult weight.

Table 5. Growth Rate and Feed Conversion Efficiency For New Zealand White Rabbits.

Age (Wks.)	Weight (Lbs.)	Feed Efficiency	
2	.61	Doe and Litter	3.3
4	1.32	4-8 weeks	2.3
6	2.64	8-12 weeks	3.9
8	3.96	12-16 weeks	6.2
10	4.95 male 5.17 female		

REPRODUCTIVE CHARACTERISTICS OF RABBITS

Rabbits reach sexual maturity at different ages depending upon breed, nutritional state, and other factors. The New Zealand White reaches breeding age at 5 1/2 to 6 1/2 months for both sexes. It is desirable to delay breeding until 8 to 10 months to allow for increased physical maturity and behavioral development. The range of litter size for the New Zealand White is from 8 to 10. Ovulation is induced by breeding and occurs approximately 10 hours after mating. Fertilization occurs 1 to 2 hours after ovulation. The gestation period is 31 to 32 days. Rebreeding can take place immediately after kindling if not lactating, or 28 to 42 days if lactating. The best rates of growth are obtained if the young are weaned at 8 weeks, but weaning can take place at 6 to 7 weeks, allowing the smaller young to remain until 8 weeks. On the average, a doe can produce 4 litters per year.

HOUSING, CAGING, AND EQUIPMENT

The purpose of housing is to protect the rabbits from environmental extremes while permitting maximum growth, given the needs of the animal and ease of care. Space recommendations for large single rabbits are 30 in. x 36 in. x 18 in., and for large does with litter, 30 in. x 48 in. x 18 in. The facility design proposed in Figures 2 and 3 allows for such space and environment requirements, although an enclosed building would offer greater environmental control.

The rabbit cages are constructed from 1-in. x 2-in. welded galvanized wire mesh (12 or 14 gauge) on sides and top, and 3/4-inch welded galvanized wire mesh (10 gauge) for the floor. The mesh is joined with wire clips crimped every 4 ins. The dimensions of the cages are based on the minimum space requirements quoted. Each cage has a nest box for cold weather and kindling. The dimensions of the nest box are 12 in. x 12 in. x 20 in. Each cage is fitted with a self-feeder and automatic-feed water fount. For temperatures below freezing, block ice is provided and the watering system drained.

The shed is of pole construction with sides of clear fiberglass panels. Aluminum roofing is used to reflect the summer heat. The cages are suspended from the rafters with the feeders, water founts, and nest boxes located along an aisle for ease of service. Wastes accumulate beneath the cages on a gravel bed which allows liquid wastes to drain. The water system is a gravity-feed distribution to individual, automatic water founts in each cage. The cages are arranged so that one male is surrounded by five females that are bred by that buck. Each nest box has a card attached for recording breeding dates, expected kindling dates, and other information.

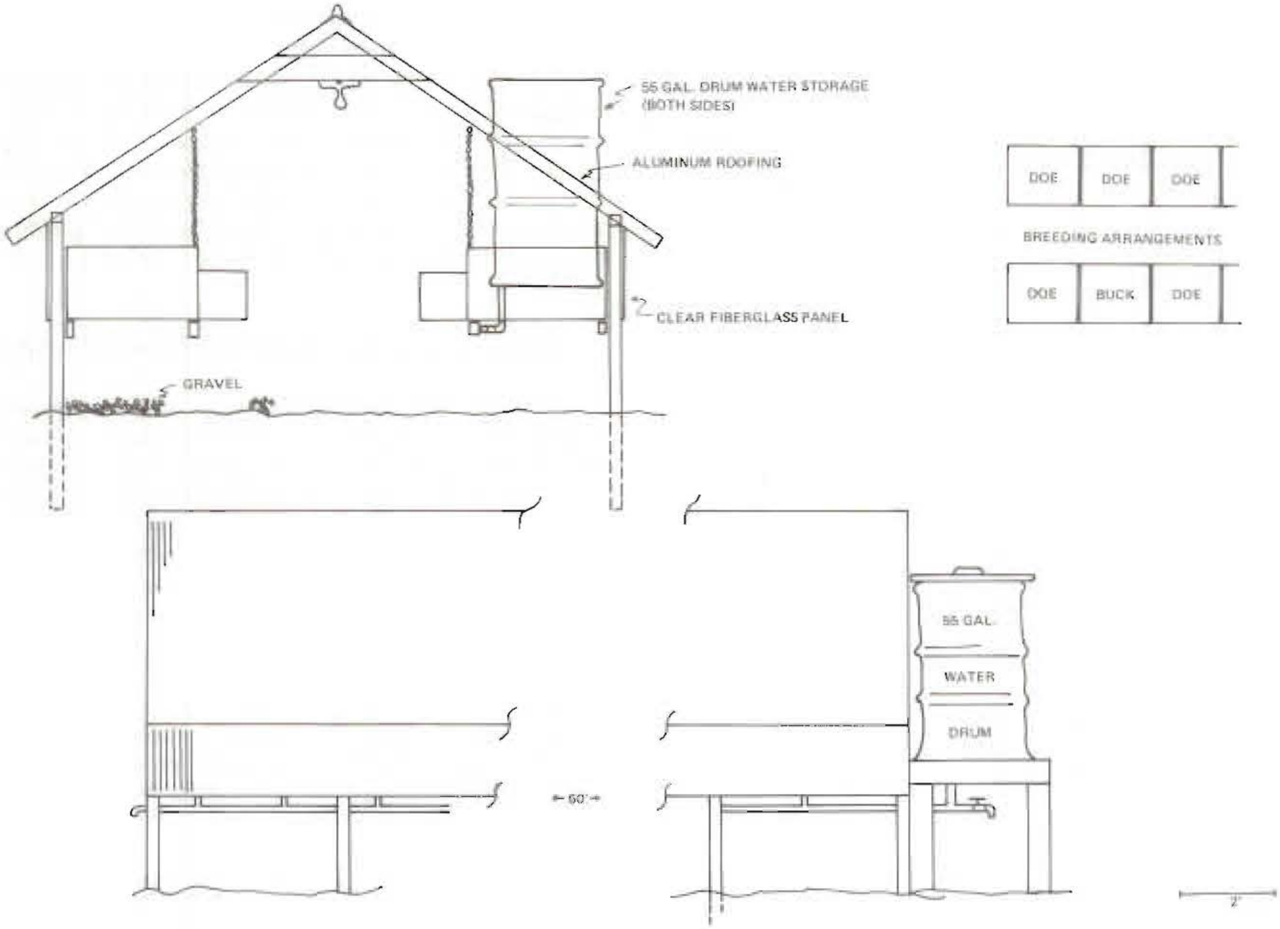

Figure 2. Rabbit grower shed with a capacity of 30 cages (Alaska Management and Planning, 1981).

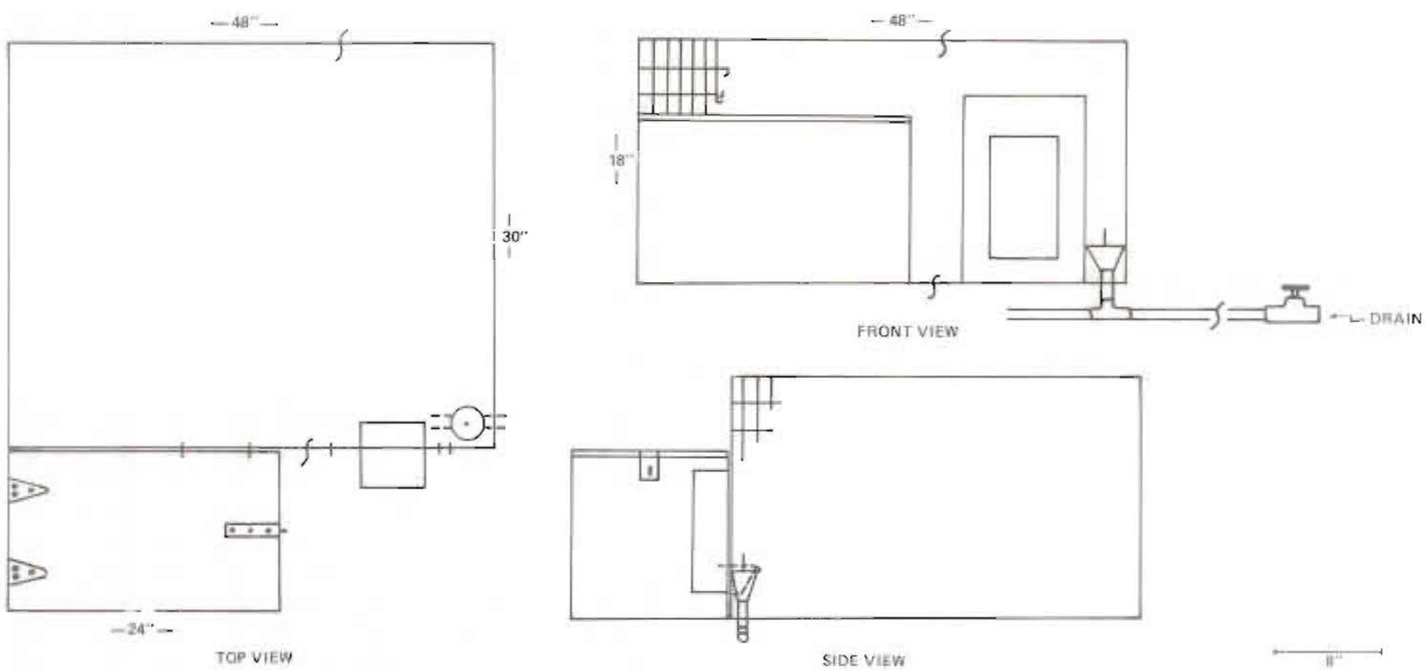

Figure 3. Basic rabbit cage design proposed as a component of grower operation shown on Figure 2 (Alaska Management and Planning, 1981).

PRODUCTION COSTS FOR RABBITS

For purpose of determining the unit cost (per-lb. price), the weight gain of the breeder stock is unimportant and the only production factor is the weight of fryer meat produced. Thus, 24 does and 6 bucks, with each doe kindling an average size litter four times a year, produces 768 fryers weighing an average of 4 lbs. for a total production of 3,072 lbs. annually.

Facilities: Fixed costs include the land, facility, and equipment. Land for this project has no immediate capital outlay. Fixed facility costs include $1,913.75 for the cages and equipment, $1,268.55 for the shed, $2,700 construction labor, and $165.60 for transportation, for a total of $5,047.90. Fixed operating expenses include insurance at $42.34, repair and maintenance at $120.96, and utilities at $420.00. On a 15-year, straight-line depreciation schedule, the unit fixed capital cost allocated per fryer is $.52. Unit fixed costs operating expense is $.76 per fryer produced.

Feeding Costs: Feeding costs are determined by the price of commercial pellet feed at $17.48 per 80 lbs., or $.22 per lb. The average doe with litter will consume 67 lbs. of feed during the 8-week period from mating until weaning. Adult consumption rates for males and nonpregnant does is 6 oz. per day. The six males will consume 821.25 lbs. of feed annually, and nonlactating does a total of 1,269 lbs. Total feed consumption for the production of 768 fryers is 8,522.25 lbs. At $.22 per lb., the total feed cost is $1,874.90, or $.61 per lb. of weight gained, and $2.44 per fryer. Barley can be substituted in a 50:50 mix, lowering the feed cost to an average of $.18 per lb., yielding an average cost of $2 per fryer.

Labor: Labor costs are based on an average of 1 hour per day checking water and feed, breeding and record keeping, and performing maintenance activities. National commercial rabbit standard for labor is 8 hours per doe per year (Arrington, 1976), and with a 40-hour week, 50 weeks of actual work, one person could manage 200 breeding does. At 6 hours a week for 52 weeks and $7.50 per hour wage rate, the labor costs is $2,340. The cost of labor per fryer is $3.05. Labor efficiency can be improved with training and experience in rabbit management and increasing the scale of operation.

Table 6 summarizes the production costs for rabbits.

Table 6. Production Cost Summary for Rabbits ($).

Fixed Cost	
Capital	.52
Operating expense	.76
Variable Cost	
Feed:Pellets/50:50	2.44[a]/2.00[b]
Labor	3.05
Other	.06
Transportation	1.53
Unit cost per fryer	8.53[a]/8.09[b]
Average weight (lbs.)	3.95
Cost per pounds live weight	2.16[a]/2.06[b]

[a] Costs for fryers on pellets only.

[b] Costs for fryers on 50:50 pellet/barley ration.

SUMMARY

The production of ducks, geese, and rabbits on a subsistence level for a local market is determined to be significantly risky given national price structure. Cost inefficiencies arise from the lack of locally available feed, high cost of transportation, and labor inefficiencies. These costs can be reduced somewhat by individuals rearing small numbers for personal use, but a significantly higher mortality rate may occur due to environmental extremes and predation by loose dogs.

The recovery of by-products was not included in the plan of production, but on a larger commercial scale would contribute to revenue. Although the cost of subsistence has not been calculated, the subsistence harvest is a competing local source of ducks, geese and rabbits. Ducks were not found to be economically feasible for production at the scale evaluated. Given adequate pasture, the rearing of geese is competitive with national prices. Individuals producing free-ranging geese in the backyard would definitely benefit, although the rate of growth and quality of meat would not be as good as those fed supplemental feeds. Revenues from marketing rabbit skins would improve the marginal return from raising rabbits.

Continued government subsidies in form of welfare and food stamps will distort the true cost of subsistence and delay the consideration of local food production.

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Solar Energy for Grain Drying in Alaska

By

Lee D. Allen*

Solar energy is free, unless one counts the cost of constructing and operating a solar collector. Even with a good solar-collector design, a conventional heating system may still be needed because the sun doesn't shine at night. Further, the characteristics of solar energy are such that hardly any collectable energy gets through a heavy cloud cover, making extended periods of cloudy weather a serious problem.

Solar energy use is therefore limited to applications in which heat need not be continuous, or where solar heat storage can be provided to even out the energy supply. Since heat storage usually adds considerably to the cost of any solar energy collection installation, the least expensive solar energy applications are likely to be those that do not require heat storage.

The drying of grain is one application where it makes little difference when heat is applied or if the supply is intermittent. It takes a lot of heat, 2000 BTU's or more, to evaporate each pound of moisture contained in wet grain, but heat at very low temperature can be effectively utilized.

All air contains heat energy. If relative humidity level of the air is lower than 100%, the energy in the air can be used to dry grain. The lower the humidity, the more available energy the air has for grain drying. If the air temperature rises even a few degrees, the relative humidity is lowered, and the air has more energy that can be transferred to the moisture in the grain to facilitate drying.

It seems, then, that drying grain in Alaska is a good potential use of solar energy. Removal of the excess moisture from the grain is not time-critical so long as the grain is dried to a safe storage level of 14 to 16% moisture content before it has time to spoil. Spoilage usually occurs due to mold growth that takes from a week to several weeks to accumulate to unacceptable levels, depending upon temperature, moisture, and air-flow conditions.

The Alaska Agricultural Experiment Station and area farmers have been drying grain in Alaska using both heated and unheated air for many years. Grain driers can be designed to do it either way. Grain can be held for several months using very low flows of unheated air that cool the grain. Low air flows will prevent moisture condensation and eventually dry the grain to a safe storage level. The use of higher air flow requires more fan energy, but speeds the drying process. The use of supplemental heat and higher air-flow rates speed the drying process, and may permit multiple batches to be dried using the same machinery.

About the only combinations of air flow and heat that can't be used for grain drying is low air flows and moderate or high amounts of added heat. These conditions drive moisture from the first grain contacted, but since there is not enough air flow to carry the moisture away it condenses in the cooler layers of grain. Then mold growth is rapid, and spoilage can occur in less than a week.

For a solar drier, we have to design for conditions which include periods of several days in which there may be no sunshine. We want to use solar heat if it is available, but can not allow the grain to spoil if a period of low solar availability occurs.

In our previous work at the Alaska Agricultural Experiment Station, we have found that total air flow rates of 1½ to 2 cubic feet per minute (cfm) of unheated air for each bushel of grain will hold the grain without spoilage. By the time outdoor temperatures are near or below freezing, the grain will have dried enough for a safe storage at these cooler temperatures. By spring the grain will be dry.

Warm, clear days speed the drying process. Heat energy added by a solar collector will shorten the drying period and theoretically reduce the time that the fans have to run until the grain is dry enough to keep without continuous air flow. The fans cannot be shut off for long periods before the grain reaches a safe storage moisture level, but once the grain is dry there is no further need for the expense of running the fans.

By increasing the temperature of the drying air 10 or more degrees we have been able to dry grain with air flow rates of 2 cfm per bushel in as little as one week. Since, even during sunny weather, we can only collect solar hear about half the time, we can expect grain in a solar drier to dry in 2 weeks to the 2 months it takes to dry grain with unheated air. This potential cost of electricity savings is the money that can go toward paying off the cost of the solar collector.

We have operated a solar grain drier at the Agricultural Experiment Station's Matanuska Farm for two seasons. Our two commercial, 1000-bushel, round, steel bins and fans are identical. Design air flow rates are about 1½ cfm per bushel when the bins are full of grain. One bin is fitted with a solar collector (see Figure 1).

The solar collector is of simple design. Aluminum roofing, painted black, was installed about an inch outside the bin wall to form the collector (see Figure 2). Wood spacers and the holes cut in the metal bin to admit warmed air are shown in Figure 3. Heat from the sun's shining on the black aluminum is transferred to the moving air behind the sheet. The heated air is admitted to the bin and drawn down through the grain to remove moisture as it passes (see Figure 4). Some heat is added to the system by the black roof. The amount of heat collected is not critical to the satisfactory keeping of the grain, but any solar energy received shortens the drying time.

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Figure 1. Similar 1000-bushel steel drying bins were constructed with one fitted with a solar collector.

Figure 2. The air collects heat as it passes through the 1-inch space between the black aluminum sheet and the bin wall.

Construction of our bins was completed just before the 1979 harvest. When harvest started August 30, the moisture content of the barley was 25%. Harvest continued until September 10, when the standing grain averaged 15.55% moisture. Bin samplings that day indicated that the average moisture content in the solar bin had been reduced to 14.68% and to 15.10% in the control bin. While the added heat to the solar bin resulted in grain about 0.4% drier than the control, this is not enough difference to allow the fan on the solar bin to be shut off before that in the control bin. An additional week of fan operation resulted in the control bin's containing 15.18% moisture in the barley, while that in the solar bin contained 15.01% moisture.

In 1980, the grain again came in at just under 17% moisture content. Continuous cloudy weather after harvest resulted in no difference in performance between the two bins. The grain in both bins dried to 14% moisture content in two weeks but increased to nearly 16% in the next two weeks. Two additional weeks of fan operation brought both bins to below 13½% moisture content. Without sunshine, no difference in the drying characteristics of the two bins would be expected, and none was

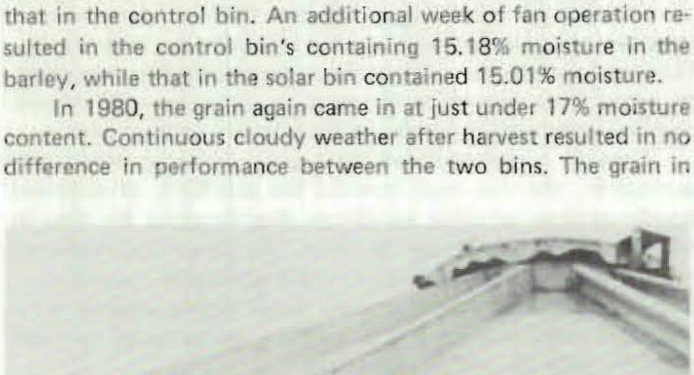

Figure 3. Holes were cut in the bin wall at the top of the air passages to admit warmed air to the bin.

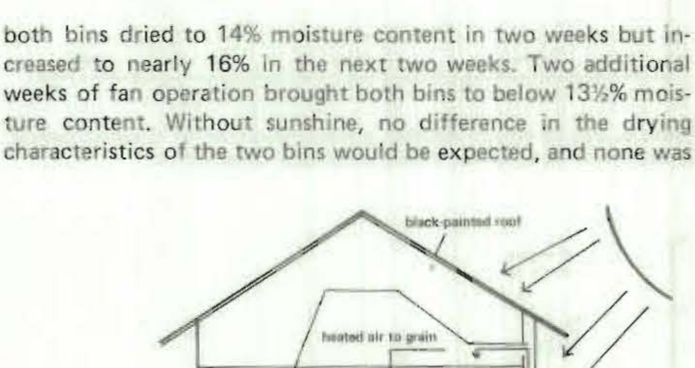

Figure 4. Schematic diagram showing how air passes through the air solar collector before being drawn down through the grain.

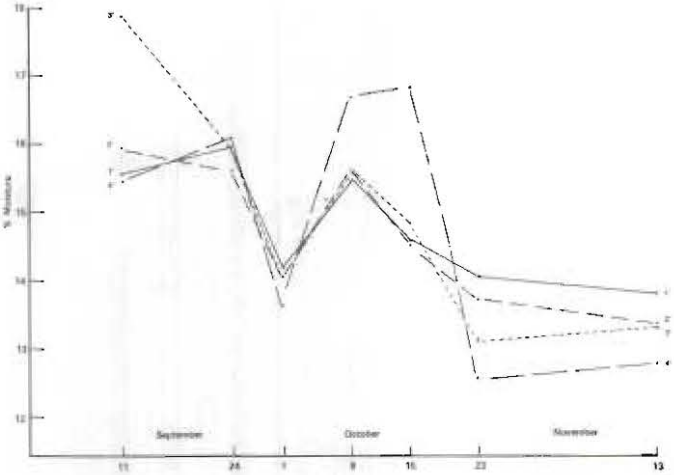

Figure 5. Grain in the unheated air bin dried quickly in 1980, but surface layers became wetter in a period of rainier weather.

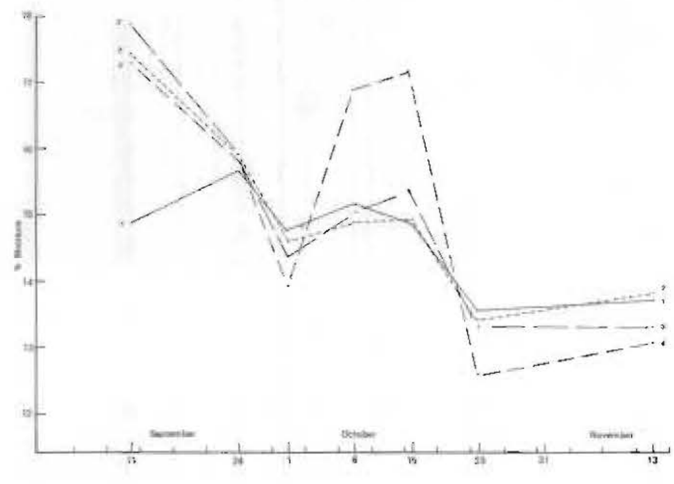

Figure 6. Due to cloudy weather, the drying curves for the solar-heated bin are similar to those for the bin using only unheated air.

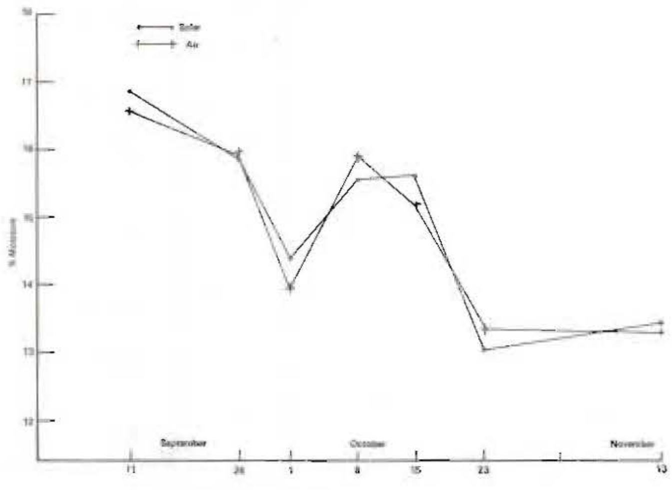

Figure 7. No increase in the average drying rates or final moisture content were accomplished by the solar bin in 1980. The moisture increase in both bins during rainy weather indicates the fans should be shut off during the periods of high humidity.

observed, as can be seen in Figures 5, 6, and 7. (The four depths shown on the curves on Figures 5 and 6 are the depths at which samples were taken.) Inclement weather and high humidity resulted in an increase in stored grain moisture content. The upper layers where the air entered increased in moisture content more rapidly and dried out more quickly when more favorable weather came again.

In these tests, the fans were run continuously. Some improved performance could be obtained by operating the fans only in the daytime, once the initial high moisture content is removed. Operation of the fans during times (at night) when dew is forming results in the deposition of the moisture in dry grain.

Figure 8. The 100°F temperatures at the top of the solar collector when the fans were shut off show that the collector could effectively add heat to the system when the sun was shining.

Solar energy can be captured and utilized in Alaska for drying grain. As it happened, in the two years that we have operated our solar grain dryer, no reduced drying time or financial savings could be determined. Figure 8 shows a thermometer in the solar bin air intake which registers 100°F air temperature. However, temperatures were not this high with the fans running. This does confirm that solar energy is being added to the system on sunny days. Operating temperature increases of 10 degrees have been recorded at midday in the solar bin on clear days.

Even in a well-designed solar grain dryer or other solar application, the user must consider the possibility of extended cloudy weather or other conditions that lengthen the time in which the system can pay for itself. The sunny conditions we encountered in 1979 made the solar bin adaptation unnecessary, since the dry air at that time made quick drying possible without solar help. The cloudy conditions encountered in 1980 made the solar adaptation ineffective.

Our drying fans cost about $6.00 per day for electrical power. This represents a potential annual savings of up to $250.00 for the solar drier if the drying period could be shortened by six weeks.

Solar collectors costing up to $1000.00 could be amortized by electrical power savings in as little as four years. However, for these maximum potential savings to be realized, ideal weather conditions would have to be encountered, and initial grain moisture content would have to be higher than we have experienced.

We cannot presently recommend solar collectors for grain driers in the Matanuska Valley, because we have not experienced any savings from two years' use. In areas where grain moisture content is higher at harvest, or where more sunshine occurs, there is a greater chance that some return on the investment in a solar grain drier could be realized.

Nitrogen

Transformations and Availability in Alaskan Soils

By

George A. Mitchell* and Joseph A. Offner**

An analysis of a soil sample taken from the plow layer of a newly cleared and broken soil in Alaska's Tanana or Susitna Valley would indicate that it contains, on the average, about 4,000 lbs/acre of total soil nitrogen (N). Knowing this, a prospective farmer may be somewhat surprised to find that he cannot grow a satisfactory crop without applying fertilizer containing a N source. He has observed what soil scientists discovered decades ago: plant-available N rarely exceeds 2% of the total N in the root zone at any given time. The remainder is combined in organic compounds of varying degrees of complexity and can be used by plants only after these compounds are decomposed and mineral N released, primarily as ammonium (NH_4) and nitrate (NO_3). If we take our inquiry a step further and compare recovery of N by the crop with the amount applied as fertilizer, the amount recovered is usually less than that applied. The fate of the unused portion of N may include temporary immobilization in the soil or permanent loss through mechanisms of gaseous release to the atmosphere and leaching losses to the subsoil.

The pathways of N in soil and plants are extremely complex. Nitrogen is more mobile and can exist in more different combined forms than other plant-essential nutrients. Even under natural conditions, N transformations occur constantly in what is referred to as dynamic equilibrium. Under such conditions, soil N content, as dictated by climate, vegetation, and parent material, is relatively constant.

Cultivation disrupts the natural equilibrium and reduces N content. The soil ultimately reaches a new equilibrium, this time dictated in large part by cultural practices. With the commencement of crop production, native soil N usually cannot be counted on as a sole source of supply. Much of the N requirement for crops must come from external sources, primarily through N-fixation (legumes) or fertilizer N applications.

Higher costs for fossil fuels used in synthesizing fertilizer N will probably have a significant impact on use of this nutrient for crop production. This restriction on what has been relatively free use of N fertilizer comes at a time when Alaskan agricultural acreage is expanding at an unprecedented rate. This combination of events will require renewed research efforts in the area of N-use efficiency for both native and fertilizer sources. The remainder of this discussion will briefly summarize first-year field and laboratory studies initiated in 1980 to study N transformations and availability in cold soils.

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NITROGEN PROPERTIES OF SELECTED ALASKAN SOILS

Despite relatively high organic matter in many Alaskan soils, the contribution of native soil N to crops is not great and response to N fertilizer is well documented (Laughlin, 1963, 1969, 1971; Laughlin et al., 1976, 1978). A possible explanation can be found in Table 1 which shows comparisons of properties important to N fertility between selected Alaskan soils. As a general rule, soils with high ratios of organic carbon to organic nitrogen (C:N ratio) tend to immobilize N while those having low ratios tend to mineralize or release N. On the average, the Alaskan soils tested had much higher C:N ratios than are generally found in mineral soils in temperate regions. The lone exception was the Kachemak series from the lower Kenai Peninsula with a ratio more closely akin to temperate regions of the world.

Table 1. Comparison of Soil Properties Important to Nitrogen Fertility in Selected Agricultural Soils of Alaska.

Soil Series	Location	pH	Organic Matter	Total N	C:N Ratio	N Mineralization*
			——%	——		lb/a/day
Bodenburg	Palmer	5.9	7.5	0.19	23	0.7
Homestead	Pt.MacKenzie	5.4	6.0	0.14	25	0.3
Kachemak	Homer	4.9	12.6	0.63	12	3.9
Knik	Palmer	6.1	6.6	0.18	22	—
Rabideux	Talkeetna	5.2	11.7	0.37	19	—
Volkmar	Delta Jct.	5.5	8.3	0.20	24	0.8
Susitna	Trapper Crk.	5.4	6.6	0.22	18	—

*46° F soil temperature.

Four of the soils were incubated for a two-month period in the laboratory to measure the rate of release of mineral N from the organic fraction (mineralization). Again, the Kachemak series stood alone with a capacity to release the equivalent of 3.9 lbs. of elemental N per acre per day compared to less than 1 lb. per day for soils having C:N ratios greater than 20. The reader is cautioned that these values represent release under optimum conditions and are undoubtedly somewhat higher than would occur in the field. These results, along with research reports from other areas, would indicate that the occurrence of high C:N ratios in many Alaskan soils would not favor release of organic N to plant-available forms. This is not to say that cultural practices cannot be found that will improve organic N release; however, cold soil temperatures would certainly be a limiting factor. The incorporation of low N plant residue (i.e., barley straw) would further widen the C:N ratio and quite probably result in a tie-up of fertilizer N. Residue management on newly cleared soils in the Delta Junction and Pt. MacKenzie agricultural projects will likely influence N availability to succeeding crops. While residue incorporation has many advantages such as building organic matter, or increasing moisture-holding capacity, there are problems associated with N immobilization which must be recognized.

At the present time, the use of all types of organic amendments must be practiced with caution. In the absence of research conducted in Alaska, about all that can be said with any degree of confidence is that these materials will react differently in Alaska than in temperate regions. While temperature is the prime factor responsible, the following discussion of urea will show that other factors, not commonly found in most agricultural soils of the world, are also at work.

UREA: A NITROGEN SOURCE FOR ALASKA

The presence of an in-state source of urea fertilizer with resultant price advantages has stimulated interest in its use. However, in studies too numerous to cite, its effectiveness, particularly when surface broadcast, is often much less than other N sources. Significant losses can result from ammonia (NH_3) volatilization and occur under conditions of high soil pH, high air and soil temperatures, and high evaporative losses of soil moisture (Terman, 1979). While this combination of conditions is uncommon in Alaska, bromegrass yields with urea have been shown in some years to be as much as 27% less than those with surface-applied ammonium nitrate (Laughlin, 1963).

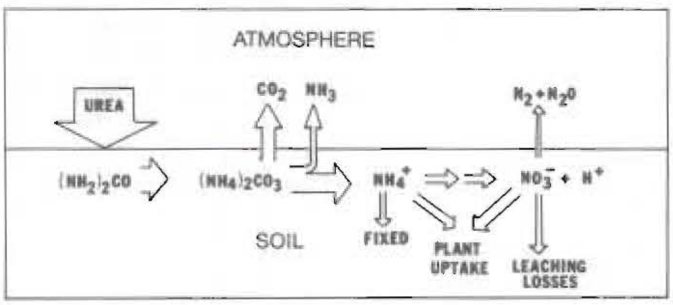

Figure 1. Urea transformation pathways in the soil.

Transformation pathways for urea in soil are shown in Figure 1. That these pathways occur in Alaskan soils is not in question. The laws of biology, chemistry, and physics dictate that they do. The real question is: How rapidly do the transformations occur and which products are favored? Before urea-N can be used by a crop it must be converted to NH_4 by a process called hydrolysis. In this process, urea is first converted to $(NH_4)_2CO_3$ which then breaks down rapidly to NH_3. When this occurs on the soil surface and conditions are appropriate, a portion of the NH_3 escapes to the atmosphere and is lost to the plant. The remainder is adsorbed by the soil and behaves as any other N fertilizer source. Ammonia loss to the atmosphere is dependent, among other factors, on the rate at which urea is converted to NH_3. The more rapid the conversion, the higher the potential for NH_3 loss. A second important reaction in the urea pathway is the conversion of soil NH_4 to NO_3 (nitrification). The rate of this conversion can have important implications in terms of the ultimate availability of urea-N to plants. Both urea hydrolysis and NH_4 nitrification are temperature-dependent reactions and essentially no data are available on the rate at which they occur in Alaskan soils. Both laboratory and field monitoring studies were begun in 1980 to collect such information.

Four soil series (Volkmar, Bodenburg, Homestead, and Kachemak silt loams) from geographically divergent locations (Table 1) were selected for laboratory incubation studies. Fifty-gram samples were incubated in controlled-environment chambers at soil temperatures of 8 and 16°C (46 and 60°F) for 8 weeks. Urea-N was applied at a rate of 100μgN/g of soil (200 lb./a.). Three replicates of each treatment were removed from the chamber at time intervals of 1, 3, 7, 14, 21, 35, and 63 days and analyzed for urea-N, NH_4-N, and NO_3-N.

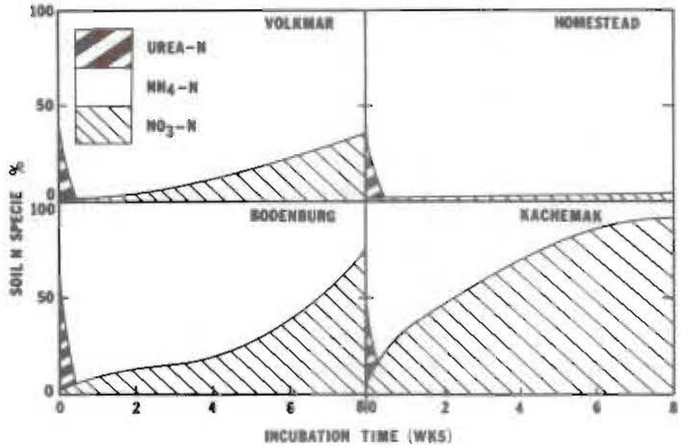

Figure 2. Effects of soil type on urea-N transformation over time (soil temperature = 46°F).

Urea transformations over time for the low temperature treatment are shown in Figure 2. Conversion of urea-N to NH_4 proceeded very rapidly on all soils and was 50% complete within 24 hours; and hydrolysis was essentially complete by the third day following application. These results are in agreement with results on California soils at similar temperatures (Broadbent et al., 1958) but are at odds with findings on Tennessee soils which showed substantial amounts of urea-N persisting for 5 weeks at soil temperatures of 10°C (Fisher and Parks, 1958). The rapid hydrolysis of urea in the Alaskan soils, while not a positive indication, would set the stage for potential loss of NH_3 to the atmosphere. Soil type had a profound effect on the conversion of NH_4 to NO_3. The Homestead series showed no nitrification of NH_4 and the Volkmar series demonstrated a capacity to nitrify only 30% of its NH_4 over the 8-week period. The Bodenburg and Kachemak nitrified 75 and 90%, respectively, of their NH_4; however, most of the Kachemak nitrification occurred during the first 4 weeks, while that in the Bodenburg took place in the last 4 weeks of the incubation period. Since temperate-region soils often show 80-90% nitrification within 2 weeks at soil temperatures of 20-25°C (Broadbent et al., 1958), temperature is a major factor in the low rates reported here.

Table 2. Effects of Soil Temperature on Urea-N Transformation Over Time on a Volkmar Silt Loam (Application Rate = 100μg Urea-N/g Soil).

Sampling Time	Soil Temp. °C	pH	Soil N Species* Urea-N	NH4-N	NO3-N	Total
			------------ μg N/g			------------
24 Hr.	8	5.54	21.0	78.8	2.5	102
	16	5.56	11.0	84.7	2.8	99
Day 3	8	5.55	10.5	87.2	5.6	103
	16	5.53	3.5	87.3	6.6	97
Day 7	8	5.52	—	97.4	6.6	104
	16	5.54	—	92.0	8.6	101
Day 14	8	5.50	—	89.3	7.8	97
	16	5.54	—	93.3	10.1	103
Day 21	8	5.46	—	89.0	8.2	97
	16	5.37	—	78.1	15.1	93
Day 35	8	5.48	—	86.7	10.1	97
	16	5.04	—	60.6	38.3	99
Day 63	8	5.20	—	73.8	32.5	106
	16	4.90	—	20.6	87.3	108

*Means of three replicate analyses.

The effects of temperature on urea transformation for the Volkmar series are shown in Table 2. Low temperature retarded urea hydrolysis somewhat and had a very significant effect on conversion of NH_4 to NO_3. Temperature had lesser effects on the transformations in the Bodenburg and Kachemak series and had no effect on the Homestead soil (data not shown). While temperature effects were evident, the very great differences between soils at the same temperature would indicate that other mechanisms are also inhibiting NH_4 conversion. The two lowest NO_3 producers, the Volkmar and Homestead series, are both recently cleared forest soils at Delta Junction and Pt. MacKenzie, respectively. Nitrification inhibition in these soils probably results from inhibitors produced by decomposing forest litter. Lodhi (1978) showed positive evidence of nitrification inhibition under different dominant tree stands. Inhibition has also been reported when urea was applied to Douglas fir and western hemlock stands in the Pacific Northwest and was most severe in soils having C:N ratios greater than 27 (Heilman, 1974). At least one report has implicated spruce, a dominant species on the Volkmar and Homestead series, in nitrification inhibition (Viro, 1963). It should not escape notice that the highest NO_3 producer reported here was the Kachemak series which is found under permanent grassland vegetation.

The evidence is not clear with regard to plant preference for NH_4 versus NO_3 forms of nitrogen. While NH_4 accumulation in the presence of low pH has been shown to have detrimental effects on crop yields (Barker et al., 1966; Blair et al., 1970; Crooke, 1980), it is generally believed that both forms are equally utilizable by most crops. There are other advantages and disadvantages to having N available in the NH_4 as opposed to the NO_3 form. Since NH_4 is much less mobile in the soil, leaching losses of soil N are less when NH_4 is the dominant available N form. Another advantage is related to soil acidification from N fertilizers. The acid is produced when NH_4 is converted to NO_3 (the H+ shown in Figure 1). If NH_4 is utilized by the plant before this conversion occurs, less acidification would be expected. This could be a definite advantage in Alaska, where lime costs are prohibitive for large-scale use. On the negative side, NH_4 accumulation in the soil may aggravate the problem of NH_3 loss to the atmosphere mentioned earlier. When nitrification of urea is retarded by as much as 60% by artificial inhibitors, NH_3 losses to the atmosphere have been shown to increase substantially (Bundy and Bremner, 1974). A similar mechanism may help explain incidents of comparatively poor performance of urea in Alaska, where conditions would not normally be considered favorable for NH_3 losses.

Although these observations were made in a carefully controlled environment, divergent behavior of soil N would also be expected under equally divergent conditions of climate and soil development in the field. While field verification and interpretation will require extended studies in a number of locations, the following field monitoring study will offer some insight.

UREA PERFORMANCE IN THE FIELD

An attempt was made in 1980 to monitor urea transformations when surface-applied to bromegrass in the field and then to compare these with transformations and availability of equivalent applications of ammonium nitrate. The two N sources were compared at different application rates, however, only the 120 lbs. N/A rate will be discussed here. Figure 3 shows the form and content of available soil N throughout the growing season along with N uptake by the first (1) and second (2) bromegrass cuttings. The soil was a Knik series which has pH and organic N properties similar to the Bodenburg (Table 1). As was the case with the incubation studies, urea hydrolysis proceeded rapidly with only trace amounts of N present in the urea form 4 days following application. No rainfall was recorded in the first 2 weeks following application. This, coupled with rapid urea conversion, would set the stage for NH_3 losses to the atmosphere.

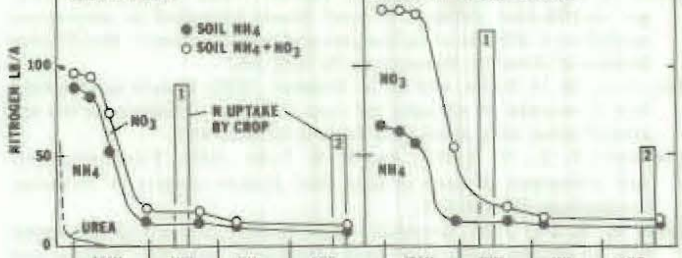

Figure 3. Seasonal relationship between available soil nitrogen forms and nitrogen uptake by bromegrass as affected by nitrogen source, 1980.

Very early in the season total available soil N ($NH_4 + NO_3$) content on the urea plots was a significant 30% less than on ammonium nitrate plots and was consistent over three sampling dates prior to crop removal. A substantial amount of N had apparently been lost from the urea plots and this was substantiated by a 15% lower first-cut yield (data not shown) and 17% lower N uptake by the crop when compared with ammonium nitrate. All comparisons were statistically significant ($P<.05$). While NH_4 was the dominant N form present in the urea plots, a preference by the crop for NO_3 is an unlikely explanation for reduced uptake. The evidence strongly supports NH_3 loss to the atmosphere, probably in the first 4 days following urea application, as the principal mechanism responsible for the somewhat inferior performance of urea.

These differences in N-use efficiency between urea and other N sources do not occur in the same magnitude all years nor in all locations in Alaska. Climate, particularly rainfall patterns, can have a major impact on the magnitude of loss. For example, Dr. Winston Laughlin failed to find significant differences between urea and ammonium nitrate as they affected bluejoint yields on the lower Kenai Peninsula (unpublished data). No differences were observed in barley yields at Delta Junction in 1980 using these same N sources (G. Michaelson, unpublished data). In both cases, the reason was probably related to incorporation — by rainfall on the Kenai Peninsula and mechanically at Delta Junction. These latter observations are in agreement with results from other regions which indicate that incorporated urea is an effective N source. It is also important to remember that, in most years, N losses from surface-applied urea are no more than 15% greater than other N sources. While this represents a significant loss, the cost advantage of urea must certainly be taken into consideration.

CONCLUDING REMARKS

Cold temperatures in subarctic Alaska have left and continue to leave a unique imprint on the genesis of soil nitrogen and on its transformation and availability to plants. This discussion only serves to scratch the surface with regard to the behavior of soil nitrogen. In the next decade, most Alaskan agriculture will take place on newly cleared forest soils. Nitrogen management will be an important factor in the success of new farming projects. Fertilizer nitrogen represents a significant economic input. The overall implications of the observations reported here are not clear. However, the N-transformation patterns are clearly different from those which occur at more temperate latitudes. It follows that N research information generated in other regions must be used with caution in Alaska. Agricultural Experiment Station staff members at Fairbanks and Palmer are currently conducting research which includes variables of nitrogen rates and sources, cropping sequences, tillage practices, lime application, and many others at Delta Junction and, more recently, at Pt. MacKenzie. These efforts should greatly increase our knowledge of efficient nitrogen use and reap economic benefits for Alaskan farmers.

ACKNOWLEDGMENTS

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What can be done when bison and agriculture meet head-on in Delta Junction?

Alaska's Bison

A Game Biologist's Range-Management Problem

By

Jay D. McKendrick*

Exploiting buffalo for hides and meat in the 1800s removed wild bison, leaving space available for agricultural industrial and building developments. Fortunately, specimens of the once-great herds remained. However, some of Alaska's agricultural pioneers in the 1980s are now facing problems with bison predation on new croplands. But Alaska's bison are probably not destined to the same "removal" methods of their counterparts a century ago. A combination of public pressure and a hundred years of progress can allow Alaska to keep the bison and harvest barley as well.

The United States Department of Agriculture (USDA) introduced 23 bison into Alaska in 1928 (Burris and McKnight, 1973). The animals came from Montana and at that time represented the only specimens in our state. The effort was part of an experimental wildlife-introduction program. The animals were released in the vicinity of McCarthy, Alaska (now Delta Junction).

The USDA experiment eventually resulted in the several bands of free-roaming bison that now comprise the Delta Junction herd. In turn, animals have periodically been removed from this herd for transplant to other regions in Alaska. Outside of Yellowstone Park, Alaska's herds are probably the only bison in the United States not confined by fences. There are free-roaming bison in Canada's Wood Buffalo National Park which, like the Yellowstone herd, exist without management (Meagher, 1978). Unlike the national-park bison, however, Alaska's Delta Junction herd has been managed by limited hunting, salting, mineral supplementation, and other attempts to control numbers and movement. During the 1930s, the herd apparently ranged among the streambeds of Jarvis and Granite Creeks and the Delta River (see map), and increased over 600% to 150 head in the 8 years following its release (Gabrielson, 1936).

In *The Delta Paper* of 3 June 1981, Dave Johnson, Delta Area Game Biologist for Alaska Department of Fish and Game, reported a 1981 count of 352 head of bison, including 51 new calves, in the Delta River area. There were perhaps more animals but they escaped detection in the 1981 survey. In that same month, the Alaska State Legislature was considering at least four bills with appropriations amounting to nearly half a million dollars either to compensate farmers for or to otherwise protect farm crops (primarily barley) from damage inflicted by the roving bands of bison from the Delta Junction herd.

It is doubtful that the USDA zoologists who released the bison in the 1920s ever envisioned any conflict between their animals and cropland agriculture. But five decades after release of the bison, the state of Alaska has elected to include agricul-

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Expanse of open vegetation along the Delta River contrasting with the closed forest (foreground). Bison forage in such openings along streams in the Delta Junction vicinity.

Forest floors provide sparse forage for bison and other ungulates in the Delta region. This early-spring photo shows only a few leafless shrubs, which offer little nutrition to bison at calving time.

Openings in the forest yield a grass and forb crop which is sought by the free-roaming bison. Notice how concentrated travel and wallowing has removed all living plant cover at the edge of the forest in this photo.

tural production in its renewable-resource development program. That goal includes cropland farming near Delta Junction, where crops may be subjected to bison damages.

The state's goal is to have 500,000 acres in agricultural production by 1990, an acreage that could yield enough produce to meet a significant portion of Alaska's food needs. Presently, over 95% of Alaska's food is imported, while at the same time she exports most of her nonrenewable resources. Currently, the Delta agricultural project designates about 100,000 acres for cropland development, or about one-fifth of the state's 1990 goal. There is an estimated 20,000,000 acres, about 5% of Alaska's area, suited for agricultural crop production (Rieger et al., 1979).

Clearly Delta's agricultural project and bison herd are important renewable resources to Alaska. But the bison have damaged barley crops through trampling. Thus, wildlife and agricultural resources are in direct conflict. Resolving the problem is of major and immediate importance. Several states are effectively using their wildlife extension specialists to help control wildlife damages to real estate, crops, and livestock (Dickneite, 1973). The impartiality of the Cooperative Extension Service and a state university is a major factor in resolving conflicts surrounding wildlife-control programs in other states. Judgements of state and Federal agency personnel are often questioned when the agency is in the midst of a severe conflict. It would seem appropriate for Alaska to have an extension wildlife specialist to address wildlife-damage problems problems such as this one with bison. A brief synopsis of the conditions of the Delta Junction bison herd's range and possible management options is in order.

As a result of heavy bison grazing and wallowing, wind erosion is attacking the forest at some locations along the Delta River. This photo shows a large spruce tree (Picea glauca) that toppled after the soil was blown from around its roots.

Range Types and Conditions

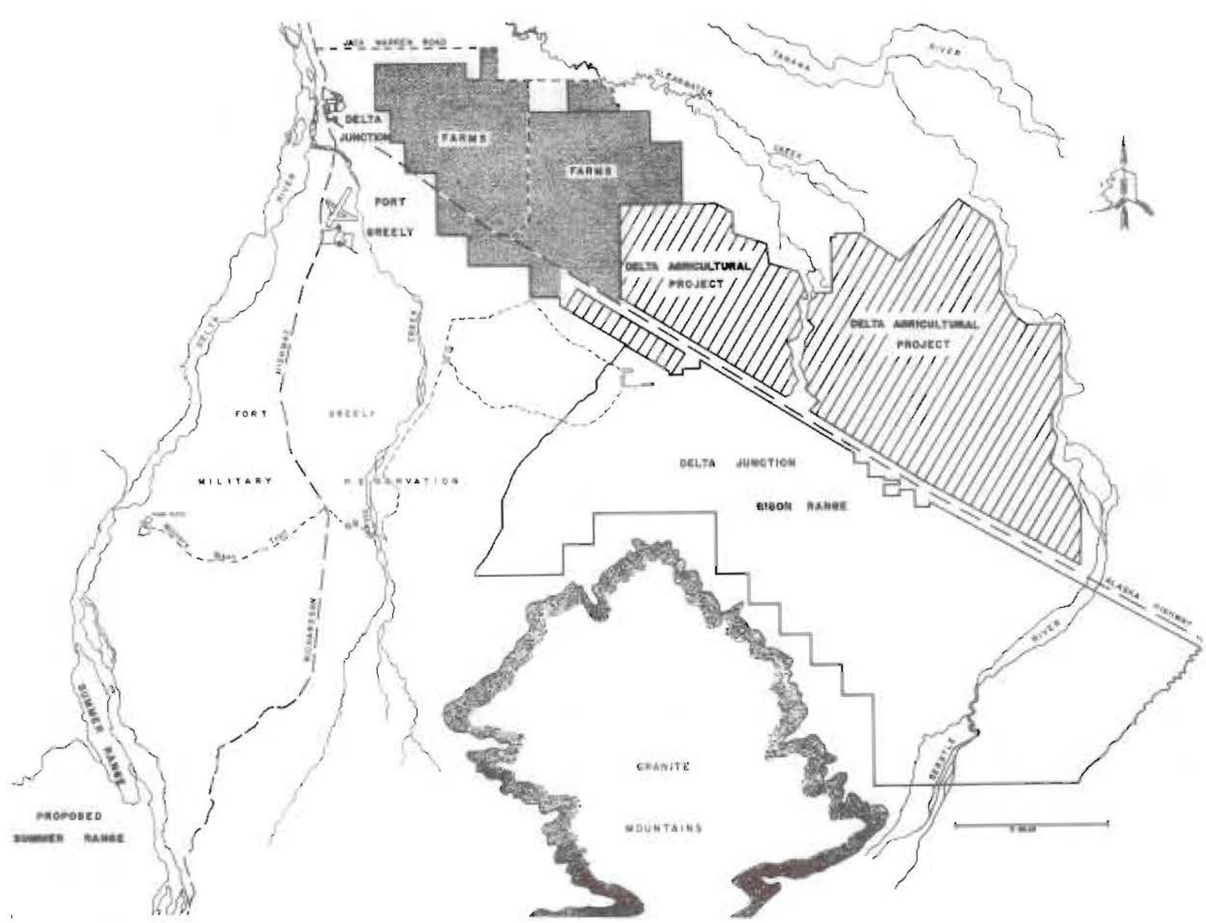
In 1980 and 1981, we examined the bison's spring and summer ranges along the Delta River and found the following: 1) annual forage supplies are prematurely exhausted; 2) bison are resorting to feeding on shrubs after their favorite grasses and forbs are gone; 3) soil is eroding because heavy grazing has removed protective plant cover; 4) apparent soil infertility exists; and 5) unpalatable trees and shrubs are dominating where grasses and forbs have previously prevailed. These observations indicate that the range is overstocked, overgrazed, and in a downward trend.

Overstocking has probably resulted from the *increase* in bison numbers since their introduction 53 years ago with a concurrent *decrease* in suitable, summer-range acreage. The loss of range production is the most serious change.

Several factors have reduced available range acreages. One is the natural, gradual tendency for trees and shrubs to replace grasses and forbs and to dominate the landscape in this region. Bison usually choose their diets from among the nonwoody plants that grow in open areas. In this region, these nonwoody plants include the grasses and forbs which are pioneers on bare sites prior to the invasion of forests. They are found primarily along stream channels and on shallow or undeveloped soils. As the forests develop, the herbaceous plants must yield space, moisture, and soil nutrients to the taller-growing trees and shrubs. Thus, numbers and production of the choicest forage sites for bison are destined to change from preferred grasses and forbs to unpalatable trees and shrubs unless periodic disturbances remove the trees and shrubs.

Fire control is a man-caused phenomenon that has probably reduced naturally available bison range more than any other factor. The natural occurrence of wildfire in Alaska is well known (Barney), 1971; Heinselman, 1971). Controlling fires reduces the "revitalizing" vegetation cycles that periodically create suitable forage for bison and rejuvenate mineral-nutrient supplies in the cold soils of interior Alaska. Instead of scattered stands of herbaceous bison forage, various forms of scrub forest predominate in the absence of fires.

Judging from the stage of forest development surrounding homesteads between Delta Junction and the new agricultural project (see map), it is apparent that fires occurred either as homesteaders cleared their lands or that homesteads were located on previously burned sites because land clearing was easier there. Regardless of how the burning occurred, succession has



The Delta Agricultural Project is in close proximity to the present bison range.

proceeded for perhaps 50 years, and land that was once devoid of trees and that could have provided natural forage for bison is now forested and unproductive as rangeland. The lands that have been farmed have not become forested but, instead, produce crops that bison readily invade during fall and winter in search of forage. Thus, man and nature have collaborated to reduce native bison range acreages and to focus bison grazing on agricultural croplands.

Possibly, agriculture and other human projects that cleared forests have promoted bison-herd expansion by providing fall and winter range. Without such, forest invasion would have reduced available forage in the herd's wintering area and thus restricted herd expansion. If this is the case, that might partially account for overstocking on the native summer range along the Delta River. A survey of available range and seasonality of range habitat selection is needed to actually determine the annual balance of available forage for the entire herd.

Plants acceptable as forage by bison occur naturally in marshes around lakes and ponds in the region. The marshes, usually too soft to support bison in summer, provide winter forage after freeze-up in late autumn and winter. Vegetation in marshes seems to be quite resistant to foraging, possibly because it is foraged when plants are dormant and most tolerant to grazing. Snow and frozen soil protect the plants' growing points from grazing and trampling damages in winter. Winter use of swampy sites by bison was noted by Soper (1941) in Canada.

Forage production on native ranges is related to soil-fertility level. On the bison's summer range, soils are thin, undeveloped silts and sands overlying river gravels. Such soils are usually infertile. As they develop, with further accumulations of silts and through the influences of plants, they increase in fertility. That natural process may require thousands of years and is beyond the scope of practical management. Consequently, range and wildlife managers encountering such conditions must either align their goals within the constraints of the natural soil-fertility regimes or resort to often-costly soil fertilization.

Soil-nutrient deficiencies must first be detected before selecting a management option. There are two indications of soil nitrogen deficiencies on the bison's summer range: 1) the relative abundance of nitrogen-fixing plants, and 2) the response of grasses to bison manure. Nitrogen-fixing plants often predominate on soils low in available nitrogen because those species obtain their nitrogen from atmospheric supplies that are unavailable to nonfixing species. Where soil-nitrogen supplies are adequate, nitrogen-fixing species must compete with other plants and thus occupy subdominant positions in the community.

The table shows basal-cover percentages for plants on the bison's summer range. *Oxytropis* species are nitrogen-fixing plants and, after mosses, they dominate with *Festuca rubra* (red fescue). Other known nitrogen-fixing plants high on the list are: *Elaeagnus commutata* (silverberry) and *Dryas drummondii* (yellow dryas).

Animal feces and urine contain readily available forms of nitrogen that can promote growth and green color development in grasses growing on nitrogen-deficient soils. Such a response is apparent in grasses growing next to bison chips on the summer range. These two indicators of soil-nitrogen deficiencies suggests the bison's summer range is limited by soil infertility.

Range Needs

Before all the bison were released at Big Delta, three were held for study at Fairbanks. The food requirement for bison was determined to be 900 pounds per month (Palmer, 1944), or about 2½ to 3% of the body weight per day. Annually, a range acreage producing at least 10,800 lb. (12 month x 900 lb.) grazable forage is needed by each adult bison. Because range plants cannot survive 100% cropping annually, and some plants are either unavailable or have no nutritional value during winter, extra acreage allowances are necessary to ensure range-plant and bison-herd maintenance.

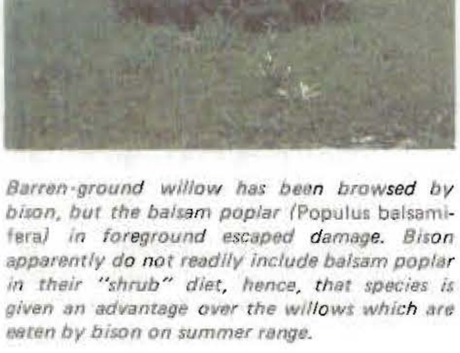
According to Soper (1941) the northern bison densities in Canada were low, 1 animal for every 70 to 90 acres compared to 24 acres per head for the southern plains. Winter-range densities for the northern bison in Canada were about 850 acres per head. Unmanaged range-acreage requirements for Alaska's bison have not been determined, but the Delta herd probably requires acreages similar to those noted in Canada. Range-forage production varies from nil to perhaps 800 to 1,000 lbs. per acre on the best sites in the Delta region. Native-range production and nutritional quality comparable to the southern plains is unlikely in the Delta region because of low fertility in the Alaska soils and competition from unpalatable plants and weather.

Assuming Palmer's (1944) figures are correct for bison forage needs and that, by removing tree and brush competition, ranges in the Delta Junction area would produce 200 to 500 pounds of grazable forage annually, 350 head of adult bison would need 8,000 to 19,000 acres of range. If improved pasture were developed by clearing, seeding, and fertilizing, production levels might average 500 to 1,000 pounds of grazable forage annually. Then 5,000 to 9,000 acres would be needed for 350 head of adult bison.

The Buffalo Drop Zone on Fort Greely is an example of range on which the growth of trees and shrubs is retarded by periodic mowing. Mowing fails to kill many woody species which simply resprout and continue competing with the grasses and forbs. Forage production on the area appears to be in the range of 600 to 900 pound per acre, which would yield about 300 to 450 pounds of grazable forage. Not all of the herbage is palatable. *Hordeum jubatum* (foxtail barley) and various unpalatable forbs are present. Palatable grasses include: *Calamagrostis purpurascens, C. canadensis, Elymus innovatus, Festuca rubra,* and *Poa pratensis.* Bison apparently use the area mostly during the winter months.

Within the Delta agricultural project and on adjacent croplands, there are examples of improved pastures and hay fields that appear to be producing 2,000 pounds or more of forage annually. If hay harvests and fertilizer applications are timed properly, these cultivars of various grasses can remain green until freeze-up. Presumably, the frozen leaves would retain much of their nutritional quality throughout the winter. Bison feed on those plants, so they are apparently palatable.

Green "halos" surrounding buffalo "chips" signal the deficiency of soil nitrogen on this gravel bar. These young soils are inherently low in fertility, having recently formed from glacial outwash.



*Barren-ground willow has been browsed by bison, but the balsam poplar (*Populus balsamifera*) in foreground escaped damage. Bison apparently do not readily include balsam poplar in their "shrub" diet, hence, that species is given an advantage over the willows which are eaten by bison on summer range.*

Basal Cover Percentages for Plant Species, Bare Ground, and Fecal Matter on Large Gravel Bar on Bison Summer Range, Delta River. (28 August 1980).

Vegetation	Cover Component
Moss species	18.00
Festuca rubra	4.48
Oxytropis sp.	5.48
Carex sp.	2.55
Aster sibiricus	1.72
Elaeagnus commutata	1.20
Salix brachycarpa ssp. *niphoclada*	1.09
Dryas drummondii	1.04
Elymus innovatus	.68
Salix setchelliana	.57
Potentilla multifida	.52
Calamagrostis purpurascens	.52
Artemisia borealis	.42
Lichen sp.	.36
Poa sp.	.36
Poa glauca	.31
Erigeron glabellus	.31
Populus balsamifera	.31
Taraxacum sp.	.26
Arctostaphylos rubra	.21
Stellaria sp.	.21
Bupleurum triradiatum ssp. *arcticum*	.15
Calamagrostis lapponica	.15
Agropyron violaceum	.10
Epilobium latifolium	.10
Shepherdia canadensis	.10
Picea glauca	.10
Parnassia palustris	.05
Potentilla fruticosa	.05
Arctostaphylos uva-ursi	.05
Geocaulon lividum	.05
Pyrola sp.	.05
Salix alaxensis	.05
Linum perenne	.05
Total vegetation	42.55
Bison chip	.62
Moose pellet	.05
Total cover	43.32

Management Options

Enclosing the entire Delta bison herd with a fence is an option suggested by some in the Delta community. Others have favored enclosing the farms with fences to exclude the bison. Given either of these options, it is probable that the bison will eventually destroy any fences as they seek the forage on the farmed land. But either method would provide immediate protection for crops. Long-

Buffalo wallows were common features of the Great Plains prior to the time of settlement. This photo shows a buffalo wallow near the Delta River in Alaska. Constant use prevents plant cover from developing.

This close-up of a natural mineral lick shows how bison have created cavities in the soil, presumably in search of nutrients lacking in their diets.

Sedges and forbs appear to be producing a lush early summer growth a few months after the shrubby birch and spruce overstory was killed by fire.

Before shrubs and trees invade gravel bars, grasses and mosses may dominate. Calamagrostis purpurascens, *is a bunchgrass which provides herbage for bison grazing in some locations along the Delta River. This photo is of ungrazed* Calamagrostis.

A late-winter wildfire was carried by high winds through brush and trees on part of Fort Greely. This fire effectively opened a significant area. Forbs and grasses will be given an advantage over trees and shrubs for a few years. This should augment the forage supply and possibly relieve grazing pressures on the nearby bison summer range.

Resin birch (Betula glandulosa) *was killed by wildfire, but the sedges and grasses only sustained burned leaf tips because they retain their buds and growing points below ground, thus escaping. The birch and other shrubs have their buds above ground, exposing them to fire. They must reinvade the burned area as seedlings.*

term management, however, must include provisions for increasing forage supply for the present herd.

Since fire is a natural means of converting forest into forage-producing range, burning could be used. It would certainly be less costly than mechanical clearing, unless commercial timber could be harvested to offset clearing costs. A wildfire burned across about 17,000 acres of brush and forest land during the fourth week of March, 1981, between Donnelly Dome and Delta Junction, killing much of the unpalatable brush and removing the organic mat insulating the otherwise cold soil. By June, the burned area was carpeted with vigorously growing grasses and sedges, immediately augmenting supplies of bison forage in the area. In time, the trees, shrubs, and organic mat will increase on the burned site, and forage production for bison will decline. The rate of decline in forage production and sequences of reinvasion by trees and shrubs should be monitored to document time frames useful to wildlife and range management for domestic livestock for this region.

Chemical treatment (herbicides) could also be effective in killing trees and brush, but this would not remove the standing dead, necessitating a follow-up with either burning or mechanical clearing. Also, chemical treatments are difficult to clear for use on public lands because of environmental restrictions.

Clearing forest lands and then seeding to preferred forage grasses is an alternative. However, such an option would be costly and require consistent management to maintain a shrub- and tree-free range. Due to the high costs of clearing, seeding, and fertilizing such a range, it would be expensive to allow woody plants to reinvade. One means of preventing reinvasion of trees and shrubs and of offsetting maintenance costs would be to lease the seeded grassland for hay harvest with a binding agreement that only the first crop of hay would be harvested each year, and that it be timed to induce a lush second growth for fall and winter grazing by bison. The fields would have to be fenced to exclude bison during early summer when used for hay production, and a soil fertilization program would be needed to maintain the grass stand, but such arrangements would provide high-quality forage for bison. Furthermore, Alaska Department of Fish and Game's management would consist of administration of contracts rather than of applying ranching practices to "culture" bison range. The side benefit would be to increase Alaska's hay, a product which is usually in short supply.

Seeded areas along the trans-Alaska oil pipeline are selectively used by bands from the Delta Junction herd. Arctared red fescue (*Festuca rubra*) is one plant particularly favored. Foraging on the seedings has been year-round, indicating that a properly seeded and fertilized range could attract bison.

Drift fencing rather than enclosures, salt and mineral blocks, selective burning, clearing, seeding, and fertilizing could be used in various combinations to control animal movements and increase the bison's forage supply. All those techniques should be aimed at keeping the bison well away from the current croplands.

Since the bison seemed to concentrate on the west side of the Delta river following their release (Gabrielson, 1936), and since that area is well removed from the present agricultural lands (see map), it should be considered a prime area for bison-range development. Lowland sites rather than hills and mountains should be selected as far south as possible, to create the utmost distance between the bison's ranges and the croplands to the north and east of Delta Junction and to yield a maximum of preferred range. Because bison dislike soft, boggy soils (Soper, 1941), well-drained areas would provide the most enticing range during seasons when soils are thawed. Soper (1941) also noted the Canadian bison selected ranges that included water, so lakes and streams will be needed for drinking water during ice-free periods. Boggy sites that would remain ungrazed during summer could be included to conveniently save grazing areas for winter use only. The quantity of forage made available combined with controlled hunting should govern herd size.

Heavy grazing of feltleaf willow by bison indicates a highly overused summer range. This late-August photo shows almost total consumption of the current-year's twig growth.

Current Activities

Currently, the U. S. Army (Ft. Greely), the U. S. Soil Conservation Service (USDA) and the Alaska Agricultural Experiment Station are cooperating to assist Alaska Department of Fish and Game with its bison-management projects. Ft. Greely has jurisdiction over much of the land occupied by the Delta Junction bison herd. Establishing game trails, "food plots," and providing salt and mineral blocks are some of the current management practices on the military reservation.

An Air Force rocket was responsible for the fortuitous burning of a portion of the bison's habitat in 1981. Even though the military probably disliked responsibility for the accidental fire, it created more bison range forage for this area than any other 1981 event.

The U. S. Soil Conservation Service is lending advice for various management techniques and hopefully it will be able to provide soil mapping in the future. The Alaska Agricultural Experiment Station is researching the bison diets and determining ecological aspects of the various range types used by the bison. Monitoring vegetation production and species composition changes on the burned area, mapping vegetation, and measuring the nutritional quality of various range plants in the area are other important aspects of the Experiment Station's studies. Results of this research are expected not only to assist Alaska Department of Fish and Game with its bison-management project, but also to provide data for domestic-livestock range management for interior Alaska.

SUMMARY

The U. S. goverment's transplant of bison into Alaska in 1928 successfully created free-roaming bison herds in the Delta River vicinity. Bands from this herd now cause extensive crop damages to Alaska's state-sponsored agricultural development project east of Delta Junction. Currently, the summer ranges are overgrazed and croplands provide winter range for bison. Alaska wants to keep the free-roaming bison as a game animal. Several hundred applicants vie annually for permits to hunt bison from this herd. Members of the local community want the herd because it lends distinction and attracts visitors to their area. Increasing the state's agricultural production is a primary state government goal and a necessary activity if the people of Alaska are to increase their self sufficiency and decrease their dependency on nonrenewable resources. Alaska's agricultural production can only occur where the climate and soils are suitable. In the case of the Delta Agricultural Project, the suitable climate and soils for agriculture happen to be too close to the Delta bison herd's ranges.

The Delta Junction game biologist has an imposing task. Devising workable and bureaucratically acceptable management schemes to keep bison out of the crops is chore enough for any game manager. Making such plans acceptable to various public groups increases the difficulty. Obtaining the financial support from a politically sensitive state government comprised of agencies whose goals and objectives may conflict lends geometric proportions to the work. The only other factors that could and, in this instance, do further compound the problem are mixed land ownership and easements. Federal, state, private and local government ownership are all part of the Delta bison herd's ranges.

Possibly the only workable approach is to start from the ground up. Obtaining support and cooperation from local community interests is the first step and is essential before the agencies of state and Federal governments will effectively respond. The local coalition approach has proved valuable in difficult range management situations where state-Federal conflicts have arisen (Sharp and Sanders, 1978). It could work here, too. The farming community and the local game biologists must first agree on a workable plan, then the tasks of managing bison and farming will be substantially easier. Delta Junction, Alaska can surely have barley and keep bison too. But it will require people cooperating and innovating and implementing range management techniques.

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Retired: Dr. Curtis H. Dearborn

Dr. Curtis H. Dearborn, research horticulturist, has retired from the Palmer Research Center after thirty years. Dr. Dearborn came to Alaska with his wife Doris in 1950 after four years at the New York Agricultural Experiment Station at Geneva where he worked closely with Cornell University in his work as a plant breeder with corn and peas.

Dr. Dearborn did his undergraduate work at the University of New Hampshire from which he received his degree in 1935 in pomology. In 1939 he received his Ph. D. in horticulture from Cornell, after which he was employed by the W. Atlee Burpee Company as a plant breeder.

Dr. Curtis H. Dearborn and his wife Doris at their home in Palmer.

Some of Dr. Dearborn's research in Alaska has included work on weed control in the production of potatoes, garden peas, lettuce, and strawberries; work with peas as an Alaska frozen-food product for local distribution; and, especially significant to Alaskans efforts to measure light quality available for crops.

Dr. and Mrs. Dearborn hope to visit New Zealand in the near future in order to observe varieties of potatoes in production there which he developed for Alaska, namely 'Snow Chip,' 'Alaska Red,' 'Denali,' and 'Alaska 114.' In the meantime, he is growing out a number of apple seedlings to see if there is a better variety for Alaska. He is also continuing to breed strawberries at his home in Palmer, and will continue work with potatoes as well. He will also continue to pursue his work with Eskimo villages in the Kobuk River valley to enable them to grow potatoes for that local market. His work in that area is sponsored by the Marston Foundation through the NANA Native corporation.

Toward a System of Grazing Fees For State Rangelands in Alaska

By

William G. Workman* and Edward L. Arobio**

INTRODUCTION

The development and production of Alaska's petroleum resources have generated tremendous wealth, yet many Alaskans are expressing concern for the future of the state's economy. This concern is based on the fact that Alaska is relying on a nonrenewable resource for its income and suggestions for development of her renewable resources are being heard more and more. These feelings are reflected in recent state legislative actions which have established entities whose functions are to encourage the further development of the agricultural and fisheries potentials of Alaska. In addition, local governments and private-interest groups have organized to promote increased economic activities related to agriculture, tourism, forestry, and mining resources. The fundamental concern of those arguing for a more diverse economy is that long-term economic stability

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will be difficult to achieve with the present heavy reliance on the petroleum industry. A broadening of the economic base to include the production of other natural resources is seen as a condition necessary for sustained economic growth.

The use of the potentially large, untapped grazing resources of Alaska by livestock enterprises is believed to represent one area of renewable-resource development holding economic promise (Burton, 1975, 1977). A growing interest in range-livestock enterprises to complement the state's fledgling farming industry is reflected in increased numbers of applications for grazing-use permits and by recent efforts by the Alaska Department of Natural Resources (DNR) to revise policies governing livestock grazing on state lands. As with any other segment of the Alaska economy, the potential for the range-livestock industry to develop into a significant contributor to the state's economic base can be enhanced if the guidelines of economic efficiency are used. One factor in the success of this potential industry will be the management of the necessary forage resources. The establishment of an allocative mechanism to distribute the use of these lands to livestock operations that can use them most efficiently will increase the likelihood that these resources realize their economic potential. At the same time, the introduction of competitive forces in this market for state-owned forage would increase the chances for Alaskans to receive the fair market rental price as payment for the use of their public grazing resources.

With these concerns in mind, DNR asked the University of Alaska Agricultural Experiment Station to suggest and evaluate several methods of calculating livestock grazing fees on state-owned range lands in Alaska. The highlights of our study results are presented here.

COMPETITIVE PRICING OF FORAGE ON PRIVATE RANGE LANDS

In the western United States where livestock grazing is an important use of public lands, the price of forage from private range lands typically serves as a reference for setting grazing fees in the public sector (Depts. of the Interior, and Agriculture, 1977). While in Alaska there are few of these transactions between private parties on which to base fees on state lands, a brief look at prices generated through voluntary exchange should be useful in evaluating other methods of establishing these charges.

In a market economy, prices of goods and services are determined by the combined forces of supply and demand. In a given market area, for example, the demand for grazing services may be depicted graphically as an *inverse* relationship between the price of forage and the quantity purchased per unit of time (Figure 1). This negatively sloping line suggests that at lower prices greater quantities of grazing services will be desired or "demanded" by those livestock operations that can make use of this forage. Alternatively, we may view this relationship as being one in which successive units of grazing yield *declining incremental benefits* or value to the user; thus the user is willing to purchase these additional units only if the unit price is lowered. This latter interpretation of the demand curve as a *marginal* or *incremental benefit curve* has a significant advantage in judging the desirability of a given level of activity in the market for a good or service, as will be seen shortly.

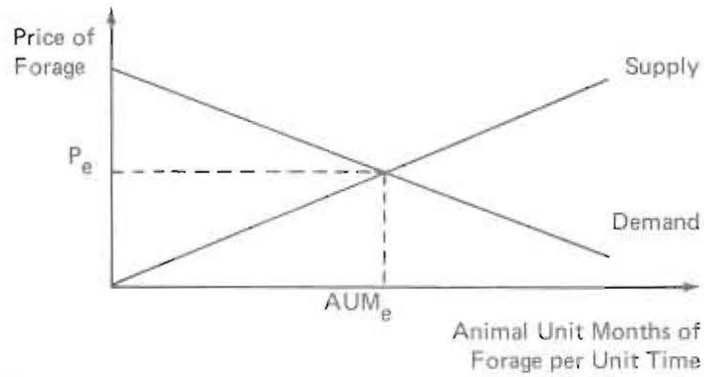

Figure 1. Hypothetical Private, Competitive Forage Market.

The positively sloping supply curve (Figure 1) reflects the fact that the amount of forage that will be offered for use by the resource owners in a competitive market in any time period is likely to be directly related to the offer price. The fundamental reason for this direct relationship between price and quantity of forage supplied has to do with the potential value of these resources in other uses. In order for greater quantities of land for grazing purposes to be put on the market, some other uses of these lands must be sacrificed. Thus, the first lands used in grazing will be those with the lowest opportunity costs (i.e., smallest amount foregone from alternative uses). However, as greater and greater amounts of land are demanded for grazing purposes, those resources better and better suited for alternative uses will be drawn upon. This means that the opportunity cost of using land for grazing has increased. The positively sloping supply curve suggests that, in order for resource owners to make greater quantities of land available for grazing, they must be compensated with higher and higher prices due to the greater sacrifices incurred by not having these resources employed in their next-best alternative uses.

The interaction of supply and demand forces establishes the quantity of grazing resources that are used and the equilibrium or market-clearing resource price (AUM_e and P_e, respectively, in Figure 1). In a competitive, efficiently operating market, these supply and demand forces determine the socially desirable level of grazing activity for the specified period. Inasmuch as the demand curve reflects society's marginal benefit from livestock grazing, while the supply curve measures marginal costs of using these resources for rangeland, at the grazing level AUM_e, total net benefits from grazing are maximized. If the grazing level were reduced from AUM_e, there would be a greater reduction in benefits than in costs since the demand or marginal benefit curve lies above the marginal cost or supply curve in this region. Conversely, if grazing were increased beyond the level AUM_e, this would involve a greater addition to costs than to benefits, thus again causing net benefits from grazing to decline. Therefore, AUM_e represents the socially optimal or efficient level of grazing activity since net benefits from this use of rangeland are maximized at this use level.

The market-clearing price of grazing services, P_e, is of special significance since, being determined by supply and demand forces, it reflects both the marginal benefits of using the resource for grazing and the marginal opportunity cost of making resources available for this purpose. Note that if the price of grazing services were temporarily below P_e, given the existing supply and demand schedules of Figure 1, then a shortage would occur since the quantity demanded of grazing services exceeds the amount that resource owners are willing to offer for sale at prices below P_e. This is a disequilibrium situation and forces exist to cause upward pressure on the price of the resource. These forces dissipate when the price P_e is established, i.e., quantities of the resource that suppliers and demanders wish to exchange are equal at P_e. On the other hand, if the price were above P_e the resulting surplus of grazing resources would generate downward pressure on the rate at which grazing services were exchanged until the market-clearing price, P_e, prevailed and the market cleared. In the presence of competition and allowing sufficient time for adjustments, the price of forage will converge to a "fair market value" and owners of grazing lands will earn a competitive rate of return on their investment in these resources.

THE THEORY APPLIED TO PUBLIC GRAZING LANDS

To the extent that the objective of public-sector resource managers is to promote the efficient allocation of publicly held grazing resources (i.e., maximize the net benefits to society from the use of these resources), efforts will be made to establish grazing fees at the fair market value as described above. One must recognize, however, that, even in the absence of non-efficiency goals such as those having to do with equity or income distribution, the details of resource allocation in the public sector may deviate from those of the exchange economy process outlined to this point. The conditions that prevail on the supply side of the "market" account for these deviations.

In the private sector, resource suppliers are motivated by opportunities to earn a profit from the sale of resource services. As outlined earlier, range resources in the private sector are made available for livestock grazing when the returns from this use exceed opportunity costs or earnings from other potential uses, and greater quantities of rangeland forage will be offered on the market as the price of grazing services increases. Thus, in the private sector, resource prices function to determine the quantity of the resource that is offered for sale as well as to ration these resources among those desiring their use.

In the public sector, on the other hand, there are many circumstances in which the quantity of a publicly owned resource offered for use may be quite inelastic or insensitive to changes in resource price. Rather, even in the presence of a mandate for the manager to direct resource use such that society's best interests are realized, due to political considerations these resources in the public sector often do not move freely to their highest-valued use. Interest groups that favor the status quo or that desire use patterns of the resources other than that combination which would maximize the net benefits to all of society may bring to bear pressure that inhibits increments of the resource from being offered for this high-valued use even in the presence of increasing prices.

In addition, some of the land resources that reside in the public sector may have little or no use value other than, say, for grazing. Even if other use opportunities exist, they may not be in physical conflict with grazing. In these latter cases, then, the opportunity cost of designating a land area as a grazing resource is very low indeed. Therefore, to the extent that the land is valuable for grazing at all, it may be put to this use with little sacrifice. If a great proportion of the public land in a particular area falls into this category and is committed to livestock grazing, then it will not be possible for the public sector to respond markedly to higher forage prices by designating greater quantities of land for livestock grazing. That is, the supply of grazing services in these circumstances would appear to be quite inelastic with respect to changes in price.

While resource price may play a rather insignificant role in the public sector in determining the quantity made available for use, price can still serve as a rationing device on the demand side of the market. Consider the situation in Figure 2 in which D represents the market-demand curve for grazing services in a given area while S is the price-inelastic supply of grazing-resource services made available by managers of public-lands in a given time period. In this case if price is set at P_1, the quantity demanded of grazing services (Q_1) exceeds the quantity available (Q^*).

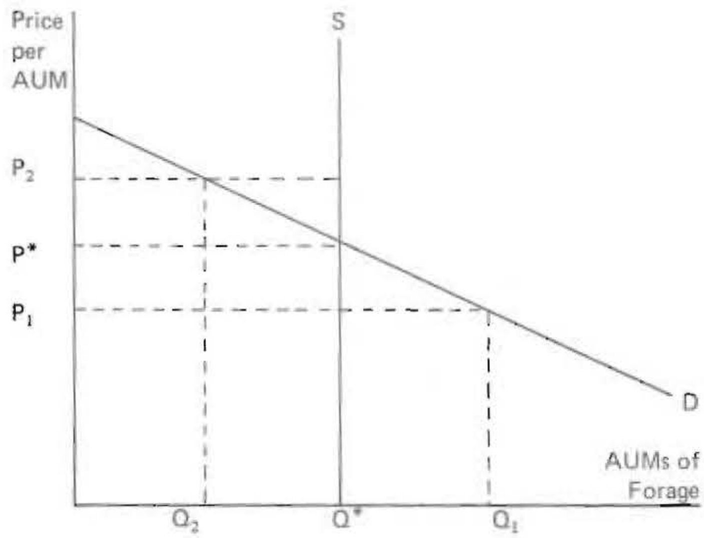

Figure 2. Allocation of Public Grazing Resources.

That is, not everyone who values the grazing services at or above the price being charged is able to purchase these services. In this shortage situation, some nonprice rationing mechanism must be employed to allocate grazing services. One approach is to use a lottery system. Alternatively, the opportunity to use public range resources might be tied to historical use or based on ownership of specific private land or other assets. In any case, the use of a nonprice rationing system to allocate the quantity of grazing services available is likely to result in inefficiencies since there is a strong likelihood that the use of at least some of the resources will be awarded to individuals who value them at a lower level than do other potential users who were denied their use. Since an operator's valuation or willingness to pay for the use of a resource is often related to the efficiency of his operation, to deny the use of resources to more productive ranchers and award their use instead to less efficient operators, whether by design or due to the outcome of a lottery, results in a loss in net benefits to society.

Suppose instead that grazing fees were set at P_2 (Figure II). This would result in surplus, unemployed grazing services since the quantity demanded at this fee is less than the quantity available by the amount (Q^*-Q_2). Only those ranchers valuing the services at level P_2 or above will be willing to pay for the use of these public resources for livestock-grazing purposes. The inefficiency in this case is characterized by resources with zero opportunity costs, and with positive marginal benefits, when used for grazing, remaining unemployed. Additional net benefits would accrue to society if grazing fees were lowered, resulting in an increase in grazing activity.

The socially efficient level of grazing fee is P^*. This is a market-clearing fee in that it brings about an equality between the quantity of grazing services demanded and the quantity available. Those gaining access to the resources are operators willing to pay at least P^* for their use. Individuals denied the use of grazing resources are those ranchers who were not able to employ them in such a way that the incremental value of grazing services was at least equal to this price. Thus, pricing grazing services at P^* assures full employment of the resources and, at the same time, distributes the use of resources among those individuals placing the highest value on them.

SETTING GRAZING FEES IN PRACTICE

As stated earlier, in Alaska there are few transactions between private parties on which to base grazing fees for state-owned forage. How, then, might we develop a system for establishing user charges to allocate efficiently the state's grazing resources? Outlined below are four possible techniques for establishing guildelines for setting such fees. While an attempt is made to use realistic figures in our illustrations of the use of the various fee-setting methods, our primary concern is with the logic and the mechanics of the techniques.

SUBSTITUTE-FEED FORMULA

Roberts and Wennergren (1963) have suggested that, in cases where comparable private transactions involving grazing lands are absent, one might consider the cost of feed that is being replaced by the state-owned resources as a basis for user charges. That is, the value of the forage is equal to the value of substitute feed required to produce livestock products were the forage not available. Adjustments for any differences in the costs of using the different feed sources must be made in applying this method. The result is that the cost-adjusted market price of the nearest substitute available feed sets the *maximum value* for the range forage.

A substitute-feed formula for establishing a grazing fee may be represented as:

$$F = (R/T)P + L$$

Where:

F = grazing fee per AUM.
R = a measure of the energy required in a substitute feed to produce the monthly gain plus maintenance per AUM realized from the range.
T = energy composition of the substitute feed. For example, it could be per cent total digestible nutrients (TDN).
P = price per pound of the substitute feed.
L = difference in nonfeed use costs per AUM for using substitute feed sources versus range.

As can be seen, a grazing fee determined by this formula is sensitive to market forces in that both P and L are determined in the livestock-feed market. While livestock prices are not explicity included in the formula, they will be reflected in market prices of feed (P) and use cost differences (L). This formula is most useful if there is a close physical substitute available for range forage. If the substitute feed is priced a great deal higher than might be reasonable for range forage, the formula may be impractical for setting fees on range lands because no one could afford the substitute. However, in most range areas, other forage substitutes (such as hay) are available which can be used with this formula to set an upper limit on grazing fees.

The use of the formula can be illustrated with the following hypothetical example. Suppose that the grazing resources on the lower Kenai Peninsula produce animal weight and maintenance requirements equivalent to 350 pounds of total digestible nutrients (TDN) per month in the form of bluejoint grass hay. Assume also that during the grazing season this grass hay is the cheapest substitute feed and is priced at $100 per ton with an average TDN content of 50 percent. Assume that it costs $2.50 *more* in nonfeed use costs per AUM to graze state range land than it does to use the substitute feed source.

Then:
R = 350 pounds of TDN required from grass hay to produce the monthly livestock gain plus maintenance realized from the range. (Other energy measures than TDN could be used.)
P = $.05 per pound for grass hay.
T = 50 percent TDN composition of grass hay.
L = -$2.50 per AUM use-cost differential between grass hay and range forage (includes differences due to labor, transportation, and death loss).

Substituting these data into the formula:

$$F = (350/.5)\ \$.05 - \$2.50 = \$32.50 \text{ per AUM.}$$

The fee can be quoted on a per-acre basis by dividing the per-AUM fee (F) by the appropriate carrying capacity for the area. Suppose, for example, that on the lower Kenai Peninsula the recommended stocking rate is 3 acres per AUM. Then an alternative annual fee quote would be:

$$F' = \$32.50/3 \ @ \ \$10.83 \text{ per acre}$$

In applying this formula to specific situations, the energy composition (T) for the substitute feed can either be read from existing tables or established through laboratory analysis. Tables giving most likely estimates of livestock TDN requirements (R) are also available. Turn-off weights necessary to compute R can be estimated from research conducted on various types of seasonal range and supplemented by observation and experience of ranchers in specific localities. The differences in nonfeed use costs between range forage and alternative feed sources (L) would have to be estimated and improved estimates could be based on research designed to measure differences in such costs as labor, death loss, transportation, water, buildings and equipment, and interest on operating costs.

It should be emphasized that the use of the substitute-feed formula appears to be a reasonable approach for establishing grazing fees only in those situations in which close physical substitutes are available for range forage. While this condition may hold for the example used to illustrate the use of the formula, this would not likely be the case in remote situations such as the reindeer-grazing operations on the Seward Peninsula. Another point to stress is that fees calculated using this formula should be viewed as maximum or upper-limit grazing charges. Obviously, if the substitute feed were an attractive alternative to using state grazing resources, we would see livestock owners adopting this feed source voluntarily.

There are several advantages to using a formula to establish fee guidelines. First, an explicit relationship is established among lessees' fees based on criteria built into the formula. Second, a formula helps to remove the question of partiality that could be charged against a fee-setting agency. Third, fees are tied in a consistent manner to grazing-market factors. In summary, the formula can be considered an aid to setting fees more objectively. It must be recognized, however, that the formula does not eliminate the need to gather accurate data as input for the computations.

RETURNS TO LAND

The difference between the total receipts of a range livestock operation and the costs of the nonland resources that go into producing this income is known as the returns to land. Viewed in this manner, the range land represents the residual recipient of any income that remains after all other expenses have been met. The returns to land form the basis for both the annual payment for the use of the resource and the capitalized value of this range land in a competitive land market. The returns to land represent the upper limit to the amount that anyone would be willing to pay to use the resource. At the same time, in the presence of competition, prospective bidders will continue to increase their offers for the use of the land as long as there exists a positive difference between the revenues and costs associated with controlling the land. Thus, the equilibrium price of the services of the land is the returns to land.

If the state's objective is to charge the fair market value for the use of its grazing resources, this is consistent with the state's collecting a grazing fee equal to the returns to the grazing land. One method of estimating the fee which would accomplish this involves the use of ranch budgets to record the costs and returns of representative livestock operations. These budgets are then used to determine the residual earnings of grazing land after all other resources have been paid their competitive earning rates. From this calculated difference, grazing fees which would capture this residual can be expressed on either an AUM or a per-acre basis by dividing the returns to land by the appropriate figure.

Again, a hypothetical livestock operation is used to illustrate the "returns to land" approach. Consider a 1500 head reindeer operation on the Seward Peninsula. Table 1 shows the annual costs and returns data for this ranch along with the method of residual imputation.

The calculations in Table 1 can be explained as follows:

1. Gross receipts represents the sales value of meat and antler production from the combination of inputs or resources.
2. Cash costs are for purchased inputs for current use. Included are labor, fuel, medicine, etc. Depreciation provides for costs associated with durable inputs such as buildings, snow machines, fencing, and breeding stock which are used over a period of time.
3. Net ranch income is the residual return imputed to the operator for his labor and management and for the use of his equity (owned) capital.

Table 1. Imputation of Returns to Land.*

		Amount
(1)	Gross receipts from meat and antler sales	$60,000
(2)	Less: Cash costs and equipment depreciation	35,000
(3)	Equals: Net ranch income (the return to the operator for his labor, management, and use of his capital)	25,000
(4)	Less: Allowances for operator's labor and management	15,000
(5)	Equals: Returns to owned capital	10,000
(6)	Less: Interest on working capital	500
(7)	Equals: Return to fixed capital (land)	9,500
(8)	Return to land per AUM (1,500 x 12 = 18,000 AUM)	.53
(9)	Return to land per acre (675,000 acres)	.01

*The method of presentation of data in this table follows that of Kearl, 1973. The data are based on those reported by Stern et al., 1977.

4. Allowance for operator's labor and management reflects the operator's opportunity cost or what his labor and management skills could earn in the next-highest, alternative employment.
5. Return to owned capital reflects the contribution of capital invested in livestock, machinery, inventories of supplies, and to land.
6. A charge for interest on working capital (including livestock, machinery, supplies inventoried, etc.) represents the opportunity cost of these resources.
7. The remaining residual is a calculated return to land, the fixed asset. If accurate returns have been imputed for all other resources involved in the production process, then this residual represents a fair market return to the land resource.

Entries 8 and 9 of Table 1 show two methods of distributing the return to land, either on an AUM basis or a per-acre basis. Given a grazing-fee structure designed to charge the fair market value for the grazing resource and, thus, to capture the land earnings, the calculations in rows 8 and 9 yield figures which reflect such fees.

COMPETITIVE BIDDING

The use of a competitive bidding process in setting grazing fees and in allocating forage among prospective permittees has been used in a number of situations by the Federal government (Depts. of the Interior and Agriculture, 1977). This allocative mechanism has been employed by the Bureau of Indian Affairs (BIA) on Indian lands, by the Department of Defense on selected range lands in New Mexico and South Dakota, and by the Forest Service in a small area in northwest Nebraska. Generally, the permits allocated through the competitive bid process specify the conditions of use such as type of livestock, carrying capacity, and seasons of use. In addition, the responsibilities of the permittee with regard to management of the livestock and maintenance of improvements such as fences and water developments are spelled out prior to bidding so that all bidders are aware of the characteristics of the service for which they are bidding.

The successful use of a competitive bidding system for state grazing in Alaska would depend on the existence of an effective level of competition for the use of the forage. That is, in any given location where the state was offering grazing land for use on a lease or permit basis, the state's chances of capturing the fair market value for the use of grazing resources would be enhanced if the number of operators interested in bidding for the use of the forage was large. In order to guard against the winning bid's being unreasonably low in a case where the number of bidders was small, the bidding procedure might include provisions such as minimum qualifying bids. The latter values might be set based on a range appraisal conducted by an independent consulting range-management specialist who would presumably employ some variation of the returns to land approach outlined earlier to establish a minimum bid.

FOREST SERVICE/BUREAU OF LAND MANAGEMENT FEES INDEXED TO ALASKA PRICE AND COST CONDITIONS

The procedure used to set user charges for livestock grazing on Forest Service (FS) and Bureau of Land Management (BLM) allotments in the western states is designed to collect the fair market value of these resources and is based on and adjusted according to private grazing land rental rates (Depts. of the Interior and Agriculture, 1977). Due to the very small amount of private grazing rental transactions in Alaska, the state is not in a position to make direct use of this same procedure to establish grazing fees on state range lands. The fair market value of grazing resources in Alaska may, however, be approximated by using the FS/BLM fees as a base and by adjusting these fees according to indexes for livestock prices and production costs in the state. An example follows to illustrate this method.

The grazing fee on Federal BLM lands in the western states was set at $2.36 per AUM in 1980. Suppose the farm-gate price of beef in Alaska is $85 per hundred weight. For the corresponding period, assume the average price received by ranchers for beef in the western states is $75 per hundred weight. Then the index of Alaska beef prices for 1980, using the western states prices as a reference or base, is found by dividing the Alaska price by the western states price and then multiplying this quotient by 100. That is, Beef Price Index (BPI) = ($85/$75) x 100 = 113.

An index of Alaska beef production costs can be calculated in a similar way. Suppose the costs per hundred weight of producing beef on range operations in Alaska and the western states in 1980 are $75 and $70, respectively. The Beef Production Cost Index (BPCI) for Alaska would then be ($75/$70) x 100 = 107.

The final step in the formation of an index to be used in establishing Alaska grazing fees is the computation of a Combined Index (CI) of prices and costs. In general, this combined index is CI = (BPI/BPCI) x 100, which expresses the ratio of Alaska price and production cost indexes as per cent. In our example, the combined index is CI = (113/107) x 100 = 106. Multiplying the combined index (in decimal form) by the FS/BLM grazing feed yields (1.06) $2.36 = $2.50 per AUM. While the mechanics of this procedure are simple, considerable research would be required to establish reliable estimates of indexes of prices and production costs. Once the procedure for estimating these indexes was in place, however, they could be updated each year rather inexpensively.

It should be noted that this indexing procedure is actually better suited to deal with equity issues than to promote efficient resource allocation. By calculating a price of forage in Alaska through the indexing procedure outlined, the state would be creating a return on the use of public rangeland that approximated the return experienced in the western states. That is, the indexing procedure serves to equalize the average profitability of using public range in Alaska to that in other range states. While one would expect a free market for resources to create these same kinds of forces for many labor and capital resources, this will not necessarily be the case for immobile resources such as land. By tying the fee for the use of rangeland in Alaska to that in the other states, one would be ignoring the local supply and demand situations for this resource. Consequently, if supply were large relative to demand in Alaska (as compared to other locations), such an indexing method would probably produce forage prices higher than those resulting from free market forces. The opposite would follow if relative supply and demand magnitudes were reversed. Thus, one must recognize this potential weakness of the indexing method in determining the fair market value for Alaska forage.

SUMMARY AND CONCLUSIONS

In this article, we began with the premise that it is in the state's interest to apply the principles of economic efficiency in establishing guidelines to allocate the use of publicly owned resources. With regard to livestock-grazing resources it is, thus, advised that user charges be established that reflect the fair market value of this forage. Such a practice would serve to distribute the use of state grazing areas among the most efficient livestock operations, thus increasing the likelihood that these resources realize their economic potential. At the same time, where alternative uses exist for lands used or being considered for use by range livestock operations, the development of fees approximating those potentially generated by competitive market forces would increase the chances for the state's citizens to receive the fair market rental price as payment for the use of their grazing resources. In this manner, a test would be provided to determine whether livestock grazing is the highest and best use of the land.

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Crab Meal

A Local Protein Source for the Alaskan Dairy Industry

By

Karen Calcaterra*

Alaska's crab has earned a reputation throughout the world for size and flavor. Yet, current processing methods can result in the waste of 75% of the raw catch. Continued use of these processing methods not only fails to utilize crab waste as a local source of protein, but also creates potential environmental problems when it is disposed of in tidal waters. As much as 30% of waste crab – viscera, unextracted meat, and shells – can be recovered as a processed crab meal averaging 35 to 40% crude protein (Husby, 1980). This crab meal has recently been proposed as a feasible source of supplemental protein for dairy cows.

Crab meal has been discounted as a protein source for livestock due to low palatability and large quantities of chitinous material and ash. However, Richards (1953) reported a similarity between the molecular structure of chitin and cellulose, with the sole difference being a substitution of an acetylamine group for the hydroxyl group on carbon-two of the glucose units. The ability of ruminant animals to partially digest cellulose indicates they may also be able to utilize part of the food value contained in the chitinous material of crab meal. Patton and Chandler (1975) and Patton, Chandler and Gonzales (1975) state that part of the chitin molecule can, in fact, be utilized by ruminants as an energy source, and supply marginal rations with supplemental crude protein. It has recently been proposed that crab meal may bypass microbial digestion in the rumen of cattle, allowing intact proteins to be digested in the abomasum and absorbed in the small intestine, enhancing utilization. *In vitro* disappearance studies by Brundage et al. (1979) have indicated adequate availability and utilization (58 to 75%) of organic matter, nitrogen, and dry matter in king and tanner crab meals for ruminants, with utilization somewhat less than with fish and soybean meals.

The Agricultural Experiment Station in Palmer approached the study of crab meal as a protein supplement for lactating dairy cows through three consecutive experiments that have been ongoing since 1976. These experiments were designed to answer the dairy industry's questions:

1. Will lactating dairy cows accept and utilize a ration with crab meal protein supplementation as readily as one with soybean supplementation?
2. Will ensiling crab meal concentrate with bulk feed increase lactating dairy cows acceptance of a ration supplemented with crab meal?
3. What is the optimum level of crab meal protein supplementation a ration should contain?

Additional experimentation underway deals with the question of whether dairy animals under 1 year of age will accept and thrive on rations supplemented with crab meal and whether milk from cows fed high crab rations acquire any detectable, undesirable taste characteristics.

Results of the first experiment have been published in the Journal of Dairy Science (Brundage, Husby, Beardsley, Burton, 1981). This experiment was designed to compare two different sources of protein supplementation, crab meal and soybean meal; two levels of protein, 14% and 17%; and the interaction of source and protein levels. A negative control ration containing neither soybean nor crab meal was included to indicate whether either of these supplements was, in fact required. Thirty multiparous Holstein cows, that is, those having had more than one calving, were randomly allotted to one of the five rations in one of six replications. Individual cows participated for 12 weeks during the 2-year experiment. Animals were allotted to the ex-

For blended rations, the silage is mixed with the pelleted concentrate prior to the daily feeding.

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periment at week 5 of lactation. During weeks 5 through 7 of lactation, all cows received the soybean meal ration. This provided a control period with which variance due to each cow, rather than concentrate or level, could be analyzed and disregarded. Beyond week 7 of lactation, animals were fed one of five concentrate rations for the succeeding 9 weeks. Silage was fed free choice to the cows, separately from, and in addition to, specific concentrate rations. Concentrates were fed according to anticipated production based on control-period data, allowing full assessment of ration preferences and palatability. Measurements of milk fat were taken monthly; liveweight measurements were taken weekly; and those of milk production and feed intake of concentrates and silage were taken daily during 12 weeks each cow participated in the experiment. Feed samples were collected weekly for laboratory analysis in order to determine total nutrient intake.

Analyses of data indicate that king crab meal has potential as a source of supplemental protein in concentrate rations for lactating dairy cows. Milk production was similar for the two sources of supplemental protein compared. Higher levels of both supplements increased production slightly. Maintenance and gain of liveweight by cows on crab meal supplementation was inconsistent. This may have resulted from palatability problems evident with some animals when rations included crab meal, especially at higher levels. At decreased intake levels, normal patterns of milk production may have been maintained at the expense of liveweight maintenance and gain.

Palatability of the crab meal posed a significant problem in the first experiment. Therefore, an attempt was made in the succeeding experiment to increase the cows' acceptance of rations supplemented with crab meal by masking objectional flavors. The method used was to ensile concentrates containing crab meal with barley and oats. This was compared to blending concentrate and barley-oat silage at the time of feeding.

Thirty Holstein cows were randomly allotted to one of five rations in six replications of five cows each, beginning the fifth week of lactation. Rations consisted of concentrates containing tanner crab meal ensiled with barley and oats, and the same concentrates blended with barley-oat silage. Two levels of concentrate, 11% and 23% tanner crab meal, were used. The fifth ration fed was a negative control containing no supplemental protein. Rations were formulated to contain 60% silage and 40% concentrate on a dry-matter basis. A positive control ration, containing 18% soybean meal in the concentrate, was fed to all cows during the first 3 weeks of their experiment period. One of five experimental concentrates was then fed for the following 9 weeks. Feed and performance data were collected as in the first crab-meal experiment.

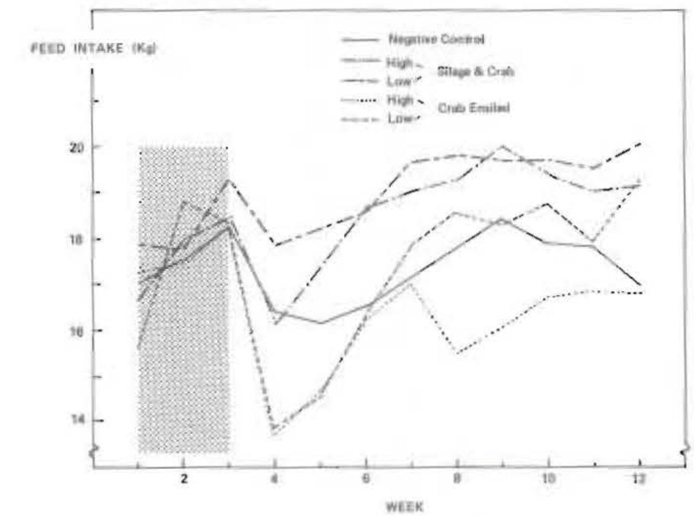


Figure 1. Unadjusted means of weekly feed intake for Experiment 2. Shaded area represents the control period.

Results of this experiment, as reported at the American Dairy Science Association meeting in July 1981, revealed that ensiling crab meal did not increase its acceptability to lactating dairy cows, but, in fact, decreased it (Brundage, Husby, and Burton, 1981). Feed intake and performance of cows on ensiled rations were negatively affected in comparison to those on similar, blended rations. Higher levels of crab meal created greater adversity within both ensiled and blended rations. While feed intake dropped abruptly during all changeovers from the soybean control ration to those containing crab meal, see figure, animals on blended rations returned to feed more rapidly than those on ensiled rations. Data were analyzed to determine whether cows on blended rations were able to sort silage from a less-preferred concentrate, thus accounting for increased acceptance of blended rations. However, least-squares estimates of silage/concentrate intake did not indicate a preference for either component of the blended rations. The negative control ration again indicated a need for protein supplementation in order to maintain milk production.

The third and current experiment is perhaps most important of all. This ongoing, 2-year experiment is attempting to identify the optimum level of crab-meal supplementation for a ration fed to lactating dairy cows. Because of findings in the second experiment, only blended silage/concentrate rations are being used in this third experiment.

Thirty Holstein diary cows are randomly allotted to one of five rations, in six replications of five cows each, during the third week of lactation. Diets differ by the percentage of soybean meal replaced by an equivalent amount of crab meal on a protein basis. The five concentrates contain 0, 25, 50, 75, and 100% crab meal supplementation to replace soybean meal. Blending is performed to provide a complete ration of 50% silage and 50% concentrate on a drymatter basis. During weeks

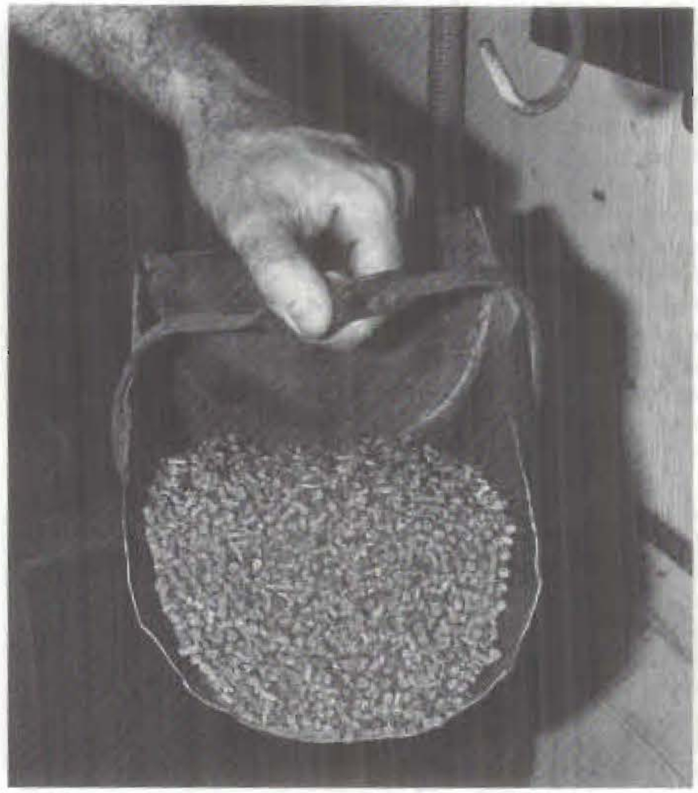
Ingredient Composition of Concentrate Mixtures for Experiments 1 and 2.

Ingredients	Concentrate Mixtures (%)[1]				
	1	2	3	4	5
Corn	33.4	42.4	29.7	41.2	51.4
Barley	15.0	15.0	15.0	15.0	15.0
Mixed feed oats	10.0	10.0	10.0	10.0	10.0
Beet pulp	15.0	15.0	15.0	15.0	15.0
Molasses	7.0	7.0	7.0	7.0	7.0
Soybean meal	18.0	9.0	.0	.0	.0
Crab meal	.0	.0	22.5	11.0	.0
Monocalcium phosphate	.4	.4	.0	.0	.4
Dicalcium phosphate	.4	.4	.0	.0	.4
Trace Mineral Salt	.8	.8	.8	.8	.8
Vitamin A	(4400 IU/kg)				
Vitamin D[2]	(13200 IU/kg)				

[1] Experiment 1 Mixtures: 1. High Soybean Meal, Positive Control, 2. Low Soybean Meal, 3. High Crab Meal, 4. Low Crab Meal, 5. Negative Control.

Experiment 2 Mixtures: 1. Positive Control, 3. High Crab Meal, 4. Low Crab Meal, 5. Negative Control.

Daily feed records are kept for animals on the crab-feeding experiments.



Concentrates containing crab meal may be purchased in a pelleted form.

3 through 5 of lactation, all cows are fed a positive control ration with soybean meal as the supplemental protein source. For 12 weeks following the control period, each cow is fed free choice according to her specific diet. The experimental feeding period was lengthened for this experiment to allow more time for dietary reactions to become evident. Feed composition, intake, and performance data are collected as in previous experiments, with the exception of laboratory testing of milk which is done weekly rather than monthly.

The first year of this experiment has been completed. Preliminary results indicate that concentrate rations containing over 50% crab meal supplementation are less than optimum. The optimum level of crab meal supplementation remains to be determined.

A new aspect of this third experiment is the incorporation of a milk taste test. This test is designed to determine whether crab-meal supplementation results in any detectable, undesirable taste. The taste test is set up as a blind tasting by four to seven panelists, asked to rate milk on a basis of 1 to 20, with 1 being most desirable and 20 being the least. A sample from the herd's bulk tank is also tasted and rated to provide a control to account for taste score difference due to individual tasters rather than the milk itself. Milk is sampled five times beginning during the second week of the control ration period and continuing every third week thereafter throughout the 15-week period. Least-squares analysis of variance on data collected during the first year of this 2-year study reveals no clear effect of diet on taste scores, indicating that crab-meal supplementation does not result in detectable, undesirable taste characteristics in milk.

During the third period of the supplementation study, a feeding experiment involving young dairy animals 60 to 360 days of age has also been initiated. This experiment is concerned with observing liveweight gain and body measurements during this important growth period while on rations supplemented with crab meal. Each year of this 2-year study, sixteen heifers and sixteen steers are allotted in groups of four to a 0, 25, 75, or 100% crab-meal-supplemented feed concentrate. Hay is fed free choice through 180 days of age, and silage free choice thereafter. Concentrates are fed up to a maximum of 4 pounds per animal per day. The first year of study has shown these animals to be unaffected by diet so far as their preference is concerned with feed intake and consistent in weight gain for normal growth. This indicates that rejection of concentrates containing higher levels of crab meal in rations fed mature, lactating dairy cows is due at least partially to unfamiliarity with crab meal in the diet and previous conditioning to other rations.

Another consideration in using crab meal as a protein supplement for dairy animals is economic. Based on prices of 80-100-lb. sacks of feed as of June 1981, crab meal cost $180 per ton (f.o.b. Seward), soybean meal cost $637.50 per ton (f.o.b. Anchorage), and ground corn used to complete the rations, retails for $337.50 per ton (f.o.b. Anchorage), (Alaska Mill and Feed, 1981; Seward Fisheries, Inc., 1981). The cost difference of major components utilized in high-protein rations in the first experiment result in a savings of $87.20 per ton when crab meal is used to replace soybean meal. Low-protein rations result in $42.00 per ton savings when crab meal is used. The cost of hauling crab meal from Seward may equalize this price differential somewhat, but an effective transportation system could allow

Lactating dairy cows are fed separately, while the young Holsteins, 60 to 360 days of age, are fed in groups of four.

savings to be realized through use of crab meal as a protein supplement for lactating dairy cows.

Research completed during the past 5 years by the Agricultural Experiment Station in Palmer has revealed that crab meal is a feasible alternative to soybean meal as a protein supplement for lactating dairy cows. Its main drawback is a problem of palatability for cows unused to its inclusion in their diet, particularly at higher percentages of crab meal. The attempt made in the second experiment to mask the undesirable taste of crab meal by ensiling the concentrate with barley and oats proved unsuccessful. Blended silage/concentrate rations were preferred, as indicated by feed intake. The current experiment is attempting to determine an optimum level of crab meal as a protein supplement in blended dairy rations. Preliminary findings indicate levels above 50% crab meal protein supplementation to be detrimental, although no definite conclusions have yet been reached. A concurrent milk-tasting study indicates that crab meal does not give milk an undesirable taste. Further, a continuing study involving young dairy animals suggests normal growth and improved acceptance of crab meal by young animals due to conditioning from an early age. This may prove to be one method of overcoming palatability problems.

ACKNOWLEDGMENTS

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Intensive Forest Management

The Bonanza Creek Demonstration Project

By

Allen P. Richmond*

Intensive management of Fairbanks-area forests for the purpose of wood production has, until recently, elicited little interest. However, an increased demand for state-owned timber, occurring over the last three years has brought about a change in attitude. This increase reflects, the growing demand for timber experienced by commercial and private operations. Commercial operators, in both the lumber and fuelwood businesses, claim that their product output is limited by a lack of timber and not a lack of demand. The demand for firewood for personal use is evidenced by the number of firewood-cutting permits issued by the state. This demand has increased dramatically since 1976 (Table 1). This is, of course, related to the large number of people who have installed wood stoves in an effort to reduce their home-heating costs.

Table 1. Estimated Volume of Fuelwood Sold by the Area Forestry Office in Fairbanks.[a]

Year	No. of Cords[b]	No. of Permits Issued
1973	884	112
1974	2,181	267
1975	1,878	219
1976	3,427	292
1977	3,664	436
1978	7,902	851
1979	18,822	2,009

[a] Information obtained from a yearly summary prepared by the Area Forestry Office.

[b] The actual volume consumed may be as much as one-third less than stated, as a survey of permittees indicates that an average of only 4.5 cords of green wood is taken by each permit.

The increased demand for firewood has placed a considerable strain on the ability of state forest lands to meet the need for timber of individuals and commercial operations. State foresters in the Fairbanks area have stated that the readily accessable timber stands are rapidly being depleted, and that people must expect to go farther to obtain wood in the future. There are legally mandated upper limits on the amount of timber which can be cut annually from state owned forest lands within a 60-mile radius of Fairbanks. These allowable cut figures have been established at, 4 million board feet of spruce sawtimber and 31,000 cords of various species of hardwoods (Wieczorek, 1980). Any additional timber harvest in excess of these volumes will have to come from privately owned lands, the salvaging of timber from agricultural disposal lands, or lands outside of 60 miles. The sawtimber allowable cut is expected to be reached in the next few years, and may actually be exceeded when the timber sold from agricultural disposals is considered. The current level of hardwood removal amounts to approximately 60% of the allowable cut, and has shown a rapid increase since 1977 (Table 1).

The use of selected intensive forest management practices such as artificial regeneration, fertilization and thinning have the potential of greatly increasing the production of timber on state lands classified for forest management. These practices can speed up the growth of timber, thereby reducing the number of years required for it to reach a specified merchantable size. Over a given time period this results in substantially more useable timber being produced from an intensively managed stand than from an unmanaged one. Obtaining a specified volume of timber over a shorter time period increases the allowable cut. These practices are used widely and successfully in other places to increase yields from limited forest land areas. General observations of growth responses for trees in the Fairbanks area which have been released through selective logging in the past, indicate that tree growth can be greatly improved by thinning.

The problem with applying intensive forest management practices is the lack of information on what level of treatment will yield the best results and at what cost. There are only a handful of references which discuss thinning and/or fertilization treatments performed on interior Alaska timber species (Frank, 1973; Van Cleve, 1973; Van Cleve and Zasada, 1976; Stiell, 1980). These have shown that separately or in combination, thinning and fertilization will result in considerable growth improvement. As the studies were designed to demonstrate and quantify growth responses, no cost data on the various treatments were obtained. Without this information, it is not possible to determine if it is economically feasible to implement thinning and fertilization on a large scale basis.

The Forest Management Project

During the 1980 state legislative session, funding was provided in HB-60 to undertake a study of the potential and feasibility of applying more intensive management practices on state forest lands as a means of meeting growing timber demands. The appropriation was requested by the Fairbanks Industrial Development Corporation as an addition to the University of Alaska budget, placing the responsibility for conduct of the study with

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the School of Agriculture and Land Resources Management. The demonstration and evaluation of silvicultural and fuelwood gathering practices that could increase the productivity and utilization of state forest lands has been established as the primary goal of the project. Each demonstration was to have four objectives:

1. Evaluation of the effects a selected management practice has on both the short-term and long-term forest productivity.
2. Determination of the operational and economic feasibility of applying the selected practice at various treatment levels.
3. Determination of wood yields from the type of timber stand being treated.
4. Evaluation of public utilization of the wood and response to the demonstration, through direct observation and interviews.

The project has been undertaken as a cooperative effort between the university, the state Division of Forest, Land and Water Resources and the U.S. Forest Service, Institute of Northern Forestry. The state has provided the land for use in the study, as it has the widest variety of timber stand types and age classes available for use in demonstrating forest management techniques. As the age of a stand has an influence on the response which can be expected from the application of a specific treatment, the demonstrations were planned to cover as wide a variety of age classes as possible within each stand type. The Institute of Northern Forestry has provided the research expertise which has been relied upon in setting up demonstrations. The project has presented an opportunity for the university to provide both of these agencies with information, which would otherwise have been difficult for them to obtain.

The Bonanza Creek Demonstration

The first demonstration area to be established was on 95 acres of land in the Bonanza Creek Experimental Forest. The timber stand present was a mixture of overmature white spruce, paper birch and quaking aspen. For the most part, the hardwood component was in decline, as was evidenced by the large amount of die-back and crown breakage present. Spruce was in the dominant position throughout the stand, having overtopped both the birch and the aspen. A timber cruise revealed that the merchantable portion of the stand consisted of 55% spruce, 43% birch, and 2% aspen. The distribution of these species was not uniform throughout the stand, as relatively pure pockets of each were present.

The treatment selected for this demonstration was a total removal of hardwoods, which was designed as the first step in placing the stand under management. All the birch and aspen four inches in diameter and larger were to be felled and skidded into decks for removal by individual firewood gatherers. By performing this harvest, the hardwood volume that would have been lost to decay had the stand remained untreated, could be salvaged for use. The resulting pure spruce stand could then be assessed to determine the next steps required to manage it for the periodic harvest of a specified volume of timber.

A contract was awarded on October 6, 1980, for the construction of one mile of access road and the harvesting of an estimated 1321 cords of hardwoods. The demonstration area was divided up into three cutting units, A, B and C. Unit A was harvested using the full-tree skidding system, in which trees were skidded and decked with limbs and tops attached. Units B and C were harvested using the tree-length skidding system, in which limbs and tops, down to three inches in diameter, were trimmed off prior to skidding and decking. The timber was skidded to the decking areas shown in Figure 1. The contract work was completed on May 8, 1981.

In order to evaluate the effects of this treatment on the stand, information had to be collected on (1) the growth response of the residual stand, (2) the amount of regeneration by spruce, birch and aspen which takes place under a more open canopy, and (3) the suceptability of the stand to post treatment damage, such as wind throw and insect attack. As a means of obtaining this information forty-six, .1 acre, permanent plots were established and inventoried to serve as a base for the assessment of stand response. A research area has been established by the Institute of Northern Forestry to monitor bark beetle infestation levels in downed spruce. Information on wind-throw problems will be handled through annual surveys of the stand.

An assessment of the damage to the residual stand caused by the skidding operation was to be accomplished upon completion of harvesting by making a 10% strip cruise of the area. Damage to the residual spruce was to be broken down into three categories, according to which part of the tree it occurred on, root, bole or crown. Root damage was defined as abrasion or

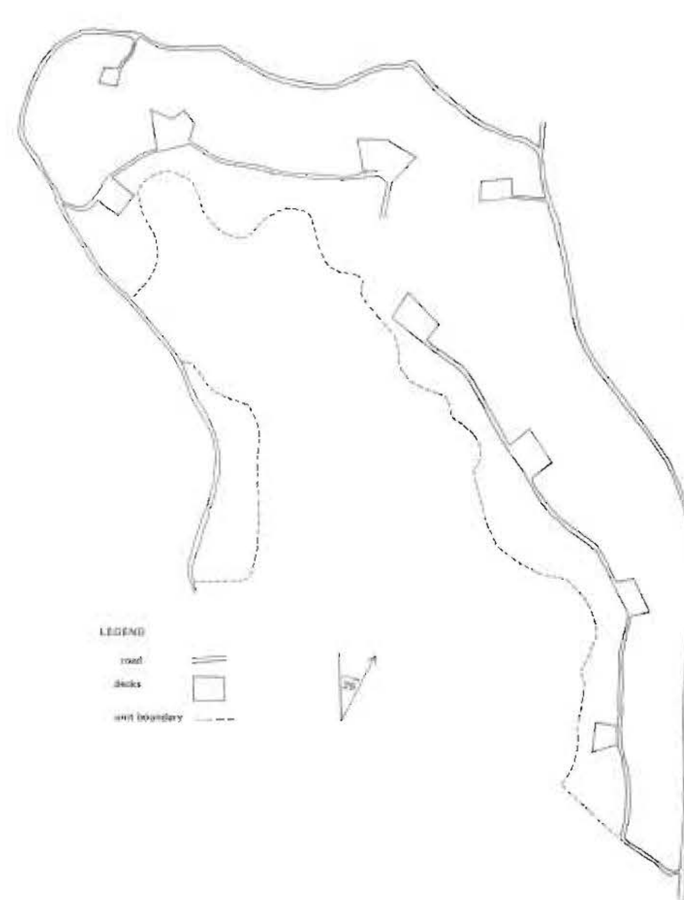

Figure 1. Bonanza Creek Demonstration Area.

Figure 2. Extensive form of root damage.

Figure 3. Common form of bole damage.

severing of roots (Figure 2). Bole damage was considered to be abrasion of the bark above the root collar, and was broken down by the percent of the tree circumference affected (Figure 3). Crown damage was classified as either mainstem breakage or percent of crown delimbed.

Of particular interest in the economic assessment of performing this kind of intensive forest management was determining the portion of the treatment cost which could be recovered through the charging of a higher than normal personal use fee for the decked wood. As this was the first demonstration of its kind, a total cost recovery was not attempted. The cost per cord required to achieve this would have been $16.88 for the 1321 cords harvested, based on a winning bid price of $22,300 for the harvesting work. It was decided arbitrarily to establish the per-cord cost of the permits at $15 for wood from Units B and C, and $10 for Unit A. Records were kept by the Area Forestry Office as to the volume of wood permitted for removal from Bonanza Creek, so that the total value of the wood removed could be determined. The price differential for wood from Unit A was allowed as a means of encouraging more complete utilization of this wood. More effort on the individual's part was required to remove the small diameter portion of these trees due to the fact that they had been decked with their limbs and tops attached. A large amount of delimbing was required before the wood could be cut to stove lengths and loaded into pick-up trucks.

Public response to the demonstration was gauged by the amount of wood removed from the area, and through interviews with wood gatherers. It was expected that a public unwillingness to pay the higher fee would have been evidenced by large amounts of wood being left in the decks. There were alternate firewood cutting areas provided by the state at a lower price, to which the public could have turned, though these areas required that the individual fell his own trees and drag them to his vehicle. Inteviews with the wood gatherers were designed to ascertain the maximum price they would be willing to pay for decked wood. The price information was important to determining the feasibility of using this method to meet firewood demand.

RESULTS AND DISCUSSION

All of the information being sought by this demonstration could not be obtained in one year, particularily with regard to stand response. It will be several years before any good information can be obtained on growth changes and the amount and types of regeneration which take place as a result of this treatment.

The assessment of damage caused during the skidding operation revealed that an estimated 25% of the residual spruce trees received some form of damage (Table 2). The majority of this was a result of the operator dragging logs around the base of standing trees, debarking the bole at the point of contact. Most of the damage was light, though there were several trees which were debarked for nearly 50% of their circumferences. The long term effects of the damage will have to be monitored to determine whether growth impairment or mortality can be identified with any level of damage. Severe root damage may result in an increased susceptability to wind throw, or insect and disease attacks. Bole damage may serve as an entry point for rot and may cause a weak point to develop as the wound heals, resulting in possible stem breakage.

In analyzing the economics of this demonstration, the costs of setting up the area, i.e. identifying boundaries, mapping, tim-

Table 2. Harvesting Damage Summary.

Type of Damage	No. of Damaged Trees Observed	Percent of Stand[a] Damaged	Average Percent[b] of Damage/Tree
Root	50	6	—
Bole	191	23	12.5
Crown	10	1	26.0
Combination[c]	23	3	—
Total	228	27	—

[a]The percentages are based on a residual spruce stand having 87 trees per acre.

[b]Bole damage refers to the percent of the circumference debarked. crown damage refers to the percent of the crown delimbed.

[c]Trees with more than one type of damage.

ber cruising and road layout were included. The total cost of these activities was calculated as $3155, based on 180 hours of labor at $12/hour, a materials cost of $150, and a travel cost of $125. Labor expended for purely research ends was not considered in the analysis. The total cost of providing wood in decks for public removal was $25,455 of which $16,512.50, or 65%, was recovered by permit fees. The cost incurred by the project in converting this mixed spruce-hardwood stand to a pure spruce condition was, therefore, $8,942.50 or $94.13/acre. The firm which was awarded the contract actually spent nearly $51,000 to accomplish the treatment. This was due to basic unfamiliarity of the firm's first subcontractor with selective logging practices, which required his replacement after only one-third of the work had been accomplished. Rather than default on the contract, a second subcontractor was hired by the contractor to complete the remaining two-thirds of the contract, at a cost in excess of the total original bid. Several of the original bidders have subsequently stated that they felt that the contract was under bid, and that a more realistic bid would have been $30,000. Based on the original setup costs the more realistic contract would have cost a total of $33,155. Subtracting the recovered costs, this would have amounted to a treatment cost of $175.18/acre. The long term response data will have to be analyzed to determine whether the expense is justified by an increase in the future value of the stand.

The public response to this method of providing firewood was very good, as all of the wood was permitted out. Interviews with individuals obtaining wood from the area revealed that 50% were willing to pay at least $20/cord for wood provided in this condition. As can be seen in Table 3, some of these people stated that they would pay $50/cord. The other 50% did not want to pay more than $10 or $15/cord, depending on how much they had paid for their permit. Only one percent of those interviewed felt that the price was too high. For the most part, people seem to be willing to pay for the convenience of having wood provided in decks, as everyone interviewed wanted the state to provide more areas like this one. Comments indicated that they enjoyed being able to back their trucks up to the wood instead of having to drag it out of the woods, as was the case with other firewood cutting areas provided by the state.

The interviews also provided other information on the individuals who made use of the area. It was found that 3/4-ton pick-up trucks were the most common type of vehicle used for wood gathering, with 1/2-ton pick-ups second. Vehicles used ranged from station wagons to 5-ton flatbeds. Individuals from as far as North Pole (45 miles), and as near as Ester (15 miles), made use of the area. The average oneway distance was 27 miles for all those interviewed. The average amount of wood required by these people was found to be 6 cords per year. Wood was the primary source of home heating for 56% of these individuals. A majority, 54%, viewed firewood gathering as a recreation opportunity, and another 28% considered it half work, half recreation.

Table 3. Responses of Interviewed Individuals Concerning the Maximum Price They Would Be Willing to Pay for Decked Wood.

Price (Dollars)	No. of Respondents	Percent of Total
10	37	21
15	52	29
20	52	29
25	25	14
30	9	4
35	1	1
40	2	1
45	0	0
50	1	1

There were several problems identified during the wood removal stage of the demonstration which warrant some discussion. The first of which concerns the difference in wood utilization which occurred between Unit A and Units B and C. Unit A was the first unit cut and people began taking wood out on November 1, 1980, yet at the end of the wood-removal period, July 31, 1981, there was more wood left in this unit than the others. Utilization of the lower portions of the trees on all units was the same, but as woodcutters in Unit A began to remove the upper portions which had large numbers of branches, utilization decreased. As all of the wood was permitted out, it appears that a number of individuals did not remove all the wood they were allowed. There was a large amount of wood less than 7" in diameter left in the decks of Unit A (Figure 4). The effort required to delimb the small diameter material apparently was a significant deterrent to complete wood utilization. The tree-length skidding system used in harvesting Units B and C resulted in much better wood utilization, as the small diameter wood was removed from these decks.

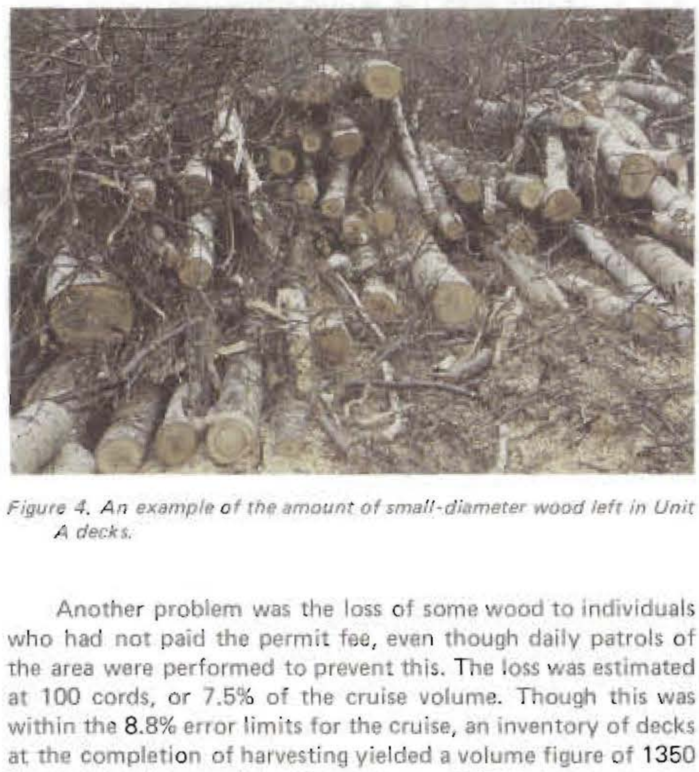

Figure 4. An example of the amount of small-diameter wood left in Unit A decks.

Another problem was the loss of some wood to individuals who had not paid the permit fee, even though daily patrols of the area were performed to prevent this. The loss was estimated at 100 cords, or 7.5% of the cruise volume. Though this was within the 8.8% error limits for the cruise, an inventory of decks at the completion of harvesting yielded a volume figure of 1350 cords, very close to the cruise estimate of 1321. It appears that the wood was lost after harvesting was completed, as the entire volume removed from Units B and C had not been issued on permits. The loss was unavoidable given the part time supervision of wood cutting and the unrestricted access to the area. The level of supervision was kept the same as for other wood cutting areas which the state manages, in order to quantify the losses which could be expected during large scale use of this method in meeting firewood demand. State forestry personnel feel that the losses can be attributed to a very small number of individuals, and that the effort required to prevent the loss is not justifiable. A commercial operator using this method of selling firewood, could restrict access with a gate so that wood could be removed only when he was present to receive payment. Full time supervision on weekends at the beginning of wood removal from Unit A proved very effective in accounting for the wood removed from the area.

CONCLUSIONS

The Bonanza Creek Demonstration was a good beginning for the Forest Management Project in meeting its goals of demonstrating and evaluating alternative methods of managing interior forest lands. It has shown that the felling and decking of hardwoods for use as firewood can be an effective way to utilize wood that would otherwise be lost to decay. Based on the differences in the utilization of trees with and without limbs, future treatments of similar stands should use the tree length skidding system, where limbing and topping takes place at the stump. The damage to residual trees resulting from use of the selective logging system was found to be consistent with levels observed outside of Alaska (Froning, 1980; Hannah, Kihn, and Kimmett, 1981). Damage levels can be reduced by better skidding techniques without interfering with logging efficiency. Removal of the hardwoods has opened the stand up so that future single tree selection harvests of white spruce should be less difficult and less damaging to the residual stand than would be the case for similar untreated stands.

The public response to providing firewood in this manner indicates that it may be possible to have hardwood removals recover all or a large portion of the total treatment cost. The total demonstration cost to the project was $20.74/cord, though the more realistic figure would have been $27.01/cord. Even though these figures are based on the total volume of wood permitted, a fee of $20/cord would have recovered 96% and 74%, of the total cost, respectively. As the prices for heating oil and delivered firewood increase, the value of decked wood should increase to the point where fuelwood users will pay the cost of obtaining it and still feel that they are getting a bargain. The agencies responsible for forest management must make the decision as to the portion of the treatment cost recovered from personal-use firewood gathering. If they are willing to subsidize the public, the total cost of stand improvement work need not be recovered through the sale of firewood. It is the author's opinion that where possible forest management should recover as large a portion of its costs as possible.

At the present time it does not appear that this system of providing firewood is feasible for a commercial operation to employ. This is due to the fact that fuelwood dealers would have to purchase the wood from the state at the present market value of $17/cord. The minimum price they would then have to charge in order to break even would be around $34/cord. Only 3% of the fuelwood gatherers interviewed stated that they would be willing to pay this high a price for decked wood. Also, there are several wood dealers in Fairbanks who presently can deliver 8 to 10 cords of tree length logs at a price of $40/cord. This appears to be the most economical means for a dealer to provide his customers with wood.

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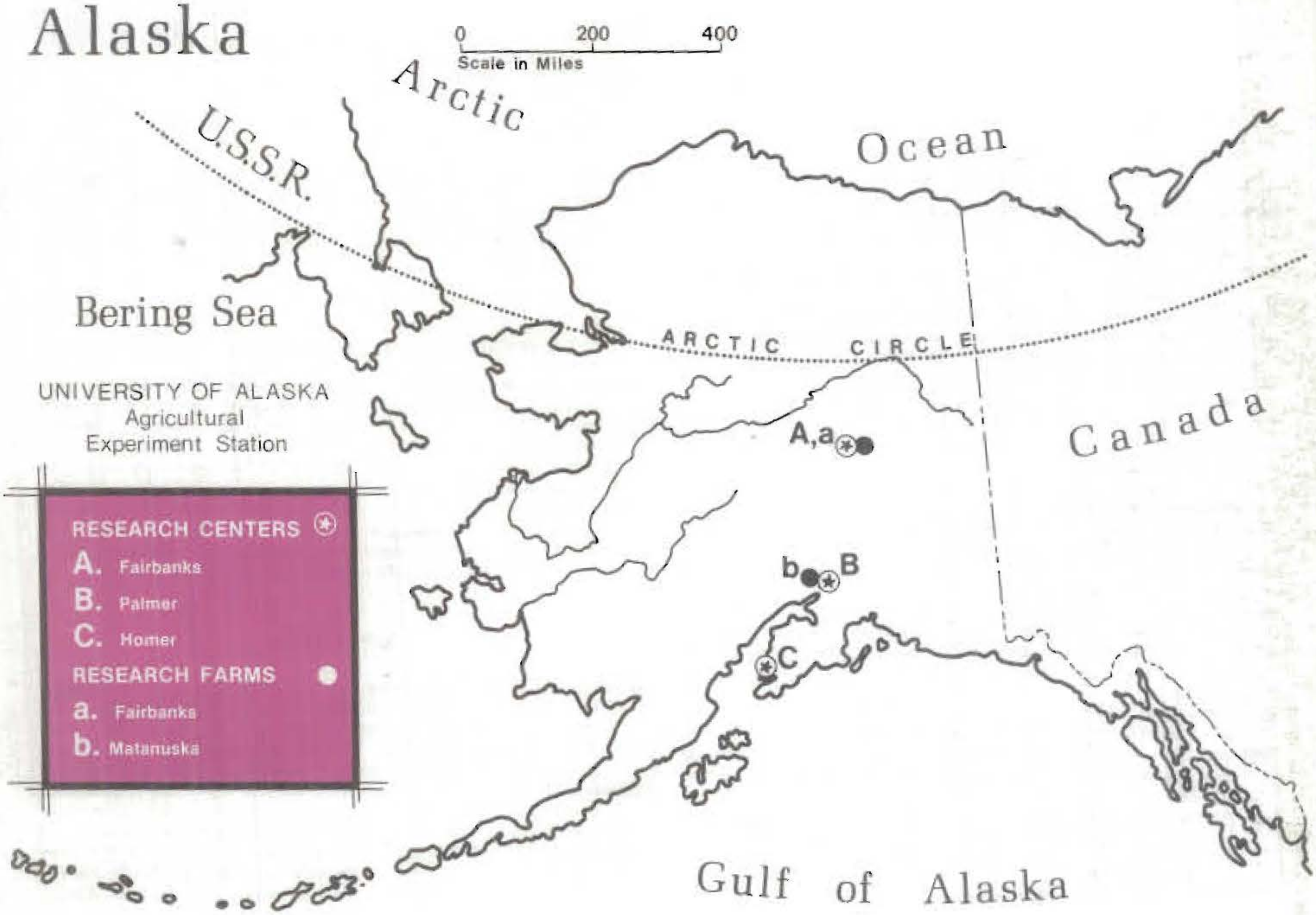

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