Agroborealis

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Agricultural Experiment Station
University of Alaska

FROM THE DIRECTOR'S DESK

Alaska's agriculture continued to grow during the past year toward the state's goal of 500,000 acres in crop production by 1990. New lands brought into such use within the Delta Agricultural Project in Alaska's interior contributed to the largest acreage planted to barley in the state's history. This production is scheduled to increase substantially as new farms are developed within the initial 60,000-acre project.

Plans are underway for a sale of state land in 1981 that will expand the Delta Agricultural Project by 45,000 acres. In addition, action by the Alaska state legislature and administration in 1980 provided funds to plan substantial agricultural development near Nenana, also in the interior. With these developments has come increased interest in providing intensive management for farm woodlots and commercial forest lands.

Legislative and administrative action in 1980 also provided funds to begin development of 15,000 acres of new land, primarily for dairy farms, near Point MacKenzie just north of Anchorage in southcentral Alaska. Projected production of milk from this project, using barley produced in interior Alaska as the feed concentrate, will supply approximately 62% of the current market for fresh milk in southcentral and interior Alaska.

A special grant from the U.S. Department of Agriculture in 1980 permitted the Experiment Station to initiate research on conservation tillage systems for small-grain production in order to determine the best practices for soil conservation and the use of soil moisture for optimum yields. Increasing feed-grain production in Alaska is stimulating in-state pork production. Alaskan barley, supplemented with protein from the byproducts of Alaska's fishing industry in rations developed by the Experiment Station, has reduced feed costs for raising pigs in Alaska. Research by the Experiment Station on intensive forest management, including selective logging, is meeting expanding demands for fuelwood.

The success of agricultural development in Alaska depends upon the application of technology and management that will permit Alaska's agricultural and forest industries to compete with food and wood industries elsewhere. Our unique day-lengths and soil temperatures require special crop varieties and cultural practices that can be developed only by research in crop and soil science in Alaska. The expanding livestock industry needs new information in range science and animal nutrition, breeding, and disease control to obtain efficient production under Alaskan conditions. Research on the economics of agricultural production, processing, transportation, and marketing are equally important. Research on forest management is needed for improved wood production and for the management of Alaska's forest lands for outdoor recreation. Alaska's agricultural and forest industries must compete with other states that have for decades received the benefits of comprehensive agricultural research from their land-grant universities.

The Alaska Agricultural Experiment Station is smaller than any other state agricultural experiment station in the United States. Nevertheless, our work is directed toward solving specific problems identified in the field by scientists, farmers, ranchers, and foresters. This issue of *Agroborealis* contains some examples of research directed at increasing the efficiency of production and providing environmentally sound management for Alaska's agricultural and forest industries.

James V. Drew, Director

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School of Agriculture and Land Resources Management
University of Alaska

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ABOUT THE COVER...

Alaska Rocket Grenadille, bred and owned by the University of Alaska. Sire: Whittier-Farms Apollo Rocket. Dam: Alaska Standout Damoiselle.

Actual Production

Age (yr, mo)	Days in Milk	Milk (lbs)	Fat (%)	Fat (lbs)
2, 0	277	15,171	3.6	540
2, 11	389	20,914	4.2	863
4, 3*	261	19,066	4.3	827

*this record still in progress.

Grenadille is part of a long-term, dairy-cattle breeding experiment at the Matanuska Research Farm and represents possible response to single-trait sire selection for milk production.

(Photo by A. L. Brundage)

A Changing Pattern in Small-Grain Silage Mixtures in Alaska

by

A. L. Brundage*, R. L. Taylor**, and V. L. Burton***

For many years, visitors to the Matanuska Research Farm at Palmer have been accustomed to seeing large plantings of forage-type oats grown in mixture with Canadian field peas and destined for use as silage. The development of Weal barley, a northern-adapted, hooded variety released in 1972 (Taylor, 1972), challenged the conventional oat-pea mixture for silage production. Unlike most varieties of barley recommended for grain production in Alaska, seed heads of this new variety do not have the long, scabrous, needle-like awns which are considered potentially harmful to livestock whether included in hay or silage.

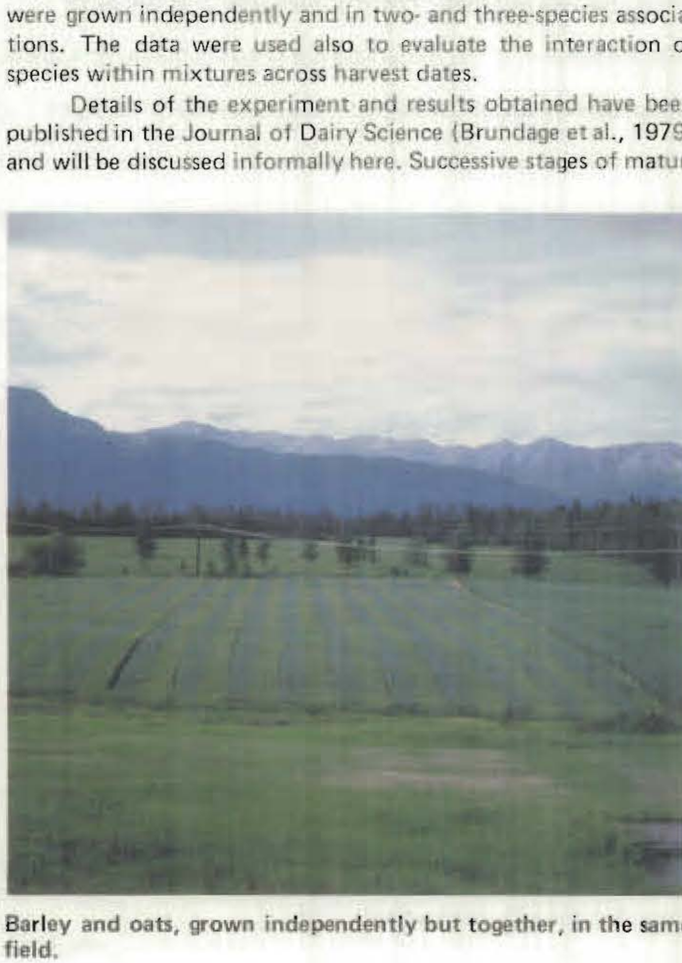
More recently, visitors to the research farm have seen fields planted to barley and oats, without peas, in combinations similar to that illustrated. Although the field has been planted obviously to barley and oats, the appearance of the field seems to be one of ordered disorder, and one might conclude that the field crew couldn't quite determine whether to plant barley or oats.

The field is sown in alternating narrow strips of barley and oats, not as an homogenous mixture, by dividing the seed hopper of an ordinary grain drill into halves with a baffle, permitting the sowing of oats from one half and barley from the other. Thus, the twelve-foot grain drill plants simultaneously a six-foot strip of oats and a six-foot strip of barley as it moves across the field.

This practice emanates from small-plot experiments conducted during 1970 to study production and certain laboratory analyses of barley, oats, and peas when planted alone and in two- and three-species, equiponderant combinations. Planting was carried out in thirty-square-foot plots at 100 lbs. total seed per acre. A complete set of these plots was harvested on each of four dates: 21 July, 10 August, 18 August, and 25 August. Forage mixtures were hand sorted into species components. Dry-matter content and yield, crude protein, cell-wall constituents, acid detergent fiber, lignin, and *in vitro* dry matter disappearance were determined for each species whether grown independently or within mixtures.

Results were used to compare the yield and forage quality of the three species at four successive harvest dates when they were grown independently and in two- and three-species associations. The data were used also to evaluate the interaction of species within mixtures across harvest dates.

Details of the experiment and results obtained have been published in the Journal of Dairy Science (Brundage et al., 1979) and will be discussed informally here. Successive stages of matur-



Barley and oats, grown independently but together, in the same field.

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ity of the barley at the four harvest dates were early milk, early dough, late dough, and mature. Concurrently, oat stages were: headed, in milk, early dough and late-dough; and pea-growth stages were: flowering, pod setting, pods filled, and mature pods.

The experimental design was predicated on the assumption that the independent yields of barley, oats, and peas would be less in mixed plantings because the mixtures included one-half to one-third the weight of seed per each species relative to the planting rate per species in pure stands. However, the yields of barley, oats, and peas grown independently and in mixtures demonstrated specific differences in ability to withstand competition. Barley yields were reduced by only 28% when grown with peas, by 48% when grown with oats, and by 50% when grown with oats and peas. Oat yields, while reduced by only 18% when oats were grown in association with peas, were 61 and 64% less when oats were grown in oats/barley and oats/barley/pea mixtures. Peas were much less competitive than either oats or barley, and yields were reduced by 72, 69, and 83% when they were grown with oats, with barley, and with oats and barley.

Average total yields increased by 64% between 21 July and 10 August and did not increase significantly thereafter. This observation supports the recommendation to delay harvest of small-grain forages until the early-dough stage of grain development in order to obtain greatly increased yields of forage compared with earlier harvests at headed or early-milk stages. Production of peas in pure stands is contraindicated by the small yields obtained compared to those of barley, oats, or mixed forages. Inclusion of peas in small-grain mixtures may be predicated on their indeterminate growth habit which confers stability of chemical composition to small-grain/pea mixtures over time, as well as the enhancement of the total nutritive value, especially crude protein. However, mixtures of oats and barley also have some stability in quality over time due to the later maturity of oats, although crude protein is considerably lower in the absence of peas.

Although the inclusion of peas enhanced the protein content of mixed forages, their use must be questioned by the inability of peas to compete successfully with small grains. The decision to exclude peas from both oat and barley strips is based on biological and economic realities. The seed cost for peas is more than either barley or oats. The failure of peas to compete effectively with either barley or oats in the two-species mixtures provided further justification for exclusion. However, exclusion of peas from the oat/barley plantings does result in lower-protein silage than that produced with the oat/pea mixtures used previously. Therefore, the use of oats and barley in alternate strips for silage, or as mixtures, will require higher protein supplementation in the concentrate portion of a feed ration than would be necessary with oat/pea silage.

Barley and oats did not differ appreciably in total yield when grown in pure stands, but oat yields were reduced when oats were grown in association with barley. However, the lag in maturity for oats in comparison with barley suggests that the mixture of oats and barley would provide a relatively longer satisfactory harvest period for the mixture in comparison to that for barley alone.

In recognition of this, one might choose to grow barley and oats independently in different fields. However, blending of the two forages in the silo would require concurrent harvest of barley and oats in the separate fields, necessitating considerable coordination of harvest equipment as it moves between fields. A practical alternative to this is to grow both crops independently, but together in the same field in alternate strips. While grown independently and with minimum interspecies competition, the oats and barley would be blended initially at the time of harvest in the field and additionally when being blown into the silo.

Research currently is under way at the Matanuska Research Farm to study the production and nutritional quality of oats and barley planted at two rates in pure, mixed, split, or alternate-row plantings.□

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Windrowed and chopped into forage wagons, alternating strips of barley and oats become a relatively homogeneous mix at harvest.

Does it Work?

A "Biological Catalyst" Leaves Bromegrass, Barley, and Wheat Yields and Bromegrass Composition Unchanged

by

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

The Alaska State Division of Agriculture supplied several gallons of BIO-CAT soil additive to the Agricultural Experiment Station with the request that we evaluate the ability of this product to increase crop production. Testing of such nontraditional soil amendments is very important from a consumer standpoint since accompanying advertising claims may be convincing. Advertising on the label of this product states:

> BIO-CAT is a biocatalytic soil additive which, when mixed with water and sprayed on plants according to directions, activates the dormant microorganisms in the soil. These microorganisms in turn help to break down the organic matter in the soil and thereby enhances the plant's ability to utilize the nutrients in the soil more effectively.
>
> BIO-CAT increases the productiveness of plants by taking advantage of and making more efficient use of the nutrients in the soil.
>
> BIO-CAT is not a fertilizer but should be used in addition to fertilizer. BIO-CAT works most efficiently when sufficient moisture is present. In addition, BIO-CAT may be premixed with water at the above stated ratio for purpose of watering the root structure of the plants.
>
> BIO-CAT is a clear bluish liquid having a specific gravity of 1.005 kg per liter (8.4 lb per gallon) with a pH value of 1.4 to 1.9 in undiluted material with total solids of 0.61%.

Following directions on the container, we evaluated BIO-CAT on crops of barley, wheat, and bromegrass in 1978.

EXPERIMENTAL PROCEDURE

Barley and wheat

Uniform areas of Knik silt loam (*Typic Cryorthents*) on the Matanuska Research Farm were chosen for separate block experiments (plots 6 by 15 feet) on spring-planted barley and wheat, each with eight replications. Weal barley, planted with a grain drill with a fertilizer attachment on May 3, received commercial 10-20-20 fertilizer at 200 pounds per acre supplying 20, 40, and 40 pounds of N, P_2O_5, and K_2O, respectively. Prior to planting the wheat on May 10, we applied 250 pounds per acre of 8-32-16 supplying 20, 80, and 40 pounds of N, P_2O_5, and K_2O, respectively, and worked it into the soil. "BIO-CAT" sprays (2 ounces per gallon of water) were applied immediately after mixing at the rate of 60 gallons per acre to 16 plots on June 8, and a second application was made on 8 of these plots on June 19. The crops were about 4 and 8 inches tall on those dates. Plots that received no BIO-CAT were sprayed with the same quantity of water from a sprayer. On August 22, four 10-foot rows of barley, and on September 18, four 10-foot rows of wheat were cut with a hand sickle from the center of each plot, placed in a sack, dried for several weeks, and then threshed. Straw and grain yields and grain test weights were determined.

Bromegrass

A uniform 6-year-old stand of bromegrass on Bodenburg silt loam 3 miles south of Palmer was selected for a block experiment with eight replications. All plots (6 by 15 feet) were top dressed on

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Table 1. Effect of BIO-CAT on Weal barley, yield, test weight, and grain-to-straw ratios in 1978, on Knik silt loam (means of 8 measurements)

Number of BIO-CAT applications	Straw	Grain T/A	Total	Test Weight (lb/bu)	Grain/straw ratio
0	1.53	1.51	3.04	42.4	0.99
1	1.54	1.54	3.08	42.1	1.00
2	1.50	1.50	3.00	41.6	1.01
C.V. (%)[1]	15.6	12.7	13.9	3.5	5.8

[1]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. None of the above values show significant differences related to treatment.

Table 2. Effect of BIO-CAT on wheat yield, test weight, and grain-to-straw ratios in 1978 on Knik silt loam (means of 8 measurements)

Number of BIO-CAT applications	Straw	Grain T/A	Total	Test Weight (lb/bu)	Grain/straw ratio
0	2.69	1.73	4.42	60.7	0.65
1	2.62	1.71	4.33	61.0	0.66
2	2.72	1.71	4.43	61.3	0.63
C.V. (%)[1]	8.3	7.4	7.4	1.1	6.6

[1]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. None of the above values show significant differences related to treatment.

Table 3. Effect of BIO-CAT on bromegrass yield, NO_3-N, total N, and total N uptake in 1978, on Bodenburg silt loam (means of 8 measurements)

Number of BIO-CAT applications per cutting	Oven-dry 1st	Oven-dry 2nd	NO_3-N 1st	NO_3-N 2nd	Total N 1st	Total N 2nd	N uptake 1st	N uptake 2nd	N uptake Total
	T/A							lb/A	
0	1.57	2.30	.05	.11	2.97	2.25	65.0	102.4	167.4
1	1.54	2.52	.05	.11	2.09	2.26	64.3	113.2	177.5
2	1.64	2.66	.05	.08	2.06	2.18	67.2	115.9	183.1
C.V. (%)[1]	12.3	14.5	7.2	31.4	6.4	11.0	12.4	12.5	10.3

[1]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. None of the above values show significant differences related to treatment.

June 2 with 120 pounds per acre of N as ammonium nitrate, 100 pounds per acre of P_2O_5 as treblesuperphosphate, and 100 pounds per acre of K_2O as sulfate of potash. BIO-CAT spray was applied to the 16 bromegrass plots in the same manner as for the grains on June 2, and 8 plots received a second application on June 16. After the first cutting, similar sprays were applied on July 18 with the 8 plots again receiving a second application on July 24. An additional 100 pounds per acre of N as ammonium nitrate was applied after the first cutting. Just after the emergence of seed heads on June 21, 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 representative samples from each plot were ground to pass a 40-mesh screen.

Soil analysis

After the barley, wheat, and second bromegrass harvest, soil samples were taken from each plot to a 6-inch depth. We determined pH and analyzed these samples for NO_3-N, P, and K, using a modified Morgan's procedure with sodium acetate buffered at pH 4.8 (Martin, 1970).

Plant analysis

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 AND DISCUSSION

Weal Barley

Yield, bushel test weight, and grain-to-straw ratios were not influenced significantly by BIO-CAT sprays (Table 1).

Wheat

Yield, bushel test weight, and grain-to-straw ratios were not influenced significantly by BIO-CAT sprays (Table 2).

Bromegrass

Yield, NO_3-N, total N, P, K, Ca, Mg, and S concentrations and N, P, K, Ca, Mg, and S uptake by both cuttings were not influenced significantly by BIO-CAT sprays (Tables 3, 4, and 5).

Soil pH and available NO_3-N, P, and K

BIO-CAT application had no significant effect on the soil pH nor on the available NO_3-N, P, or K on either the Knik or Bodenburg silt loam (Table 6).

The pH and NO_3-N values for the Knik silt loam in August and September were relatively uniform and were not influenced by BIO-CAT treatments.

Over the years several soil additives and foliar sprays have appeared on the market. Their claims frequently exceed product performance. They are sold as nutrient-release agents, soil amendments, and soil conditioners, since most do not contain enough N, P, and K to be sold as fertilizer. Most of these products have common characteristics, such as low application rates compared to fertilizer, and may be applied to the soil directly or used as a foliar spray. Testimonials are often based on 1 year's use in nonreplicated trials, and the reason for the claimed results is either unknown or a "trade secret." Most of these products will not cause any harm to the crop. However, replicated field experiments seldom show any beneficial effects.

CONCLUSIONS

The results from these three experiments showed no crop response to BIO-CAT applications. The uniform yields and other values are reflected in the extremely low coefficients of variability.□

Table 4. Effect of BIO-CAT on percentages of P, K, Ca, Mg, and S in bromegrass forage in 1978 on Bodenburg silt loam (means of 8 measurements)

Number of BIO-CAT applications per cutting	P 1st	P 2nd	K 1st	K 2nd	Ca 1st	Ca 2nd	Mg 1st	Mg 2nd	S 1st	S 2nd
0	.24	.31	1.65	1.88	.42	.40	.17	.22	.16	.17
1	.23	.31	1.66	1.78	.42	.41	.16	.22	.16	.18
2	.23	.29	1.59	1.77	.42	.40	.17	.22	.16	.18
C.V. (%)[1]	5.6	7.5	6.8	7.0	9.6	11.1	7.2	12.7	4.4	7.9

[1]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. None of the above values show significant differences related to treatment.

Table 5. Effect of BIO-CAT on P, K, Ca, Mg, and S uptake by bromegrass in 1978 on Bodenburg silt loam (means of 8 measurements)

Number of BIO-CAT applications per cutting	P 1st	P 2nd	K 1st	K 2nd	Ca 1st	Ca 2nd	Mg 1st	Mg 2nd	S 1st	S 2nd
0	7.4	14.3	51.5	86.0	13.2	18.4	5.2	10.0	4.9	8.0
1	7.1	15.4	50.8	90.2	12.8	20.5	5.0	11.1	4.9	8.8
2	7.4	15.7	52.0	94.6	13.7	21.1	5.5	11.5	5.2	9.3
C.V. (%)[1]	12.0	14.4	10.7	17.4	16.9	16.4	15.5	15.1	13.2	14.6

[1]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. None of the above values show significant differences related to treatment.

Table 6. Effect of BIO-Cat on the soil pH and available NO_3-N, P, and K in 1978 (means of 24 measurements)

Number of BIO-CAT applications	Knik (barley (Aug. 23) pH water	available NO_3-N	P	K	Knik (wheat) (Sept. 18) pH water	available NO_3-N	P	K	Bodenburg (Aug. 24) pH water	available NO_3-N	P	K
0	6.0[1]	15.4	9.2	98	6.2	15.2	8.6	114	5.8	26	10.9	130
1	6.1	15.9	8.8	93	6.2	15.4	8.6	119	5.9	22	9.4	136
2	6.1	15.3	8.6	99	6.2	15.1	8.5	118	5.9	28	10.5	129

[1]Column values followed by the same letter are not signficantly different at the 5% level, according to Duncan's Multiple Range Test. None of the above values show significant differences related to treatment.

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Editor's Note: Cooperative investigation of the SEA-AR, USDA, and the Alaska Agricultural Experiment Station. To simplify terminology, the trade name of the product (WEX) 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.

"You Gotta Put it Somewhere"

Land Application of Sludge

by

Ronald A. Johnson*, James W. Winslade**, and Frank J. Wooding***

Sewage sludge is obtained from the processing of both domestic and industrial waste waters. The organic and inorganic matter in waste water are separated by a variety of treatment processes. The solid materials removed during these processes are referred to collectively as sludge (McCalla et al., 1977).

The passage of the Federal Water Pollution Control Act of 1972 resulted in several changes in the water pollution control field. The mandate of the law for secondary-treatment facilities and stricter discharge limitations resulted in an increasing amount of solid waste that must be disposed of in some manner. The amount of solids to be disposed of in the United States is expected to increase from 9.9 billion dry pounds per year to 17.6 billion dry pounds per year during the 1980s (Pahren et al., 1979).

As the amount of sludge increases, so does the public concern over the means of its disposal. In the past, this disposal consisted of ocean dumping, incineration, landfilling, and land application. Ocean dumping of sludge will be prohibited after 1981. Incineration uses a great deal of energy and may result in air-pollution problems. Landfilling provides a means of disposal, but the lack of suitable sites frequently limits use of this method. Land application not only provides a method of disposal, it also allows for the recycling of plant nutrients contained in the sludge.

When lands used for disposal are properly managed, it is possible to avoid many of the problems associated with the other disposal methods. However, land application is not without its own problems. Poorly managed land application schemes may result in a build-up of heavy metals and other contaminants in the soil, or in pathogen transfer through the food chain. The lack of large industrial plants in the Fairbanks area should preclude toxicity problems caused by heavy metals. Chemical analyses of the Fairbanks sludge have shown that cadmium, a metal contaminant which has caused problems in other parts of the United States, is present in very small amounts.

Microbiolgical studies, using fecal coliforms as indicator organisms, were conducted on land applications of sludge at Fairbanks during the summer of 1978 (Figure 1). It was found that sludge incorporated into the soil by tillage had a rapid die-off of pathogens. The data collected in the Fairbanks test, coupled with the thousands of case histories of land application of sludge throughout the world, show that land application of sludge can be accomplished in a sanitary manner in interior Alaska (Johnson, 1980).

During the year of sludge application, the soil in the study area was summer-fallowed. Crop response to sludge was measured the following year. 'Hudson' oats and 'Otra' barley were grown

Figure 1: Land application of sludge.

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** **Graduate Student, Environmental Quality Engineering.**
*** **Associate Professor, Agricultural Experiment Station.**

on land receiving sludge, commercial fertilizer, and sludge in combination with commercial fertilizer. A control treatment receiving neither sludge nor fertilizer was used for comparison. Sludge was applied at the rate of 20 tons of solids per acre. Commercial fertilizer was supplied from a 20-10-10 mixture at the rate of 250 pounds per acre. Grain yields for these treatments are presented in Table 1.

Table 1: Crop Response to Applications of Sludge, Commercial Fertilizer, and Sludge in Combination with Commercial Fertilizer

Soil Treatment	Grain Yield (lbs/acre)	
	Oats	Barley
Control	2761	3887
Commercial Fertilizer*	4014	4864
Sludge**	4867	4482
Commercial Fertilizer* + Sludge**	5873	5137

*250 lbs/acre of 20-10-10 mixed fertilizer.
**20 tons of solids per acre.

Oats showed a greater response to sludge than barley. Application of sludge alone resulted in a 76% increase in yield over that of the control. Oat yield for the sludge treatment also exceeded that for the commercial-fertilizer treatment. The reverse was true in the case of barley. The barley yield produced by the commercial fertilizer treatment was greater than that resulting from the sludge treatment. However, the highest yields for both oats and barley were produced by the combination of sludge and commercial fertilizer.

Sludge should be considered as a low analysis organic fertilizer in which nutrients are released in forms available to plants over a period of several years. Although extremely variable, the total nutrient content of sludge is generally higher than manure. The mean compositions of Fairbanks sludge and cattle manure (Donahue and Follett, 1976) are given in Table 2.

Table 2: Nutrient Content of Fairbanks Sludge Compared to Cattle Manure

Nutrient	Fairbanks Sludge	Cattle Manure
	Dry Weight (%)	
Nitrogen (N)	3.3	2.0
Phosphorus (P_2O_5)	5.3	1.0
Potassium (K_2O)	0.5	2.0

When compared with cattle manure, sludge contains, on the average, 1.65 times the total nitrogen, 5.3 times the phosphorus, and 0.25 of the potassium. One thousand pounds of dried sludge contains 33 pounds of nitrogen (N), 53 pounds of phosphorus (P_2O_5), and 5 pounds of potassium (K_2O). This same amount of nutrients that is contained in 1,000 pounds of dried sludge would require the following quantities of commercial fertilizer in order to provide the same amounts:

73 pounds of urea (45% N)
115 pounds of triple superphosphate (45% P_2O_5)
8 pounds of muriate of potash (62% K_2O)

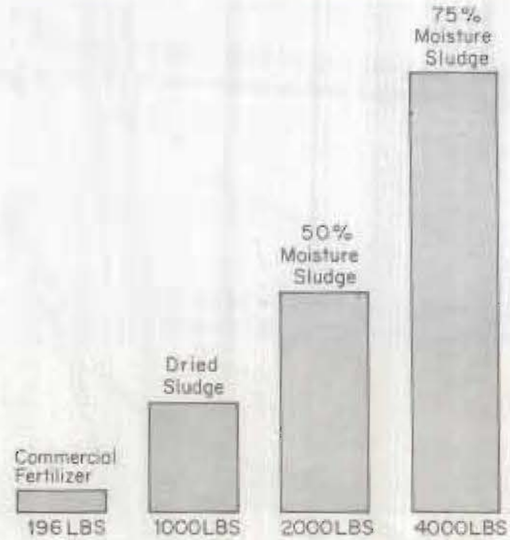

Figure 2: Weights of commercial fertilizer and sludge materials needed to supply 33 lbs N, 53 lbs P_2O_5 and 5 lbs K_2O.

The total weight of the commercial fertilizer is 196 pounds. The cost of the commercial fertilizers based on 1980 Fairbanks prices is $39.06. This then could be considered the value of 1,000 pounds of dried sludge in terms of the major plant nutrients in its composition. However, the residual value of the sludge under Alaska conditions over a period of years is uncertain. The sludge has an added value as a soil conditioner. Therefore, the true value of the sludge is not known.

The sludge at the Fairbanks treatment plant is not available in a water-free form. Drying of sludge requires a considerable expenditure of energy and the cost could far exceed the value of the end product. Under the present system of handling, sludge moisture contents of 50 to 75 per cent can be expected. If the sludge contains 50 per cent moisture, this means that twice the weight must be transported to obtain the same amount of nutrients as in the dried material. But, there exists the potential to allow much moisture to be economically removed by solar drying in the summer.

Figure 2 shows a comparison of the weights of commercial fertilizer and sludge materials of several moisture contents that must be transported and applied to the land in order to obtain the same amount of nutrients. It is obvious that the greater the distance the sludge is to be hauled the less advantageous it becomes. It is currently the policy of the treatment plant to offer the sludge free of charge to those who will come to pick it up.

This work represents only a preliminary investigation of the use of sludge as a soil amendment for interior Alaska. There is much to be learned regarding its use. More research is needed to determine optimum rates of application and the length of time over which benefits will be derived by crops. Also, information is needed on how best to supplement the sludge with commercial fertilizer in order to maximize crop response. These initial results indicate that sludge should be considered a resource of yet-to-be determined value.□

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Figure 1: Roses in production at the University of Alaska, Fairbanks campus. The nylon netting shown in horizontal layers above the rose plants is used for stem support.

Marketing Alaska's Roses

by

Cathy A. Warren* and Carol E. Lewis**

Roses have been referred to as "the queen of flowers." Their sensuous appeal, a combination of elegant beauty and charm and thorny strength have made them one of the most popular cutflowers worldwide. They have long symbolized love and affection:

> The gift of a single red rose signified "I love you." A proper Victorian lady might reply with a single yellow rose which implied her lover was fickle, or a white rose which told him "I am too young to love." or a single rose leaf which meant "I care not." If the suitor was really a gentleman, he would sign off with a musk rose which meant "Thou art a capricious beauty." But if his original red rose elicited another red rose in reply, a match was made. (Crockett, 1973).

Even in modern times, roses remain symoblic. Roses are given as gifts on Valentines Day, Mothers Day, anniversaries and birthdays. Although if the modern lady or gentleman were aware of 19th century flower language, more care might be taken in color selection. Alaskan consumers exhibit a rose-buying pattern very similar to that seen nationwide.

All roses sold in Alaska are imported. Our market research indicates that Alaskan retailers and wholesalers would prefer to purchase an Alaskan product comparable in price and quality.

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Figure 2: "Forever Yours" hybrid tea rose.

Figure 3: The orange-red color and ruffled pink petals are distinctive of the sweetheart variety "Mercedes."

However, roses, like most plants, prefer a warm soil and are grown as a perennial crop. Alaska's cool soils, short growing season, and severe winters preclude growing roses as a commercial crop without some type of artifically obtained environmental augmentation.

Large amounts of low-grade or waste heat are released in Alaska by power plants, pumping stations, and geothermal sources. Since rose yields and greenhouse growing rates are enhanced by warm root-zone temperatures, the University of Alaska was prompted to investigate the use of waste heat in rose production (Dinkel, 1979). Roses are being produced in the greenhouses on the Fairbanks campus (Figure 1) using heat provided by a boiler in such a manner as to simulate waste heat such as that just mentioned. Waste heat in the form of warm water is funneled underground through a network of pipes in order to warm the soil. Roses have been grown in this manner for the past three seasons. Several varieties and colors are grown though studies have concentrated on the red and yellow hybrid teas (Figures 2 through 5). Roses brought into production in mid-February bloom by mid-April. The growing season for these

Figure 4: The red and white petals of "Love" give this variety a unique look.

Figure 5: The ruffled petals of this hybrid tea are characteristic of the "Golden Fantasie" variety.

roses extends from February through November, at which time production and quality decrease due to low light levels. At this point, the roses are cut back and held dormant at about 33°F until February when the heat is increased and production is reinstated. An alternate system would be to plant bare-root roses in February, destroying the crop in December.

MARKET POTENTIAL

Retail florists were sent questionnaires on which they were asked to estimate sales volumes for 1978. Fifty-one florists were found to be in business. Two of these firms are also wholesalers. Table 1 shows the statewide distribution of retail florists.

Table 1. Number of Retail Florists in Alaska

City or Area	Number of Outlets
Anchorage	21[a]
Fairbanks	6
Juneau	4
Ketchikan	3
Homer, Kenai, Sitka	6[b]
Rural	11[c]
TOTAL	51

[a]Includes 1 at Eagle River and 1 at Elmendorf.
[b]Two outlets at each of the three locations.
[c]One outlet at each of these locations: Barrow, Soldotna, Ninilchik, Cordova, Kotzebue, Seward, Valdez, Palmer, Glennallen, Delta, Kodiak.

Retail florists were asked to report their sales volume on a per-month basis by subtracting the volume discarded as waste from the number of blooms ordered. Average monthly blooms sold statewide for twelve months for each reporting firm was 1,019. Average blooms sold monthly per firm by region are shown in Table 2.

Table 2. 1978 Estimated Rose Blooms Sold by Alaskan Firms

Area	Average Monthly Blooms Sold for Responding Firms	Estimated Yearly Sales for All Firms
Anchorage	1,055	265,860
Fairbanks	1,307	94,104
Juneau	2,150	103,200
Kenai & Seward	415	14,940
Rural	415	84,660
TOTAL		562,764

Alaskan retail florists sold an estimated 562,764 blooms in 1978 when Alaska's population was estimated at 405,500 by the Alaska Department of Labor (1978)—an estimated 1.39 blooms per capita. This is lower than U.S consumption of 1.59 blooms per capita (Bureau of Census, 1978; Illinois State Florists Association, 1980).

Approximately 80% of the 435,702,000 blooms sold to retail florits in the contiguous 48 states reach the consumer; the other 20% is the estimated loss to waste throughout marketing channels in the floral industry. Since Alaskan figures were derived from retail sales less waste, the volume purchased by florists in Alaska will be greater than the sales shown in Table 2. To estimate wholesale sales volume, estimates of sales from Table 2 may be multiplied by 1.2. The percentage of waste roses reported by Alaskan florists virtually agreed with the U.S. average. If Alaskan roses were available, this waste factor may be reduced because of longer shelf life.

The Alaskan rose volume figures do not include an estimate for roses sold through channels other than retail florists. Recent studies estimating the nonflorists' share of the market indicate one-third of all floral crops are sold through mass market channels. i.e. department and grocery stores. This includes bedding, potted, and foilage plants, as well as cut flowers, with the latter accounting for 55% of these sales (Goodrich and Avermaete, 1978).

Cut flowers are also beginning to appear in Alaskan mass markets, particularly grocery stores. However, no estimates were available of the number of roses which are marketed in the state in this manner. Sales in mass markets could increase the demand which an Alaskan grower would face. Therefore, the volumes shown in Table 2 estimate the least blooms sold on the Alaskan rose market.

Three definite peaks occur in Alaskan rose sales according to the response from retail florists: Valentine's Day, Mother's Day, and Christmas. The Florists' Transworld Delivery Association (FTD) reports show that floral crop purchases by volume as reported by retail florists in the U.S. are Christmas, Mothers Day, Easter, Valentines Day, and Thanksgiving, ranked in that order. Funerals represent 40% of the average florist business, while weddings represent only 10% of sales (Illinois State Florists Association, 1978). The FTD information represents all floral crops. Roses were not differentiated.

It should be noted that Christmas and Valentines Day occur during the winter season when Alaskan roses have not been produced in the past. Supplementary lighting and much greater heat will be required to meet production during these two peak periods. Alaskan wholesale florists indicate their relationships with west-coast suppliers are such that a constant supply must be guaranteed by the grower. If supplies were available only a portion of the year, relationships with these suppliers would probably suffer. Further, opinions of Alaskan wholesalers regarding a commercial rose grower in Alaska are diverse. Some are skeptical, viewing a commercial rose grower as competition with existing wholesalers. On the other hand, others welcomed Alaskan producers as a signal of market advancement, allowing them to receive a fresher product.

WHAT DOES THE LOCAL CONSUMER LOOK LIKE?

Seventy-five Fairbanks families were surveyed in an effort to examine consumption patterns for roses. Names were selected from a 1975 Municipal Utilities System mailing list which grouped customers by residental area. Representative samples of equal size were taken from each region. Names were then checked against the 1979 phonebook to ensure current residency.

Thirty questionnaires were completed and returned. All men responding indicated they preferred red roses whereas women's preferences were fairly evenly distributed between red, pink, and yellow: 39, 33, and 28%, respectively. The number of roses purchased for a one-year period ranged from 0 to 120 for each respondent, with 27.6 roses the average yearly purchase. Age, years married, income, and years of education at common purchasing levels are shown in Table 3.

Table 3. Average Purchasers of Roses in Alaska Categorized by Typical Amounts Purchased

No. of Roses Purchased for 1 year	Age		Years Married	Educational Level		Income
	Husband	Wife		Husband	Wife	
0	60	51	31	12.8	14	$15-30,000
1-12	51	45	30	14	14	$15-30,000
13-24	46	42	24	16	12	over $30,000
25-36	47	43	20	15.2	14.8	over $30,000
more than 36	60	53	20	14.5	14	over $30,000

Volume purchased increases as husbands occupation changes. At lower purchasing levels, blue-collar jobs predominate. At the "over-36" purchasing level, all purchasers are white collar workers. Women are employed at lower purchasing levels, but at higher purchasing volumes, almost all women list their occupation as housewife. At all purchase levels, husbands purchase 65% of the roses, while wives purchase 20%, daughters 10%, and sons 5%. Thirty-seven percent of all persons responding purchased no roses, while 17% purchased over 3 dozen blooms. Forty-three percent indicate they receive no roses from outside family members and 40% receive between 1 and 12 roses.

HOW IS QUALITY DETERMINED?

Efforts to guide the industry in setting quality standards have not succeeded because this determination has been so subjective. Appearance, chemical composition, and anatomical composition are used to determine quality at the time of purchase by retail and wholesale outlets. Components of appearance are size, form, surface, cleanliness, color, and condition. The chemical quality of cut flowers is determined by fragrance, and the anatomical quality by texture . After purchase, quality characteristics change, with lasting quality of major importance (Staby et al., 1978).

To improve lasting quality, producers should be aware of the influence of pre-harvest factors on post-harvest lasting qualities. Pre-harvest production factors which may effect lasting quality are environmental factors such as light levels, growing temperatures, growth regulations, soluble salt levels in the soil, under-fertilization and pest control (Staby, G., et al., 1978). Quality can be controlled throughout the production cycle. A high temperature in the greenhouse will result in higher production, that is, a shorter time for bud maturity. A slower growth cycle with a lower growing temperature, results in a larger bloom, but less production. Commercial growers must make a trade-off decision between quality and production yields. Harvest should occur when high levels of carbohydrates are present. This time is during the afternoon for roses. Post-harvest factors include the maintenance of even storage temperatures, the influence of ethylene sources and the importance of relative humidity control. Ethylene gas has been known to reduce lasting time of floral products. Sources of this gas are fruits and vegetables, diseased plants, and some types of internal combustion engines and petroleum-fired heaters, where air exchange is minimal.

The quality of roses grown at the University of Alaska was found to be extremely high through preliminary testing by a local florist. Appearance, fragrance, and lasting time were all superior to roses received from west-coast suppliers.Figure 6 shows the comparison of roses grown in Fairbanks to those shipped in from outside the state. Alaskan florists queried indicate they could expand rose sales if a superior quality rose product were made available. Lasting quality can be lengthened by producing a local crop. Furthermore, some non-Alaskan middlemen could be eliminated.

INDUSTRY STRUCTURE

Growers produce, wholesalers and shippers divide large lots into small lots, retailers sell and consumers purchase. Integration may occur, growers may also act as wholesalers to retailers and wholesalers may also sell floral products through retail stores. The structure of the Alaskan floral industry, beginning at the wholesale level is largely that of an integrated industry. Anchorage has at least three suppliers that act as cut flower wholesalers. Two of these are retail florists who have diversified into wholesaling, while continuing to operate retail outlets. One wholesaler sells mainly to retailers. There is additional evidence of integration, both horizontal and vertical, within the industry. Several firms have more than one retail outlet. One Anchorage firm has two outlets, while another maintains five branches in that city. A firm located in Kenai has an outlet in Soldotna and an Anchorage retailer has another branch in Homer.

An Alaskan rose grower would most likely fall into the combination grower (selling to retailers and wholesalers) category, very similar to the wholesale/retail firm in Anchorage. With a well-developed market plan, the growers product could replace an imported product in both retail and wholesale markets, not disrupting the existing distribution chain. That is, many Alaskan retailers buy directly from sources outside the state. It is a portion of this share of the retail market that the grower would seek to capture, not that portion of the market now buying from in-state wholesalers. An Alaskan grower would most likely attempt to capture a portion of the wholesale market share now brought from out-of-state, as well.

WHO ARE THE COMPETITORS?

California has consistently held a major share of the domestic rose market. In 1978, 49% of all domestic hybrid tea roses and 38% of all domestic sweetheart roses sold in the United States were supplied by California (Fossum, 1980; Federal-State Market News Service, 1978). Imports from foreign countries into the United States more than doubled from 1978 to 1979. Colombia held 77% of the rose-import market in 1979, while Israel maintained 16%. Total rose imports were approximately 35 million blooms of which Colombia's share was 27,066,000 and Israel's share was 5,629,000 (U.S. Department of Agriculture, 1980). There is no information to indicate regional distribution within the U.S. of the imported roses. Seasonal import fluctuations throughout 1978 were relatively minor compared to 1979 imports. One possible explanation for the high imports of roses during holiday peaks is that the U.S. suppliers could not meet demand during these times. Most rose imports occurred during December, when growing conditions in the exporting countries were perhaps more favorable than those in the United States.

U.S. export data is unavailable for cut roses. Export data is grouped for all cut flowers, fresh bouquets, wreaths, sprays, or similar articles by value, not volume. Prior to 1978, export data was categorized in an even more general manner as "flowers or buds, cut for ornamental purposes." Thus, even the limited 1978 data cannot be compared to previous years' figures. Contacts with the United States Department of Agriculture, California Market News, and the Bureau of Census suggest the U.S. does export roses to at least Canada, but amounts are unknown.

If Alaskan roses are marketed in the contiguous 48 states, the buyers will more than likely be at the wholesale level. In a 1973 study 13 wholesale markets were surveyed (U.S. Department of Agriculture, 1973). While the northeast and midwest depend largely on local suppliers, the south and west import the major portion of their rose supply from California. It would, therefore, be reasonable to assume that if Alaskan roses were to be sold in the contiguous 48 states, an attempt would have to be made to gain a share of California's market, particularly in the west. At present, a lack of information exists concerning demand for roses in the Pacific Rim countries. Alaska does have an air-mile advantage over the western U.S. to these countries. However, until more information is available, the competition Alaskan growers might face if they attempt to enter this market cannot be determined.

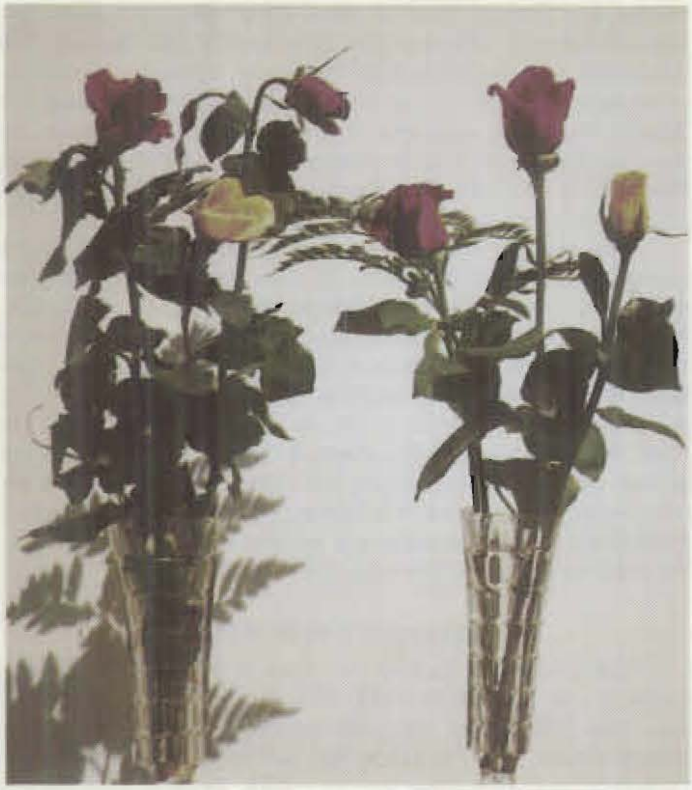

Figure 6: Roses pictured on the left were purchased from a local florist. The roses on the right were grown at the University of Alaska Agricultural Experiment Station greenhouses. The red roses in each arrangement are "Cara Mia." Note the larger bud size and stronger stem of the local roses.

FREIGHT COST

Interstate and intrastate transportation modes other than air are limited in Alaska. Since roses are a highly perishable commodity and transportation by air is available to almost every city and rural village in the state, air shipment will be the mode of transportation considered throughout marketing channels. Freight charges will have to be competitive with freight cost from the west coast into the state in order for Alaskan roses to be competitive in the Alaska market. To be competitive on the export market, freight cost must be equivalent to that between selected sites in the contiguous 48 states. For example, if Alaska is to ship into the Seattle area, it must be competitive with roses coming into Seattle from the San Francisco area. The assumption is made here that economies in production can be realized which will bring Alaskan production costs in line with those of U.S. producers.

Freight cost per rose was calculated based on regional estimated high and low demand. Demand was found to be as high as 3,828 blooms per week in the Juneau area and as low as 1,394 blooms per week in rural areas. Freight rates are step, that is, the price per pound decreases as volume shipped increases. This decrease occurs every 100 pounds. Therefore the demand figures will affect the freight rates. The demand figures used vary by region and box sizes to accommodate demand. Savings per rose between Fairbanks- and Anchorage-based firms are minimal. A surprising comparison is that of freight cost per rose for an Alaska-based grower to that of freight cost for a Seattle distributor to Juneau. Freight cost to Juneau per rose is less for a Fairbanks- or Anchorage-based supplier than for Seattle or San Francisco suppliers. Freight savings within Alaska, except to Juneau, are substantial.

One point made by Alaskan florists is that freight costs will still be incurred when other floral products are purchased from west-coast suppliers if Alaskan roses are purchased. This includes carnations, other cut flowers, and foliage. The freight costs per rose estimated here do not account for differences in ordering other floral products from west-coast suppliers and roses from within Alaska. We have assumed that since weight shipped will decrease, smaller box sizes will be used if roses are not purchased from west-coast suppliers.

Freight rates for three possible export markets were calculated. Seattle was chosen to represent the western export market, Dallas the south, and Minneapolis the midwest. San Francisco, Anchorage, and Fairbanks were considered as supply points. Since California produces the majority of domestic roses, this is the likely market with which an Alaskan grower would compete. If we assume that one-half of 1% of the market for California roses could be captured by Alaskan growers in each of the three regions, this would amount to 800,000 roses per year or 15,385 per week to each destination. The freight cost per rose is based on these figures. Preliminary evidence indicates the possibility of penetrating the Seattle market if wholesalers were willing to pay 1 to 2 cents more per rose over California prices for the superior quality of Alaskan roses. Penetration of the Dallas market by Alaskan growers is marginal based on estimated freight-cost comparisons. Freight costs from Alaska to Dallas are approximately 3 to 4 cents higher per rose than from San Francisco to Dallas. If roses were produced in Anchorage, entrance into the Minneapolis market might be achieved. Excessive freight costs from Fairbanks to Minneapolis preclude Fairbanks as a supplier.

One thing is certain if Alaskan wholesalers and retailers are to depend on Alaskan growers, supply patterns will have to be relatively stable for major floral purchases. It is doubtful, therefore, that state buyers would depend on a single grower for their supply. If there were several growers in Alaska, a larger share of the market might be captured. This may be more probable with year-round production. Until Alaskan growers build at least a short-run history of dependable production, outside products will continue to make up a large portion of the industry.□

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Two-thirds of the world's Sandhill Crane population migrate through Delta Junction, Alaska, in spring and again in fall. Some of these 200,000 migrants are shown on the OHM farm in Delta Junction 8 May 1978. Cranes use these fields for resting and feeding in the spring, but hunters prevent such use in the fall when the hunting season is open.

Agriculture and Wildlife

Are They Compatible in Alaska?

by

L. J. Klebesadel* and S. H. Restad**

Some interesting differences exist across our nation regarding the relationships of agricultural and wildlife interests. In New Jersey, and other eastern seaboard states, wildlife and environmentalist interests ally themselves with farmers to keep land in agriculture in attempts to forestall urban, commercial, and industrial uses of the same land. In Alaska, however, many of these same interests currently are arrayed against agricultural development, some because they may favor wilderness over any type of human inroads, some because they may be unaware of how compatible agriculture and much of Nature's wildlife actually are.

Agriculture and wildlife are not universally compatible, however. Wilderness animals such as the grizzly bear, timber wolf, and mountain lion are incompatible with many agricultural ventures and have disappeared from many developed agricultural areas. Agriculture and the coyote coexist with difficulty, but the wily, resourceful coyote has survived admirably in agricultural areas, despite the costly efforts of farmers and ranchers to drive out the coyote. Even wildlife that normally coexists with agriculture without conflict can become troublesome if crop damage becomes excessive.

But there is another side to the coin—wildlife and agriculture actually share many compatibilities. What follows here is a look at Alaskan land-use decisions, what agriculture is and does, and some of the conflicts and compatibilities between agriculture and wildlife, both in Alaska and elsewhere.

LAND-USE DECISIONS

Extremely important decisions are now being made by state and national legislators and appointed officials that will have far-reaching effects in determining the destiny of the people of Alaska and the nation. Many of these decisions involve such land-use issues as wilderness, wildlife, renewable resources, and agriculture.

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Some vocal advocates of land-use categories for Alaska that would omit agriculture urge hasty decisions in favor of wilderness and parklands.

Few areas within Alaska are suited to agriculture, but areas that are suited for agriculture have been identified and many feel strongly that these should be set aside for agricultural purposes. These people also feel that one of the few things worse than ignoring the need for wilderness, parks, and other nonagricultural areas in land-use planning would be to ignore the need for meeting mankind's most basic need—that for food—provided principally by agriculture.

The middle-of-the-road position is that, in Alaska, there is adequate room for agriculture as well as other land uses. Alaska contains 586,000 square miles or just over 375,000,000 acres, one-fifth of our nation's total area. Decisions on future land uses in Alaska must consider not only the desired area for each type of use, but the suitability of an area for the purpose intended. The U.S. Department of Agriculture's Soil Conservation Service has identified approximately 20 million acres of soils suitable for cropland in areas of Alaska where the climate is conducive to agriculture (Freeman, et al., 1974). This may seem a large area, especially since only about 30,000 acres are presently cropped in Alaska. However, these 20 million acres of potentially arable soils represent only about 5% of Alaska's total land area.

If agriculture in the state were to expand to its fullest potential, adding rangelands for reindeer and domestic livestock to the 20 million acres of cropland soils, *most* of Alaska would still be left for such other uses as National Forests, National Parks, Wildlife Refuges, Wilderness Areas, Wild and Scenic Rivers, urban and other nonagricultural uses, such as industry.

Some statements by one of America's pioneering and visionary wildlife biologists, Dr. Olaus J. Murie, especially his insight into land-use priorities, are of special interest. In a discussion of planning for Alaska's large wildlife species, Dr. Murie states:

> . . . planning for wildlife in Alaska involves a procedure that completely ignores the spirit of personal exploitation of resources. *It means careful study of land-use possibilities, on a regional basis, with an eye to determining what areas are best fitted for agriculture,* what localized places, if any, are suitable for national parks, which should be left in a primitive state for the wilderness type of recreation. Several of these needs, especially in the diverse field of recreation, can be combined in the same area, provided that the management or administrative plan is not too narrow in application. For example, conservation of caribou and mountain sheep could well be combined with *a system of wilderness areas, selected so as not to encroach on agricultural land.* These two purposes go very well together.
>
> *Above all, in planning for Alaska's big game, personnel should be called on who are competent to evaluate the emerging human needs.* (Murie, 1950, italics for emphasis are ours).

WHAT IS WILDLIFE?

Taken as a whole, "wildlife" embraces all fauna or animal life not domesticated or under direct human control; in this discussion, the term "wildlife" is used to encompass all birds and mammals, but not fish, reptiles, insects, arthropods, or other lower animal forms.

WHAT IS AGRICULTURE?

During ancient times, when human beings first began to coexist with the other fauna and the flora of this planet, all was "wildlife." Humans coexisted on a near-equal basis with the world's "wild" animals and plants. To feed themselves, humans hunted wild animals and gathered other food where and when they could find it. There was little or no disturbance of the natural environment; however, short- or long-term food scarcity leading to hunger or starvation was a never-ending problem to be surmounted.

Agriculture evolved as man's culturally contrived insurance against hunger; and it remains that today—the artificially managed production of crops and livestock from the land—ensuring a more stable and adequate food and fiber supply than was possible through hunting and gathering.

Agriculture is pursued at many levels of scale, from part-time to full-time farms and ranches, and from backyard gardens to large farm and ranch units comprised of hundreds, even thousands, of acres. And America's agriculture, often little appreciated in a nation where it has succeeded so marvelously in meeting food needs, feeds daily both its practitioners and, in addition, the vast uninvolved populace.

Agriculture is mankind's original and only truly essential industry. America's history of agricultural development and productivity is one of the greatest success stories in humanity's relatively short history. Some critics of agriculture seem to feel that there will always be adequate food in grocery stores. These critics are perhaps victims of media saturation during the 'fifties and 'sixties when crop surpluses were rampant, farm production subsidies were common, farmers were paid to take land out of production, and a general public resentment was generated against agriculture's production successes.

WHY AGRICULTURE IN ALASKA?

The United States has become a key food supplier to many nations of the world. However, per-acre crop yields that climbed steadily over the past several decades are now beginning to level off. Currently, nonagricultural developments nationwide claim each year from two to five million acres of America's best farmlands; these acres disappear to urban growth, new highways, and other developments. Demographers and others project that the growing world population will require as much *additional* food production in the next 25 to 50 years as world humanity has learned how to produce since cave-man days.

Where will that food come from? With such influences as desert advances, urban expansion, growing water shortages, and soil erosion—all of which deplete soils productivity—Alaska's considerable agricultural potential should be neither ignored nor thwarted, but thoroughly evaluated for its potential to produce food and fiber.

Alaskan agriculture currently produces less than 10% of the total food consumed in the state. Alaska's long food lifeline, dependent on long transportation routes and production in far-away areas, places this state's ever-growing populace in a precarious position, considering the future global food outlook and . . .the uncertainty Alaskans would face if military hostilities severed food-supply routes. An expanded agricultural industry in Alaska can reduce dependence on distant food supplies and provide a more diversified economic base in the state.

WILDLIFE IN AMERICAN HISTORY

The early chapters of the history of European settlement in North America read like an account of exploitation and decimation of wildlife. Before early mistakes forced the collective conscience of the nation to take stock of those errors and the values and limits of our wildlife, the passenger pigeon was gone forever.

As white settlers moved westward across the continent, the vast wildlife resources were looked upon as inexhaustible.

Uncontrolled market hunting of the American bison, that had totalled 40 to 60 million animals, reduced them to mere scattered remnants in less than 50 years (Allen, 1954). Market hunting of whitetail deer, pronghorn antelope, elk, passenger pigeon, and waterfowl also decimated those species in America, mostly during the last half of the nineteenth century.

These abuses of wildlife populations occurred because of market hunting, lack of alternative food sources for a growing human population, and absence of a conservation ethic and the laws and enforcement necessary to limit wildlife harvests to tolerable levels.

A list of endangered species around 1900 would have included the snowy egret, trumpeter swan, whooping crane, pronghorn antelope, and wild turkey. Conservation measures have brought all of these species back from the brink of extinction to the extent that thousands of the latter two species are now safely harvested each year.

AGRICULTURE AND WILDLIFE

Early depredations of American wildlife occurred at the time of, but very few directly because of, agricultural settlement in the country. It has been amply demonstrated over the last half century that much alliance and harmony, exists between agriculture and a great many wildlife species.

Over 200 million acres of the U.S. have been set aside, with wildlife production one of the primary aims. These include Wildlife Refuges, National Parks, Wild and Scenic Rivers, National Seashores, nature preserves, wilderness areas, etc. However, in some instances, agricultural lands of the United States produce and sustain more wildlife than the lands specifically set aside for wildlife and other natural values. Approximately one-half of the total land area of the conterminous 48 states consists of land in farms. Yet, this one-half of the nation's land, devoted by its owners to the main purpose of producing food and fiber, succeeds peripherally in producing and sustaining an estimated 80% of the nation's wildlife (Spencer, 1971). Could it be that agriculture and wildlife are compatible? Shouldn't most wildlife thrive best where lands are set aside for wildlife alone?

FOOD FOR WILDLIFE

Many natural ecosystems are relatively sterile and support wildlife in surprisingly low numbers. This is especially true in northern regions of the world (Elkins, 1950). In mature forests, and in other types of climax, woody vegetation, nutrients are tied up in organic forms poorly available as food for wildlife. Spencer (1971) emphasizes this point, stating that "... the unbroken forest, where the closed canopy shades out the ground cover, is almost a biological desert for game."

A rich, fertile soil supporting only a dense, closed stand of tall timber offers little food for humans or domestic animals and little for wildlife, for the nutrients there are tied up in largely inedible, organic forms. A mature, virgin forest may represent an incorporated abundance of nutrients in a tall stand of timber permitting no available browse or understory for food, and yielding only a modest annual production of food in the forms of seeds in cones or nuts. The same soil under agricultural production engages nutritional elements in a dynamic flux within an array of rapidly growing, productive crops that are edible and can nourish, directly or indirectly, humans, domestic animals, and wildlife.

It is not only the crops produced on farms that can feed wildlife. Many annual weeds that inevitably thrive in and near agricultural fields, especially along field borders and in peripheral areas such as roadways and lanes, are extremely productive of seeds. These are a valuable and much-used food source in the sustenance chain of many wildlife forms.

To be economically viable, agriculture other than at the subsistence level must be highly productive and competitive. This means culturing crops on productive soils that are either naturally very fertile or in which deficient nutrient supplies are reinforced by added animal manures and/or concentrated commercial fertilizers. It is this artificially managed concentration of nutrients for production of crops that makes agricultural areas so much more productive of food, domestic animals, and some wildlife species than is afforded in natural ecosystems.

The heaviest concentration of nesting ducks in North America is not found in the pristine parklands or wilderness areas, but coexists with the grain-farming region of Nebraska, the Dakotas, and the Canadian provinces of Alberta, Saskatchewan, and Manitoba. Approximately 13 to 15% of the ducks and geese that migrate south in North America originate in Alaska (USDA, 1977) and the waterfowl that do nest in arctic and subarctic areas are most concentrated in river-delta areas which contain the concentrated fertility from the respective drainage basins (Allen, 1954).

Allen (1954) reports that, in the midwestern states, numerous forms of wildlife (rabbits, raccoons, muskrats, wild turkey, quail) were more abundant, larger, healthier, and more reproductive in areas of fertile agricultural soils than where soils were infertile or where no farming was practiced. A food-habit study of 497 Hungarian partridge collected throughout the year in North Dakota showed that wheat, oats, and barley from farm fields constitutes 56% of the total food consumed (Spencer, 1970). In Idaho, a study showed that relative jackrabbit densities, as influenced by demonstrated choice of food plants and with counts averaged over the entire year, were: 11 jackrabbits for barley and alfalfa, 7 for crested wheatgrass, 4 for potatoes, and 0.6 for unplanted rangeland (Fagerstone et al., 1980). These examples serve to illustrate a poorly appreciated principle of agriculture/wildlife interrelationships and help explain why many forms of wildlife in America are more abundant now, when agriculture stretches the length of our land, than when European explorers first reached this continent.

WILDLIFE HABITAT

Not only is food production stimulated by agricultural development, but new habitat is created, much of it favorable to wildlife. "Habitat" is defined as "the place or type of site where a plant or animal naturally or normally lives and grows" (Morris, 1976). Fence-rows, the margins created between separate farm fields, and the interface between farm fields and woodlots are all ideal sites for nesting and concealment of wildlife.

Biologist Dr. Donald A. Spencer has devoted over 50 years to studying wildlife and its relationship to various environmental and habitat influences, including those of agriculture. Of the nearly half of the United States area that is listed as "land in farms," Dr. Spencer (1971) relates:

> Only about a third of this area is in cultivated fields, the remainder in permanent pastures, in wooded areas, in ponds and aquatic habitat, and lanes and farmsteads. To the extent that these differing plant communities occur in association with one another, diversity is achieved that does much to enhance game and wildlife abundance.
>
> The forested areas on farmlands—145 million acres—are of particular significance for wildlife in that they are characteristically small blocks interspersed with open areas of croplands and pastures. Wildlife is the product of the forest margin—not the closed canopy within where little food and ground cover exist.

During the first half of this century, much aquatic wildlife habitat was eliminated where swamps and marshlands were drained in order to develop farmlands. This practice aroused much antipathy and adverse publicity has led to legislation protecting wetlands. However, a much less publicized but important counteractive contribution of agricultural development in the conterminous 48 states that has enhanced wildlife is the artificial provision of water through irrigation, impoundments, and construction of farm ponds. There are now over two million farm ponds in the U.S., and some 50,000 are added each year. Many farm practices encouraged by the Soil Conservation Service are specifically designed to foster wildlife habitat; for example, constructing a small island in farm ponds enhances their value for nesting of Canada geese and ducks. The U.S. Department of Agriculture has assisted in the construction of 260,000 ponds in North and South Dakota, Montana, and Western Minnesota, and duck counts there reveal an average of two breeding pairs per surface acre of water. According to data compiled by the U.S. Fish and Wildlife Service, the number of breeding ducks per square mile is substantially greater in North and South Dakota than in the Yukon Flats of Alaska (U.S. Dept. Int., 1964). It could be assumed from these data that agricultural development on well-drained soils of the Yukon Flats could result in increased duck production.

A further consideration on agriculture and wildlife habitat involves a relatively recent trend, fostered by larger equipment and larger fields, that tends to operate to the detriment of wildlife. Allen (1954) notes that large-scale, intensive agricultural development that completely occupies the land leaves little area for wildlife ". . .when high agricultural value means laying bare the land from one road to another for production of cultivated crops. . .there may be practically no place at all for wildlife in the land-use economy."

The trend to larger fields, thus fewer fence-rows, more intensive agriculture during recent decades in many of the vast farming areas, especially in the midwestern states and the Canadian prairies, has eliminated some wildlife habitat and lowered populations of several wildlife species that formerly benefited from close coexistence with smaller agricultural areas. This trend toward more intensive agriculture and sharply increased yields on the most productive soils made possible by technological advances, has, however, permitted a market reduction in cropland soils required in the U.S., thus releasing land for other uses (Barrons, 1971). The potential for future increases in per acre yields probably cannot match those of the most recent half century, however, and future needs for food production increases likely will require more agricultural lands, such as Alaska can provide.

Alaska does not possess broad, extensive areas conducive to agricultural development as in the Great Plains; areas in this state that do offer potential for agricultural development are relatively limited in extent and are almost invariably interrupted by wetlands, rough terrain, and streams that will undoubtedly remain as wildlife habitat and cover. Moreover, the total 20,000,000 acres of Alaskan soils identified as suitable for agricultural production exists as several separate areas in widely scattered localities within the state (Freeman et al., 1974).

No single habitat type is suitable for more than a few species of wildlife; for this reason a wide variety of habitat types is desirable for maximum wildlife diversity and numbers. Management for optimum wildlife populations recognizes that other factors beyond food availability and habitat abundance limit the numbers of a wildlife species that will occupy a given land area. The phenomenon called "territorialism" (Allen, 1954) represents a social intolerance within many species, the effect of which is a "self-imposed," upper limit on the number of individuals or pairs that will occupy a given land area.

HUMANITY/WILDLIFE CONFLICTS IN GENERAL

Agriculture is not the sole human activity that leads to incompatibilities with wildlife; rather, almost all human activities conflict with certain wild species such as the grizzly bear, timber wolf, and mountain lion. Dahlberg and Guettinger (1956) record the demise and disappearance with white settlement in Wisconsin of such former native wildlife species as the cougar, lynx, marten, fisher, wolverine, elk, moose, caribou, buffalo, and wild turkey. Effective early limits on hunting, trapping, and in some cases, habitat destruction would probably have perpetuated there many of the species listed.

Certainly a number of conflicts exist between agriculture and wildlife in addition to those involving large predators. Some conflicts common in the 48 conterminous states include prairie dogs vs. livestock; foxes, weasels, and skunks vs. poultry; eagles and coyotes vs. sheep; rabbits, mice, and grouse vs. fruit orchards; wild duck flocks vs. small grain farming (Burton, 1978); and some instances of competition for forage between domestic livestock and mule deer, bighorn sheep, and pronghorn antelope.

AGRICULTURE AND WILDLIFE IN ALASKA

Conflicts

Although Alaskan agriculture is limited in scale, some conflicts do exist between agriculture and wildlife. However, these are not of great extent, and efforts are being made to minimize such occurrences.

Perhaps the oldest continuous conflict between agriculture and wildlife in Alaska is found on Kodiak Island, where some livestock is lost or injured each year to predation by the brown bears of the island. The bears are indigenous to the island, and some livestock has been raised on the northeast portion of Kodiak since first introductions of cattle by the Russians during the eighteenth century, and this problem will probably continue. The present range of the bears includes most of the island and this will remain their inviolate province. Conflicts arise when the bears move into the range areas and livestock became their prey.

Sheep ranchers on islands in southwest Alaska are free of large predators such as wolves and bears. However, they report frequent injury or death of lambs in their domestic sheep flocks from smaller predators during the critical period when lambs are immobile and defenseless immediately following birth. Ravens sometimes blind lambs by pecking out their eyes, and eagles and foxes often kill lambs. One rancher reports some relief for lambs by providing predators with alternative food sources at lambing time, thereby luring the predators away and sparing the helpless lambs until they become ambulatory and less susceptible to harm.

Another agriculture-wildlife conflict involves the free-roaming bison herd of 400-600 animals in the Delta-Clearwater area. Twenty-three American bison were introduced in this area from Montana about 50 years ago. Agricultural development started in the same area two to three decades ago, and there has been crop damage by bison in some of the grain fields. More recently, considerably expanded land clearing and grain farming has been undertaken in the Delta-Clearwater area. Both Department of Fish and Game personnel and farmers are trying to devise methods to reduce future bison incursions and damage in farm fields.

Figure 1: Pintail ducks take wing from a field of small-grain stubble in the Matanuska Valley where the birds have been feeding.

Figure 2: Geese stop in an Alaskan stubble field in spring to glean grain missed during previous summer's harvest.

Compatibilities

Having taken note of certain agriculture/wildlife conflicts in Alaska, it must be stated that there are numerous examples of compatibility as well as enhancement of wildlife contributed by Alaskan agriculture.

Waterfowl

The early spring migration of ducks and geese through southcentral Alaska to nesting areas in the more western and northern portions of the state reveal an interesting affinity of the migratory waterfowl for agricultural lands (Figures 1, 2, and 3). Flocks often stop for a few days of feeding in farm fields of the Matanuska and Tanana Valleys to glean grain left in the stubble from the previous growing season. Weather conditions before or at grain harvest time often cause some grain heads to snap off and fall to the ground, and some heads of lodged plants also escape harvest to remain in the fields. Most of the feeding in Alaskan farm fields occurs during the inward migration in spring. The birds' return south in autumn occurs after most of the grain is harvested, resulting in little or no crop loss.

Winter snow melts earlier in spring from agricultural fields than from neighboring, wild vegetation, providing a place for rest and food for the migrating waterfowl as they pass through settled areas toward their nesting grounds. In late spring, the migration is often held back as birds wait in areas like Matanuska Valley fields and coastal tideflats before continuing north and westward to nesting areas. Increased agriculture in the Fairbanks and Big Delta areas of interior Alaska has increased the spring resting and feeding areas for the birds there also.

A specific example that demonstrates agriculture/waterfowl compatibility involves fields of a several-hundred-acre former dairy farm just north of the city of Fairbanks. For many years, Fairbanks residents enjoyed seeing large flocks of migrating ducks, geese, and cranes in the farm fields each spring. When the farm was to be sold for real estate development, a local group organized to encourage the purchase of the open field area by the Alaska Department of Fish and Game for the continued use by waterfowl. However, following the purchase the fields were not planted to crops as had been done when the land was actively farmed (Johnson, 1978). As a result, the geese and ducks did not stop there the next year, but went instead a few miles away to other farm fields that had been planted to small grains the year before, and where the waterfowl could find leftover grain. When a grain crop was planted the next year on the farm fields that had been purchased for waterfowl use, the geese and ducks then returned to those fields in great numbers the following year.

Wildlife, like all other living creatures, requires an adequate food supply. They prefer, and thrive best in, areas in which food is abundantly available. Not infrequently, this is where agriculture is practiced.

Cranes

Early settlers in the Susitna River Valley report that the lesser sandhill (little brown) crane (Figure 4) was unknown in that area when the valley was covered by unbroken forest (Saunders, 1979). Since the advent of land clearing and agricultural development there, however, flocks of these migratory cranes, that winter in New Mexico and west Texas, are commonly seen in grain fields throughout the summer. They now frequently visit most cropland areas of southcentral and interior Alaska.

Matanuska-Susitna Valley Moose

Chatelain (1951) reports that while a great many species of food plants are generally available during the summer, the availability of browse, principally willow, determines whether moose can survive the winter and what the carrying capacity of a winter range will be. He reported that winter aerial surveys in undisturbed forested areas of the Susitna Valley showed average moose population densities of 0.61 per square mile. In other areas where the virgin forest cover had been disturbed by natural or unnatural causes (changes in river channels, beaver activity, fires) increased food availability resulted in moose populations ranging from 5.2 to 57.5 per square mile. He states:

> The largest and most important of the moose winter ranges lies adjacent to the Alaska Railroad between the towns of Palmer and Talkeetna. Here, fires occurred during the railroad construction and afterward, destroying much of the original forest. A great amount of second growth willow and other food plants came in and created an excellent moose winter range.

When the first white settlers arrived, Alaska's Matanuska Valley was covered by dense birch-spruce-cottonwood forest. Moose were virtually nonexistent here when the mature, unbroken, climax forest provided little in the way of desirable habitat, especially browse for food (Chatelain, 1951; Elkins, 1950).

The rural farming activities of the 1930s and 1940s, with the clearing, wood cutting and range-management activities,


Figure 3: Early spring flight of swans over Matanuska farm fields.

Figure 4: Little brown (sandhill) cranes nest during summer near farming areas and often seek food in farm fields.

Figure 5: Two moose are photographed on an Alaskan farm as they forage for food.

caused moose browse to flourish in the periphery of man's activities. Moose numbers expanded so much that game counts of the Palmer area in 1967 (ADF&G, 1972) were higher than ever previously recorded. (See Figure 5).

It is informative that about 60,250 moose were killed in 1976 in Sweden (National Board of Forestry, 1977), a subarctic country one-third as large as Alaska, but where agriculture and forestry are relatively much more extensive than in Alaska; in Alaska the moose harvest for the same year was only about 4500 (ADF&G, 1980).

Midwest Whitetail Deer

Increased moose populations in the Matanuska Valley, as a result of agriculturally induced habitat alterations are not unique; they follow somewhat the population trends of the whitetail deer in the northern part of the midwest states. That species, the most widespread big-game animal in the U.S., is also much influenced by habitat change and relative food abundance (Dahlberg and Guettinger, 1956; Taylor, 1969; Trefethen, 1970).

In the late nineteenth and early twentieth centuries, major logging efforts removed the great mature forests across northern Michigan, Wisconsin, and Minnesota. Prior to the logging, whitetail deer had been scarce in the mature, heavily shaded forests. With opening of the forests, followed by the subsequent generation of new, lower-growing browse, the deer populations grew dramatically.

With creation of large national forests, rigid control of fires, and consequent return of tall, heavily canopied forests, browse plants have become more scarce and deer populations in several areas have declined. Areas repeatedly cut for pulp wood and areas where farmsteads provide both food and a break in the uniform forest cover retain better deer numbers.

A few hundred miles to the south, other habitat changes, more directly affected by agriculture, also have had a dramatic impact on the whitetail deer and other wildlife. Before the arrival of white settlers in the undulating area that is now southern Wisconsin and Minnesota and northern Iowa and Illinois, much of the area was composed of open prairie grassland and savanna. It had been kept in that state by great sweeps of periodic fires effectively preventing forest cover on the land. With settlement and agricultural use of the relatively level areas, the great fires were stopped and unfarmable steep slopes formerly covered with prairie grasses now support dense forest cover of oak, hickory and red cedar.

This patchwork of dense woodlands, alternating with farm fields, now presents an array of diversified habitat which supports increased wildlife numbers. Whitetail deer, raccoon, ringneck pheasant, ruffed grouse, opossum, Hungarian partridge, and many other species formerly unknown, or present in low numbers, are now plentiful in the area. Cropland food available to wildlife in fields adjacent to the unfarmed woodlots and marshlands provide an area supporting such an abundance and diversity of wildlife that numbers must be kept in check through annual harvests by hunters and trappers.

Agriculture favors many forms of wildlife, but the reverse is true, also. For example, such wildlife as hawks, owls, foxes, coyotes, and bobcats preying on destructive rodents that damage crops is an instance of wildlife's contributing direct benefits to agriculture. Moreover, many birds consume insects harmful to crops and livestock.

WILDLIFE IN BALANCE

In natural ecosystems, such as wilderness areas, predator and prey usually maintain an effective balance, but with fluctuations common in both types of populations. With suppression of many natural predators through human activities, wildlife populations must be monitored and kept in balance with their food supplies and other limiting factors of their environment, and to prevent excessive crop damage. This is most effectively achieved through harvest of surplus animals and birds by hunting.

Hunting, both for recreation and for the meat provided by game birds and animals, is much in demand in America. For example, from 4 to 16 million ducks are harvested for food annually in the U.S. (USDA, 1977), and in a single year it was estimated that 54,000,000 pounds of dressed meat, principally deer, was harvested from American forests (Taylor, 1969). The recreational values and food supplies afforded by wild-game harvest also benefits the wildlife itself. Left to multiply unchecked, wildlife populations can rapidly outstretch food supplies, resulting in weakened, starving animals and wildly fluctuating populations.

The recent, justified national concern for a certain few threatened and endangered species, resulting in much-publicized cases should not obscure the much broader, but less-publicized, general status of wildlife in North America; current populations and the outlook for a great many wildlife species in North America are better now than at any time during this century. To illustrate, the surplus numbers of a few of the wildlife species that must be harvested annually in order to keep remaining numbers healthy and in balance with food supply and habitat increased during the 20-year period, 1948-1968. These include whitetail deer, mule deer, elk, pronghorn antelope, fisher, blacktail deer, black bear, peccary, wild boar, fox, nutria, raccoon, moose, mountain goat, and bighorn sheep—the first five by a factor of 2 or more, the last three by a factor of 10 or more (U.S. Dept. Int., 1970).

Excessive wildlife inroads into croplands can also be controlled by the provision of "lure crops." The pothole regions encompassing the prairie provinces of Canada, the Dakotas, Montana, and Minnesota represents the largest and most productive breeding ground for ducks in North America. However, it is also one of the world's greatest small-grain producing areas. Occasionally, extremes such as wet field conditions slow grain harvest, allowing fall-feeding ducks to consume millions of dollars worth of grain. Provision of large grain acreages as lure crops, intended for duck feeding, and compensation payments to hard-hit farmers, are being used there with some success to offset these losses (Burton, 1978).

SUMMARY

The foregoing discussion presents some viewpoints on agriculture/wildlife interrelationships often overlooked in deliberations on land-use planning for Alaska. Inasmuch as whole volumes are compiled on wildlife, its habitat and food considerations and the interrelationships of wildlife and various human uses of land, this discussion is necessarily less than comprehensive in scope and depth.

Agriculture is not only compatible with a great many wildlife species, it clearly enhances the existence of many forms of wildlife. Wildlife must have food—and one of agriculture's prime objectives is the production of food. And, coincident with agriculture's main objective of food production is the inadvertent or planned creation of habitat beneficial to wildlife.

Are agriculture and wildlife compatible in Alaska? Because the term "wildlife" encompasses so many species, there is no clear 'yes' or 'no' answer. Some wildlife species are clearly incompatible with agriculture. However, only a small portion of Alaska's total area possesses soils and climatic conditions suitable for cropland farming and ranching. Alaska currently produces less than 10% of the food required to feed itself and the remainder must be imported from other areas over lengthy transportation routes at increasing transport costs. The critical importance of agriculturally produced food to the future well-being of an increasing human population here and worldwide suggests that most of the roughly 5% of Alaska's area that is suited to agriculture should be reserved for that purpose. This will leave the vast majority of Alaska's landscape for other land uses, including parks, mineral extraction, wilderness, industry, forestry, communities, etc. Wilderness wildlife will have abundant areas within which to exist apart from agricultural lands. Moreover, many forms of nonwilderness wildlife will not only be compatible with and coexist with agriculture, but many species will be enhanced in health and numbers by the existence of agriculture in Alaska.

Without healthy agriculture, transportation, manufacturing, processing and other industries that provide jobs, taxes, and other underpinnings to propel an economically healthy nation and society, there can be no public funds to be used for wilderness preservation and wildlife protection, management, and conservation. Human economic well-being and viable public programs for wildlife are inextricably linked.□

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A Simple Structure for Plant Environment Enhancement

by

Lee Allen*

Many garden crops, popularly grown in warmer climates, are marginal under Alaska's climatic conditions. The most popular warm-climate varieties of sweet corn, tomatoes, cucumbers, squash, and peppers usually fail in Alaskan outdoor gardens because of the cool environment. Clear plastic mulches have come into widespread garden use in Alaska for producing sweet corn and squash. For other crops, an additional level of environmental enhancement is needed.

The simple protective structure described here has been beneficial to crops that respond to significantly increased air temperatures and a modest increase in soil temperature. This protective structure, a plastic-covered cage, has improved the survival and establishment of transplants and has resulted in faster growth throughout the season and better production. Our work was confined to transplant protection, but we believe that some benefits would accrue to seeded or perennial plants.

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THE PROTECTIVE STRUCTURES

Cages were constructed from 6x6-inch, 6- and 9-gauge reinforcing mesh. The bottom ring is cut off leaving protruding wire ends to push into the ground to hold the cage in place. Cylinders 6 and 14 squares in circumference (11- and 26-inch diameters) and about 24 inches high have been used. A rectangular piece of plastic film is held in place around the wire cylinder by wrapping its ends around a stick secured with a string. The wire cages and plastic covers can be made up well ahead of transplanting time.

Figure 1: A sheet of plastic is wrapped around a welded wire mesh cage. The sheet can be held taut by wrapping its end around a stick secured with strings.

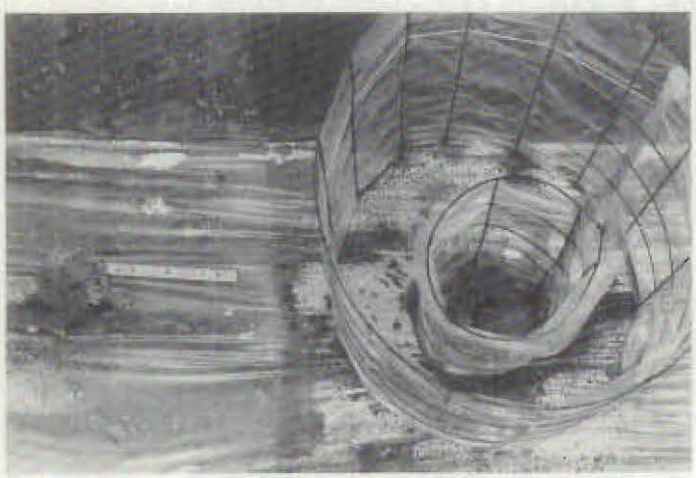

Figure 2: For sensitive crops, plastic mulches or double cages can be used for additional protection.

There does not appear to be any visible difference in early plant performance due to cage size, but tomato plants filled the smaller cages by midseason. This caused restricted air circulation and moisture collected on the leaves. At this growth stage the plastic cover was removed and a larger cage added. One test used both large and small cages, with the plastic film removed from the inner cage when the increased foliage restricted air movement.

IMPROVED PLANT ENVIRONMENT

The film enclosure reduces air currents, cutting down on moisture loss from the plant and soil. This reduces stress and aids plant growth, especially in the first few days or weeks after transplanting.

Higher daytime air temperatures occur inside the protective structure but the structures do not offer frost protection at night. Reduced evaporation of soil moisture results in slightly warmer soil temperature and lessens the cooling effect of rain or irrigation water.

The protection of the plant from direct physical damage by wind can be a significant factor for windy locations. The

Figure 3: When a tomato plant grows to fill a cage, a larger cage can be substituted for better air circulation.

cages can be securely anchored to the ground by J-shaped wires with the curve hooked over the bottom ring of the cage.

TESTING THE CAGES

Tomatoes, cucumbers, and peppers were grown with and without plastic-covered cages at Palmer in 1977, 1978, and 1979. Fruit produced were counted and weighed. Tomato results reported here are representative of the response that occurred with other crops.

In 1977, the cages were used with large-fruited Delicious and Fantastic tomatoes that are normally grown in greenhouses. The summer of 1977 was unusually warm, and these conditions contributed to very good yields of green fruit, averaging over 8 pounds per plant with or without cages. Delicious produced more green fruit with cages while Fantastic produced slightly less. Fantastic produced some ripe fruit with cages, but Delicious did not produce ripe fruit by the September 19 harvest date.

The 1978 tomato trial included three large-fruited greenhouse varieties and three smaller-fruited varieties recommended for outdoor use in northern areas. The greenhouse varieties were Fantastic, Delicious, and Sonata. Outdoor varieties were Early Tanana, Manitoba, and Subarctic 25. For every variety, the plastic-covered cages were effective in producing more ripe fruit and more total fruit.

Figure 4: With plastic removed from the inner cage, the plant requires no stake to hold the foliage and fruit off the ground.

Figure 5: Vigorous growth may be obtained even without plastic mulches so that tomatoes may eventually fill even 26" diameter cages.

Table 1: Total yield of green and ripe tomatoes, pounds per plant.

Year	Small-fruited varieties: Unprotected	Single-cage	Double-cage	Large-fruited varieties: Unprotected	Single-cage	Double-cage
1977	—	—	—	8.1	8.7	—
1978	0.9	3.1	—	0.1	0.9	—
1979	0.9	2.0	2.7	0.5	0.6	1.3

The three outdoor varieties grown in 1978 averaged 3.1 pounds total fruit per plant when protected by the cages but only 0.9 pounds per plant without cages. Ripe fruit yields averaged 1.2 pounds per plant with cages and only 0.4 pounds per plant without. The greenhouse varieties produced almost no fruit without protection and averaged only 0.9 pounds total fruit per plant even with cages.

In 1979 a system of additional protection consisting of the 11-inch diameter cage inside the 26-inch diameter cage was compared to single large cages or no protection at all. When the tomato plants in double cages grew too large for the available growing space, the inner plastic was removed leaving the cage to support the plant and fruit. The tests compared Early Tanana to three large-fruited greenhouse varieties, Fantastic, Delicious, and Early Girl.

Early Tanana produced 0.9, 2.0, and 2.7 pounds per plant of mostly green fruit at the no-protection, single-cage, and double-cage levels of environmental enhancement, respectively, used in 1979, while the large-fruited varieties averaged 0.5, 0.6, and 1.3 pounds of green fruit per plant, respectively.

Early Girl produced higher yields and more tomatoes than either Fantastic or Delicious. Early Girl produced nearly as many fruit as Early Tanana, and since the fruit were larger the yields were similar. While this new variety was included in the test only one year, it appears that Early Girl has some of the cold weather tolerance exhibited by Early Tanana, and might be a good large-fruited variety for home gardeners to use on a trial basis.

GENERAL OBSERVATIONS

The summer of 1977 was warm and sunny in the Matanuska Valley. Greenhouse varieties of tomatoes grown outside produced high yields and fruit size that could probably not be expected from more hardy small-fruited outdoor types. Additional protection from the elements did not increase yields significantly. Growing conditions were adequate.

The summers of 1978 and 1979 were more normal, and cooler cloudy weather prevailed. Marked differences in varieties were noted, and each level of treatment that added heat or protection increased plant growth and fruit production.

Some of the new varieties included in the test only one year showed considerable promise. Subarctic 25 and Manitoba both had larger fruit and good yields compared to Early Tanana. Early Girl showed more cold tolerance than Fantastic or Delicious and produced much better the year when included in the outside tests.

The variety grown always proved to be an important factor, but no single variety was best in every year. Since the kind of weather to be experienced in any particular summer cannot be predicted in advance, a grower might do well to use both large- and small-fruited varieties and provide as much microclimate improvement as possible. By using plastic-covered cages, many Alaskan gardeners will be able to grow fruits and vegetables outside that would otherwise require full greenhouse protection.□

Natural Revegetation of Dredge Tailings at Fox, Alaska

by

Kay W. Holmes*

INTRODUCTION

Large-scale, gold-dredging operations are now largely a part of Alaska's history and the giant gold dredges responsible for recovering over 7 million ounces of gold from interior Alaska's rich placer deposits lie abandoned, of interest only to historians and tourists. Other forms of land disturbance, however, including road and pipeline construction, logging, and the extraction of a variety of minerals and rock, continue to generate areas stripped of vegetation and, in many cases, of productive soils as well.

Between the years 1928 and 1964, active gold mining in the Goldstream Creek and Tanana River drainages resulted in the removal of vegetation and soils as well as the gold from large areas of land leaving behind elongated parallel mounds of coarse gravel tailings. Mined at a time when there was little concern for assisted revegetation, which involves any of a number of deliberate measures taken by man to promote the reestablishment of vegetation on a disturbed surface, these lands were left to nature to revegetate.

Information dealing with assisted revegetation in high latitudes is relatively scarce, largely because concern for environmental quality is only recent. Studies of natural succession in the far north have been the source of much of our information on revegetation in arctic and subarctic regions. Peterson and Peterson (1977) note that the oldest known attempts at assisted revegetation in these areas are less than 10 years old. In order to gain an understanding of ecological trends it is necessary to look at the natural revegetation on surfaces of known age. While accurate dating of disturbed land surfaces often proves to be the greatest obstacle in this pursuit, the dredge cleanup maps owned by the Alaska Gold Company documenting dates of mining made the Fox tailings ideal for successional studies.

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The primary objective of the study project was to determine what plants have recolonized the Fox dredge tailings without man's assistance and to assess the relative importance of each species present. A second objective was to determine if any vegetational patterns could be detected and related to readily measureable physical features of the tailing mounds such as dates of mining, mound orientation, slope, and percentage of fine particles mixed in with the coarser gravels. Knowledge of what factors most affect regrowth would help land managers decide what practices, implemented during and/or after mining, would be most apt to encourage successful plant invasion. We are optimistic that the findings from a broad-scoped study such as this will aid in more detailed ecological studies and facilitate assisted-revegetation programs in the future.

An abandoned dredge in Fox, Alaska, reminds us of a bygone era. The bare tailings in the foreground were deposited in 1959.

Figure 1: Nearly bare of vegetation except for some lichen growth, these tailings deposited in the 1930s support some birch saplings in the valleys between ridges.

Figure 2: An "intermediate" stand of birches, aspens, and balsam poplars of varying sizes. Clumps of mineral soil with abundant moss and lichen growth are evident in undulation furrows.

Figure 3: A "dense" stand with developing moss mat and tall fireweed and grasses in the understory.

Figure 4: Differences in surface topography are reflected in vegetation patterns. The undulation furrows generally support more growth than the ridge.

Figure 5: A number of birch trees are lined up in an undulation furrow.

METHODS

We selected the study area with the help of Dean Earl Beistline of the School of Mining and Mineral Engineering of the University of Alaska and Mr. Dan Eagan, vice president of the Alaska Gold Company. The study area is located near Fox, Alaska, about 10 miles north of Fairbanks. The site for intensive study was chosen because it was easily accessible by Fairbanks road systems, was under single ownership, and its tailings surfaces remained relatively undisturbed since dredging. Much of the rest of the mined area surrounding Fox has been subjected to other land uses.

After an initial reconnaissance of the area, it became apparent that in many instances, tailings of the same approximate age varied widely in the amount of plant growth each supported and that a direct and positive correlation between date mined and degree of growth seemed doubtful. For example, mounds deposited in 1930 and 1931 could be found that were still nearly bare of vegetation except for some lichen growth, while other mounds, mined the same time, supported dense stands of trees. In order to minimize further variation, we decided to restrict the intensive study to tailings of the same age.

Investigation of the vegetation on the various sites was conducted between June and October of 1979. Areas of relatively uniform vegetation were selected that represented an array of differing degrees of recolonization. The following descriptive factors were:

1. Relative amounts of crown or shoot cover of different kinds of plants, i.e. trees, tall shrubs, low shrubs, herbs, mosses and lichens.
2. Relative height and girth of tree and tall shrub species.
3. Physical features of the mound surface that were estimable such as the percentage of fine particles, average gravel size, etc.
4. Any physical features of the mounds as a whole such as: orientation and steepness of the mounds and whether the dredge deposited gravel while moving up- or downstream.

All but the most common species were collected and brought back for identification and verification. Hulten's *Flora of Alaska and Neighoring Territories* (1968) was used for identification of the vascular species. Crum's *Mosses of the Great Lakes Forest* (1976) and Dahl and Krogs' *Macrolichens of Denmark, Norway and Sweden* (1973) were the main sources used for identification of mosses and lichens, respectively.

Permanent plots were set up on a limited number of mounds so that vegetational changes could be followed over time. Certain vegetative features of these stands were mapped and information on plant size, vitality, and distribution were recorded. In addition to providing a permanent record, mapping furnishes the only practical method of securing reasonably precise quantitative data from a limited number of stands that were too small to be plot sampled at the tree and large shrub level. Soil samples were collected on these permanent plots and nutrient analyses were carried out by the Agricultural Experiment Station Soils Laboratory at Palmer. Data collected are currently being analyzed and we hope that additional patterns that may exist but were not detected in the field will emerge.

PRELIMINARY RESULTS

The vegetation present on the Fox tailings represents a wide range of natural recolonization from almost totally unsuccessful to stable productive mixed hardwoods forests. Though there exists a continuum of intermediates between these two extremes it is possible to divide the range of vegetation types into three broad categories for purposes of discussion.

BARE STANDS

As noted above, vegetation on the sites ranged from relatively little to dense. The barest sites had less than 25% total ground cover by woody species (Figure 1). The fines mixed in with the coarse surface gravel comprised about 5% on these sites; deficiency of fine particles was the only obvious reason for the failure of these sites to revegetate. Paper birch (*Betula papyrifera*) was the most common tree species, but it accounted for less than 2% cover. Most of the tree species were sapling sized; tree-sized individuals 10 ft. tall and 2 in. in diameter 4½ ft. above ground level were rare and widely scattered. Balsam poplar (*Populus balsamifera*) and quaking aspen (*Populus tremuloides*) saplings were present in lesser amounts. Willows (*Salix* spp.) accounted for 1 to about 5% ground cover. Other tall shrub species, frequent on the more developed sites, were absent or rare in these stands.

Bare gravel predominated in the ground cover and any accumulated litter was restricted to the furrows of the small secondary undulations which characterized the surface of the mound tops. Herbaceous plants were few to occasional and always accounted for less than 5% total ground cover. The most common herbaceous species present were: fireweed (*Epilobium angustifolium* and *E. latifolium*), hawksbeard (*Crepis elegans*), a shield fern (*Dryopteris fragrans*), and a crucifer (*Arabis Holboellii*).

The most abundant plants were the lichens of which *Stereocaulon* spp. was the most common and formed loose mats on bare rock as well as on pockets of exposed mineral soil. Though present with far less cover, species of *Umbilicaria* were as numerous as *Stereocaulon* spp. Several moss species were found in very low numbers and provided little cover.

INTERMEDIATE STANDS

These stands had greater than 25% cover by woody species but less than 50% cover by all species (Figure 2). Generally, the same tree species were present as in the sparsely covered stands, but in greater abundance, with relative cover percentages varying from stand to stand. Birch had the greatest abundance and cover in all of these stands. One or two white spruce (*Picea glauca*) saplings or seedlings were commonly found in these stands, though they were usually suppressed and stunted.

Tall willows and other tall shrubs, especially wild rose (*Rosa acicularis*), were also more abundant than in the bare stands. Low shrubs and herbs, while infrequent in the bare stands, were more common in these stands, though none had high cover values.

As with the vascular plants, the cover values for lichens and mosses were much higher; members of the lichen genus *Stereocaulon* accounted for up to 50% of the total ground cover.

Litter was a much more important component of the ground cover than it was in the barer stands. Discontinuous to sometimes nearly continuous layers of leaves were apparent in the undulation furrows of the surface. On gravel substrates such as these, the accumulated organic matter in the form of leaf litter provides the moisture essential to the growth of a number of understory low shrubs, herbs, mosses, and lichens.

DENSE STANDS

The sites with the heaviest growth (greater than 50% cover by woody species) had a much smaller percentage of exposed rock, and the fine-particle component of the gravel matrix averaged 30 to 50% of the total volume of solids (Figure 3).

Tree species present in the dense stands were the same as those growing on the other stands, though densities, average height, and average girth were substantially greater. Larger and more vigorous white spruce also appeared to occur more regularly in these more developed sites.

The composition of tall shrubs was also similar to those of the intermediate stands with increases in the occurrence of highbush cranberry (*Viburnum edule*), American red currant (*Ribes triste*), and rose. Increases in the abundance of Labrador-tea (*Ledum palustre* spp. *groenlandicum*), bearberry (*Arctostaphylos uva-ursi*), blueberry (*Vaccinium uliginosum*) and Lingonberry (*Vaccinium vitis-idaea*) characterized the low shrubs of these sites. Bluejoint reedgrass (*Calamagrostis canadensis*) and tall fireweed were the two most abundant herbaceous plants, together comprising up to 15% ground cover.

The greatest compositional changes seemed to occur in the moss and lichen flora. Members of the lichen genus *Stereocaulon* which were dominant as a ground cover in the intermediate stands were all but absent from these denser stands and *Peltigera* and *Cladonia* lichen species predominated. Feathermoss (*Hylocomium splendens*), rarely found on the more open sites, was a dominant moss species in these stands. This position of dominance was shared by members of the moss genus *Drepanocladus*, a genus well represented in the intermediate stands.

The nitrogen-fixing shrub, green alder (*Alnus crispa* spp. *crispa*), although present, did not play an important role in the revegetation of the Fox tailings as it has in other primary successional sequences, e.g., on glacial moraines, material sites, and interior Alaska riversides (Crocker and Major, 1955; Viereck, 1970; Neiland, 1978). On the Fox tailings, it attained high densities only in depressions between mounds that had plentiful mineral soil and along some of the mining haul roads. Nitrogen-fixing herbaceous legumes were similarly limited to these abandoned roads where fine particles were again a large component of the gravel-soil matrix. Those alders that were examined were found to be nodulated. Similar findings were reported by Errington (1975) in his study of the natural revegetation of abandoned mining sites and logging roads. Nonvascular nitrogen fixers, however, were widespread and common on the tailings including the lichens *Stereocaulon* spp. and *Peltigera* spp.

One trend that appeared consistent throughout the study area concerned the distribution of woody plants with respect to the minor surface undulations. The undulations provided sites of varying suitability which were often reflected in patterns of growth (Figure 4). Somewhat protected from the drying effects of wind and sun exposure, the more moist undulation furrows generally supported more tree and shrub growth than did the adjacent undulation ridges (Figure 5).

The larger and deeper ravines between tailings mounds generally supported dense willow and grass growth. In some locations these intermound low areas were up to 25 feet below the level of adjacent mound tops, often intersected the water table, and were more protected from sun and wind than the relatively shallow surface furrows. Although these sites were ideal for germination, temporary flooding, inadequate drainage and poor aeration after heavy summer rains made these sites generally unsuitable for good tree growth.

In summary, the major influence on natural revegetation success appears to be related to the percentage of fine particles in surface material. The larger the proportion of fine particles in the gravel-soil matrix, the greater the cover. Similar findings were shown in Meidinger's study (1979) of the natural revegetation of coal fields in British Columbia. Texture, or the particle size composition, of a soil strongly affects the moisture- and heat-holding capacity of a substrate, the ability of a substrate to retain and release mineral nutrients in a form available for plant uptake, and the amount of oxygen available to plant roots. The very coarse nature of the gravel substrate prevented determination of other soil characteristics that may have been limiting to plant growth.

The relationship of woody-plant densities to the surface topographic features as well as the increased vegetation on surfaces having a high fine-particle content suggest that moisture and moisutre-related conditions are probably the most important factors limiting recolonization. Further nutrient data analysis, however, may reveal nutritional deficiencies which may also be important in inhibiting plant establishment. Causes for the small-scale, mesotopographic patterns and the larger-scale, mound-to-mound variations may be impossible to pinpoint without extensive controlled experimentation.

CONCLUDING REMARKS

Extensive and limited intensive studies of the Fox tailings revealed a wide array of vegetational types in which vegetative cover was not consistently and positively correlated with age. The presence of 50-year-old tailings mounds with essentially no vegetation on them indicates that without assistance these areas may well remain barren for several hundreds of years. Other densely vegetated mounds of similar age supporting vigorous mixed hardwood forests indicate that man's assistance may not be requisite to successful revegetation in many instances. Findings such as these suggest the need for a variety of revegetation techniques selected according to the capabilities and location of the site, concentrating assistance on those areas of high value and nearest population centers and which have little potential for natural rehabilitation.□

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Techniques for Continuous and Improved Vegetable Harvests

The Effect of Plant Spacing, Transplanting and Direct Seeding

by

D. H. Dinkel,* P. J. Wagner,** and G. E. Matheke**

Many gardeners think that it is necessary to use large transplants in order for some crops to achieve maturity when, in fact, the growing season in southcentral and interior Alaska is sufficiently long to mature most of the cool-season vegetable crops seeded directly in the field early in the spring. Confusion also extends to the proper time to start seeding in order to obtain transplants of a size and age best suited to various production schemes. Older transplants may result in an earlier harvest, but yields are usually reduced.

Actually, there are many options available for growing cool-season crops and the desired time of harvest and yield per plant or unit area will determine the choice of a production scheme. The intent of this report is to present the results of numerous studies with cabbage, broccoli, cauliflower and lettuce which might assist growers in producing a more continuous harvest of products of a desired size.

Sometimes commercial growers as well as home gardeners wish to avoid a single large harvest during a short period of time. Most producers know that varying the crop variety can result in a spaced or planned continuous harvest. Also, in areas with a long growing season, direct seeding at various times to produce a spaced harvest is a common practice. The possibility of using the same variety with direct field seeding and transplants of different ages to space the harvest during our shorter growing season is not as well known.

Table 1: Weight per head and yield for cabbage grown at different spacings in rows spaced three feet apart in 1974.[1]

Variety	Spacing (in)	Size (lb/hd)	Yield (lb/100 ft^2)
Hybrid 15	8	2.73	136.5
Hybrid 15	12	3.36	112.0
Hybrid 15	15	5.09	135.0
Prime Pak	8	2.89	144.5
Prime Pak	12	3.67	122.4
Prime Pak	15	4.98	132.9
Stonehead	8	2.58	129.0
Stonehead	12	3.15	105.0
Stonehead	15	4.28	114.3

[1] 3-week old transplants were used.

Data for cabbage (Tables 1 and 2) show the effect of various plant spacings on head size and yield per unit area. It is clear that if a smaller head of cabbage is desired it can be obtained by closer spacing without a reduction in total yield using either direct field seeding or 3- to 4-week old transplants. Yield per unit area in most cases is greater at the closer spacing. A 5-pound head of cabbage produced by the 15- or 16-inch spacing may be nice if one is making sauerkraut or cole slaw for a large picnic but the 2- to 3-pound head produced by the 8-inch spacing is more desirable for the average family and therefore more marketable by the grocer. On the other hand, if the grower is trying to produce a large cabbage to exhibit in the large-cabbage division at the local fair, it is desirable to leave ample growing space. Data from these studies do not show much affect of spacing on maturity although it is generally accepted that relatively wide spacing promotes a slight earliness as well as a greater yield per plant.

Table 2: Weight per head and yield of cabbage grown at different spacings with transplants vs. direct field seeding in 1975.

Crop Variety	Treatment	Spacing (in)	Size (lb/hd)	Yield (lb/100 ft^2)
Hybrid 15	Transplant	8	2.75	137.5
Hybrid 15	Transplant	12	3.39	113.0
Hybrid 15	Transplant	16	5.00	125.0
Hybrid 15	Seeded	8	2.66	133.0
Hybrid 15	Seeded	12	3.04	101.4
Hybrid 15	Seeded	16	3.33	83.3
Tastie	Transplant	8	1.83	91.5
Tastie	Transplant	12	2.66	88.7
Tastie	Transplant	16	2.83	70.8
Tastie	Seeded	8	2.02	101.0
Tastie	Seeded	12	2.22	74.0
Tastie	Seeded	16	2.46	61.5
Earlianna	Transplant	8	1.15	57.5
Earlianna	Transplant	12	1.59	53.0
Earlianna	Transplant	16	2.31	57.8
Earlianna	Seeded	8	.96	48.0
Earlianna	Seeded	12	1.03	34.3
Earlianna	Seeded	16	1.39	34.8

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Figure 1: Delira variety cauliflower grown from young 3-4 week old transplants that have not been subject to severe environmental stress.

Figure 2: Mark Dinkel with his 68 lb prize winning O-S cross cabbage which was grown by using the correct variety and maintaining a consistent and near optimum growth system.

Table 3: Size of transplants vs. field seeding on yield and weight of harvest for Green Duke broccoli and Snow Crown cauliflower[1]

Crop	Treatment	Wt. of Terminal Head/Plant (lb)	Total Wt. Terminals & Laterals (lb)	Average Harvest Date
Broccoli:				
Green Duke	Seeded	2.60	3.45	August 12
Green Duke	3-wk transplant	1.09	1.97	July 26
Green Duke	6-wk transplant	.62	1.30	July 16
Cauliflower:				
Snow Crown	Seeded	—[2]	—[3]	—
Snow Crown	3-wk transplant	1.42	—	July 26
Snow Crown	6-wk transplant	1.36	—	July 18

[1] Transplants and direct field seeding done May 21, 1975. All crops grown at 15 inch spacing.
[2] Comparable stand not obtained with field seeded cauliflower.
[3] Not applicable.

The time needed to attain a harvestable size is greatly affected by the use of seedlings or transplants of different ages. Data from studies with broccoli comparing the age of transplants with direct field seeding and with cauliflower comparing only the age of transplants are presented in Table 3. These data are typical for most cool-season vegetables that can be grown by direct seeding or by the use of a transplant. In general, older transplants will mature earlier, while younger transplants will produce a larger yield per plant. If transplants are too old they may fail to produce usable heads. When seed is used to establish plants in the field, maturity is almost always later but in many cases these plants produce the highest yield. Broccoli which is direct field seeded almost always produces the highest yield when compared to transplants if cultural conditions are near optimum.

Table 4 compares yields produced by direct seeding and the use of a 3-week old transplant for a number of crops on heated and unheated soils. Soils were heated using cooling water from an electrical power generation facility at Fort Wainwright. In the warmer soils, the yield of some of the seeded crops in the tests exceeded the yield of the transplants, which suggests that if conditions are more nearly optimum for emergence and growth, the grower can expect the greatest yield from direct-seeded plants although they will mature later. This is consistent with the accepted principle that any growth scheme which does not cause a period of reduced growth will result in the greatest total yield. Although it is difficult for the grower to completely eliminate nutritional and environmental stress even on direct-seeded plants, these stresses are far more severe on transplants which inevitably are subject to at least some transplanting shock.

In summary, it is possible to use ones favorite crop variety, to spread the harvest by using transplants of different ages, and to control the size by spacing appropriately. For a very early yield a few plants can be grown from transplants 6 to 8 weeks old. A main crop for processing or market can be grown from seed or young transplants and this will produce the highest yield although it will mature later. Smaller heads or terminals can be produced by using closer spacing without reducing the total yield per unit area. In fact, the total yield will probably exceed that from plants with wider spacing if sufficient nutrients and moisture are available.□

Table 4: Weight of cabbage, broccoli, cauliflower and lettuce crops grown on heated[1] and unheated soil from transplants or direct seeding, 1979.

Crop	Treatment	Size (lb/hd) Heated	Unheated
Broccoli			
Green Duke	Seeded	.58	.89
Green Duke	Transplants	.46	.32
Green Dwarf	Seeded	.82	.37
Green Dwarf	Transplants	.59	.50
Cabbage			
Tastie	Seeded	3.56	2.89
Tastie	Transplants	3.25	4.67
Hybrid 15	Seeded	4.03	2.82
Hybrid 15	Transplants	5.59	4.78
Cauliflower			
Snow Crown	Seeded	1.51	1.55
Snow Crown	Transplants	1.90	2.61
Super Snowball	Seeded	1.76	1.62
Super Snowball	Transplants	2.10	2.65
Lettuce			
Minilake	Seeded	1.65	1.32
Minilake	Transplants	1.48	1.48
Ithaca	Seeded	1.44	2.18
Ithaca	Transplants	1.91	1.67
Ostinata	Seeded	.69	.60
Ostinata	Transplants	.68	.88

[1] The soil was heated by using the rejected cooling water from an electrical power generation facility. Soil temperature at the 6" depth was increased 10 to 20 degrees in the heated plot during the growing season.

Figure 3: Closely spaced Hybrid 15 cabbage plants produce small marketable heads.

Figure 4: A well grown Green Duke broccoli plant using a young transplant properly hardened to reduce transplant shock.

Optimum Herd Structure in Alaska Reindeer Herds

by

Edward L. Arobio*

The question of herd structure should be of major concern to a reindeer herd owner if he wishes to obtain the highest return in meeting the objectives he has set for his herd. The structure, or number of male and female reindeer of differing ages, of the herd will change with alternative objectives. Though it is generally held by economists that individuals strive to maximize net income from an economic activity, it may well be that reindeer herd owners have modified objectives. For example, a herd owner may wish to maximize net revenues subject to a minimum level of meat production or herd growth, even though these objectives may provide less than maximum net income. Research now being conducted at the Agricultural Experiment Station, University of Alaska, Fairbanks is directed at determining optimum herd structure, and we have obtained some preliminary results and defined our future research plans.

At the present time there are approximately 25,000 reindeer in 18 domestic herds within the state (McNicholas, 1980). These reindeer herds are owned by 14 individuals, three villages, and one Native regional corporation. Herds range in size

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Reindeer being herded from a large holding area into smaller pockets for vaccinating, tallying, and antler harvest.

from less than 500 to over 7,000 reindeer; however, the majority of herds number between 500 and 2,000 animals. Approximately 17,700, or 71 percent, of the reindeer located in Alaska are on the Seward and Baldwin Peninsulas.

Until recently, reindeer herding has been conducted partially on a subsistence, partially on a cash basis (Arobio, 1979). Typically, herds have been oriented to the production of meat and hides for village use. They have been extensively managed and generally provided small returns. A few herds have been large enough to sell meat to stores and individuals in Nome and Kotzebue, and at times outside of the region.

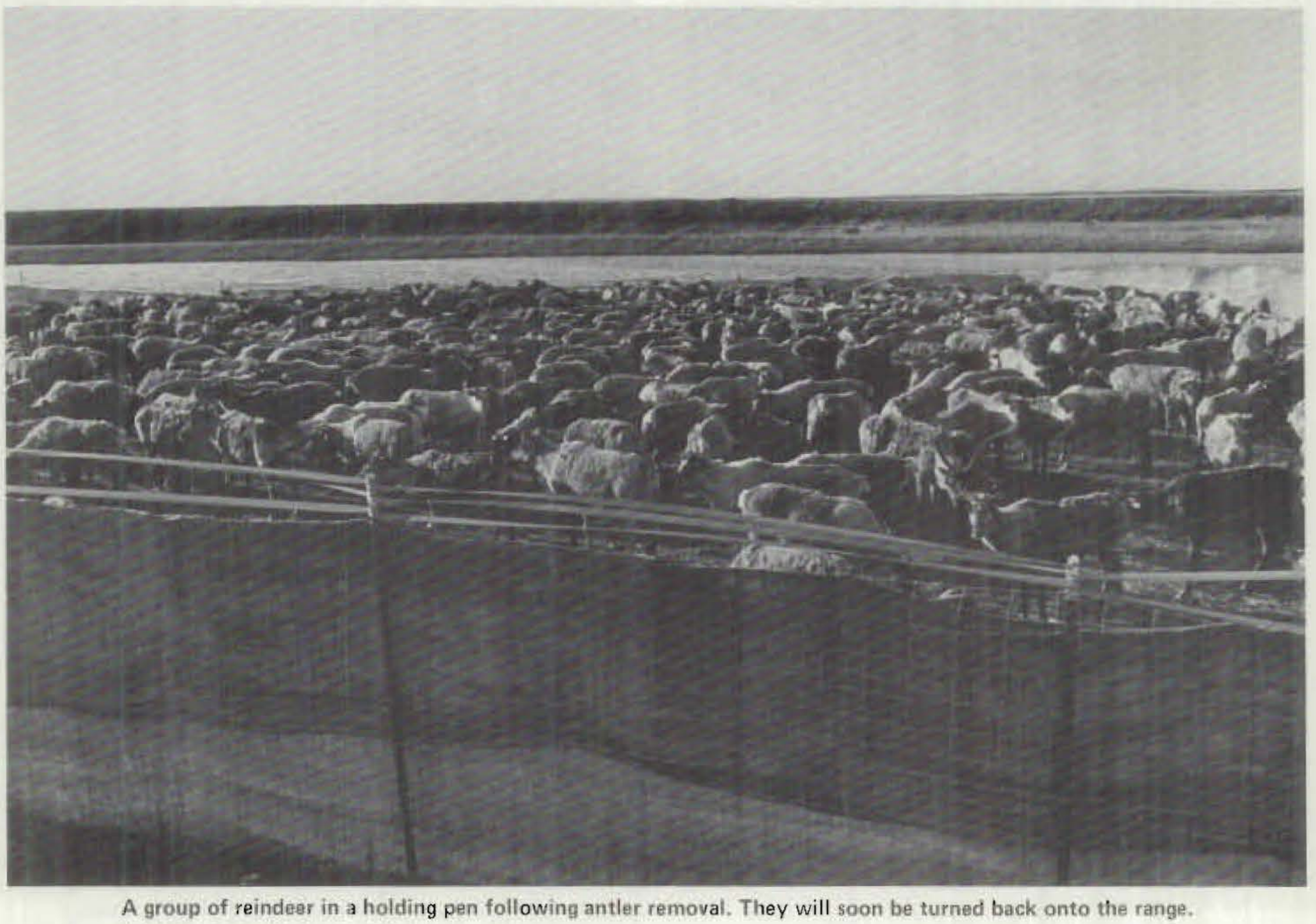
Recently, the increase in price of another reindeer product, velvet antler, has increased the production possibilities and economic potential of the industry. Reindeer velvet antler is harvested in June and early July and is purchased by buyers who sell the antlers in the Orient, principally to South Korea . While herd owners have been harvesting and selling reindeer velvet antlers since the mid-1960s, only recently has price increased to a point which establishes velvet antler as a major product. As late as 1969, velvet antler was being purchased from herd owners at \$2.20 per kilogram (Arobio, 1979), but in 1977, the majority of herd owners received \$17.60 per kilogram. Average prices received for velvet antler in 1979 have been reported at between \$66 and \$88 per kilogram (McNicholas, 1980).

Reindeer herd owners, because of the addition of velvet antler as a major reindeer product, now have two major choices of which to emphasize production. Emphasizing the production of one will lead to a decrease in the other. Bull antlers are generally larger than cow or steer antlers and a herd structured to maximize antler production will be different from one maximizing meat production. The former will have more bulls of older ages than one oriented to meat production. Though meat will still be produced, it will be much less than that produced by a traditional herd, the structure of which was based on meat harvest. The typical meat-producing reindeer in Alaska is a steer two years of age and older.

Instead of emphasizing one product at the exclusion of another, herders have the option of a compromise situation in which some meat or antler production is given up in return for more of the other. In another production alternative, it has been suggested that where maximum meat production is desired, calf slaughter would provide more meat than current steer production.

Herd owners thus need to determine the types and quantities of reindeer to produce for slaughter and antler production as well as defining the overwintering structure of their herds. Each reindeer of a particular age and sex and kept either in the breeding herd or slaughtered can be thought of as a separate production activity. Reindeer herd owners are faced with the possibility of many production activity options and must answer the question of how many they should have of each.

This question would be relatively easy to answer if the herd owner were not bound by a limited supply of production inputs, i.e. land, labor, and capital, which limit total production as well as production of an individual activity. As several production options coexist with several resource or other constraints which limit the maximum level of each reindeer production activity, simple budgeting tech-



A group of reindeer in a holding pen following antler removal. They will soon be turned back onto the range.

niques may be insufficient to determine the best course of action for the herd owner. More sophisticated techniques may provide better answers.

The first research that looked at optimum herd structure for Alaskan reindeer herds was done by Luick (1978). He calculated the optimum precalving herd for four production options: (1) antler production, (2) fat-steer production. (3) calf production, and, (4) long yearling production. Results of the study suggested that reindeer herds had significant economic potential that was not being realized by herd owners under current herd composition. Study limitations included exclusion of economic restrictions, e.g., capital, labor, machinery, etc., which might constrain a production alternative, the estimation of gross returns instead of net returns, and the inability to look at combinations of production alternatives.

Agricultural economists at the Fairbanks Research Center have used a mathematical technique called linear programming to estimate optimum precalving herd structure and annual slaughter and antler harvest schedules. This technique takes into consideration economic, resource, and managerial constraints to production and estimates net revenue for the annual operation. Because of the large number of equations to be solved simultaneously, special mathematical techniques have been developed to solve these problems. A common method is to use computers to find a solution using an iterative technique called the simplex procedure.

As one step in the improved management of reindeer herds, this reindeer belonging to the NANA Regional Corporation is being vaccinated for internal parasites.

The product of summer antler harvesting. These velvet antlers will be frozen and shipped to San Francisco for drying. They will then be sold in the Orient, primarily in South Korea.

The general linear programming model works in the following manner. First, an objective function is developed to estimate the annual net return per unit (gross revenues per unit of activity minus variable production costs per unit of activity) for each production activity. The objective function for the reindeer linear programming model includes production activities which we have divided into two groups: producing activities and selling activities. Producing activities involve reindeer which overwinter and provide replacements for animals slaughtered, and are comprised of calves, one-year-old males and females, two-year-old males and females, three-year-old males, cows (females ages three and older), four-year-old males, and bulls (males five years of age and older). Selling activities are groups of reindeer which are slaughtered annually. The model allows for the slaughter of six groups of reindeer. These are: (1) male calves, (2) female calves, (3) one-year-old males, (4) four-year-old steers, (5) bulls, and (6) cows. The objective function values for the producing activities are differences between annual revenues received per reindeer from harvesting of velvet antler and annual variable production costs per head for animals continuing in the herd. Negative values for some cohort groups implies either nonproduction of velvet antler or insufficient antler revenue to cover herd-production costs. The values for selling activities are revenues received from each slaughtered animal from the sale of carcass meat and velvet antler minus the per-animal variable production costs. Slaughtering is an additional expense associated with selling activities which are not a part of the production costs for producing activities.

The objective function is maximized subject to a series of linear restraints. These restraints can be of three types: (1) resource or input restrictions, i.e. limited quantities of land, labor, and capital; (2) external restrictions, i.e. government grazing limitations; and (3) subjective restrictions—restrictions imposed by the operator on himself, for example, requiring a certain level of one activity although doing so limits another activity which may produce greater returns.

Restrictions to the reindeer linear programming model are of five types: (1) grazing, (2) labor , (3) maintenance of a minimum bull/cow ratio, (4) transfer constraints, and (5) cull requirements. In this model it is assumed that the end-of-winter grazing of reindeer is limited to 1000, 2000, or 3000 animals. The labor constraint assumes that each reindeer takes .5 hours to slaughter. One thousand total man hours of slaughtering labor are available. The minimum bull:cow ratio is set at a minimum of 1:10. There is no restriction, however, on bulls in a ratio greater than 1:10.

The next set of constraints are livestock transfers. Based on the optimum number and types of reindeer to be slaughtered, these constraints provide replacements for all slaughtered animals. This is done by requiring enough cows to be in the herd in order to produce replacements that eventually will reach slaughter age. These constraints specifically account for the mortality that will take place within cohort groups and the calving percentage of cows. The final restrictions provide for culling cows and bulls over ten years of age.

Three classes of information are needed to make the model operational: (1) production costs, (2) reindeer product prices, and (3) production parameters. Although the model assumes these are known with certainty, it should be noted that often data for Alaskan reindeer herds are not available and rough estimates must be made to facilitate the model's construction.

Production costs are for 1977 and are described in a report by Stern et al. (1977). The model reindeer herds produce two products: carcass reindeer meat and velvet antler. The prices most commonly received for these products in 1977 are used in the model (Stern et al., 1977). Production costs and output prices are provided in Table 1. There are three production parameters with which we are concerned: (1) calving percentage of cows, (2) herd mortality, and (3) carcass and antler weights of cohort groups (Luick, 1978, 1979). These data are presented in Table 2.

Solutions to the basic model are presented in Table 3. Solutions are provided for three end-of-winter herd sizes: 1,000, 2,000, and 3,000 reindeer. Results are given assuming either a low or a high rate of mortality. The initial solution (maximization of net returns) might be termed the antler/meat solution. Because of the value of velvet antlers, herds are oriented to the production of bulls. Since bulls have the heaviest antlers, the model maximizes the number of bulls in the herd subject to requirements for maintaining herd size and culling older bulls. This is

Table 1. Per-Reindeer Production Costs Incurred and Product Prices Received by Herders for Model Reindeer Herds, 1977.

	Annual Per-Reindeer Production Costs ($)		Prices Received for Carcass Meat and Velvet Antler ($)	
Herd Size (Head)	Cost (No Slaughter)	Cost (Slaughter)	Carcass Meat (per kg)	Velvet Antler (per kg)
1,000	15	16	1.87	17.60
2,000	14	16	1.87	17.60
3,000	10	12	1.87	17.60

SOURCE: R. O. Stern et al., 1977.

Table 2. Production Parameters for Model Reindeer Herds

	Calving Percentage[a]	
	68	
	Annual Herd Mortality (%)	
	Low Mortality	High Mortality
Calves	10	20
1-year old	5	10
2-year old	2	4
Adult	1	2
	Carcass and Wet Velvet Antler Weights	
	Carcass Weight (kg)	Antler Weight (kg)
FEMALES		
Calf	18.18	0
1-year old	27.27	.45
2-year old	31.81	.90
Adult	43.18	1.36
MALES		
Calf	18.18	0
1-year old	31.81	.90
2-year old	43.18	2.27
3-year old	54.54	3.63
4-year and older	54.54	4.54
STEERS		
4-year old	63.63	2.27

[a]This calving percentage is for summer handlings which take place approximately 1 July.
SOURCE: J. R. Luick, 1978, 1979.

Table 3. Herd Structure and Sales: Herds of 1,000, 2,000, and 3,000 Reindeer (Antler/Meat Production)

Herd Structure	1,000 Reindeer[a]		2,000 Reindeer[a]		3,000 Reindeer[a]	
	Low Mortality	High Mortality	Low Mortality	High Mortality	Low Mortality	High Mortality
End-of-Winter Herd						
Male Calf	71.4	79.5	142.9	159.0	214.3	238.5
Female Calf	71.4	79.5	142.9	159.0	214.3	238.5
1-Year Male	64.3	63.6	128.6	127.2	192.9	190.8
1-Year Female	29.3	35.1	58.6	70.3	88.0	105.5
2-Year Male	61.0	57.2	122.1	114.5	183.2	171.7
2-Year Female	27.8	31.6	55.7	63.3	83.6	95.0
3-Year Male	59.8	54.9	119.7	109.9	179.6	164.8
4-Year Male	59.2	53.8	118.5	107.7	177.8	161.5
Bulls	345.1	310.5	690.3	621.0	1,035.5	931.5
Cows	210.1	233.8	420.3	467.7	630.4	701.6
Total Head on Hand	999.4	999.5	1,999.6	1,999.6	2,999.0	2,999.4
Animals Slaughtered[b]						
Male Calf						
Female Calf	34.9	28.4	69.9	56.8	104.8	85.2
1-Year Male						
4-Year Steer						
Bulls	58.6	52.7	117.3	105.5	176.0	158.3
Cows	27.3	30.4	54.6	60.8	81.9	91.2
Total Slaughtered	120.8	111.5	241.8	223.1	362.7	334.7
Value of Objective Function	$30,033.40	$27,088.10	$62,066.80	$56,176.30	$106,552.00	$97,603.80

NOTE: The lack of proportionality when comparing objective function values in this table is due to different production cost coefficients (see Table 2) for each of the three herd sizes.
[a]Herd limit at end of winter.
[b]All slaughter takes place in November.

Table 4. Herd Structure and Sales: Herds of 1,000, 2,000, and 3,000 Reindeer (Steer Production)

Herd Structure	1,000 Reindeer[a]		2,000 Reindeer[a]		3,000 Reindeer[a]	
	Low Mortality	High Mortality	Low Mortality	High Mortality	Low Mortality	High Mortality
End-of-Winter Herd						
Male Calf	103.8	110.8	207.6	221.7	311.4	332.6
Female Calf	103.8	110.8	207.6	221.7	311.4	332.6
1-Year Male	93.4	88.7	186.8	177.4	280.2	266.1
1-Year Female	93.4	88.7	186.8	177.4	280.2	266.1
2-Year Male	88.7	79.8	177.5	159.6	266.2	239.5
2-Year Female	88.7	79.8	177.5	159.6	266.2	239.5
3-Year Male	86.9	76.6	173.9	153.3	260.9	229.9
4-Year Male	5.2	5.6	10.4	11.3	15.7	16.9
Bulls	30.5	32.6	61.0	65.2	91.5	97.8
Cows	305.3	326.1	610.6	652.3	915.9	978.4
Total Head on Hand	999.7	999.5	1,999.7	1,999.5	2,999.6	2,999.4
Animals Slaughtered[b]						
Male Calf						
Female Calf						
1-Year Male						
4-Year Steer	80.8	69.4	161.7	138.9	242.5	208.3
Bulls	5.1	5.5	10.3	11.0	15.5	16.6
Cows	86.9	76.6	173.9	153.3	260.9	229.9
Total Slaughtered	172.8	151.5	345.9	303.2	518.9	454.8

[a]Herd limit at end of winter.
[b]All slaughter takes place in November.

reflected in the large number of bulls that are kept in the overwintering herd. Annual meat production involves the slaughter of excess females, calves, and cull cows.

The value of the objective function (bottom of Table 3) is an estimate of net returns over variable costs associated with this production option. Fixed costs are not included and need to be subtracted to determine net income to the firm. Because of difficulties of estimating costs and returns for Alaskan reindeer herds, the value of the objective function is probably biased upward. Results are therefore more useful in determining optimum herd structures.

In a second analysis (Table 4) maximum meat production is examined. This is done by arbitrarily lowering velvet-antler prices. Note particularly the change in end-of-winter herd structure and annual slaughter. The number of cows in the herds increases while the number of bulls decreases drastically. Annual meat production was from steers and cows. Calves were not slaughtered although this has often been suggested as the method by which meat production can be maximized. With the animal carcass weights we have used, the increased number of calves does not overcome the larger adult carcass weights. However, the reindeer carcass weights used here are estimates of field weights only and further data collection could change the implied advantage of adults over calves.

Nevertheless, in order to determine herd structure under a program of calf-meat production, a computer run was made to force calf slaughter into the solution. This is done by raising meat prices for calves (Table 5). Again, note how end-of-winter herd structure and annual slaughter have changed. This situation requires the largest number of cows in the herds and only enough animals are kept in age classes beyond calves to replace culled cows and bulls.

Table 5. Herd Structure and Sales: Herds of 1,000, 2,000, and 3,000 Reindeer (Calf Production)

Herd Structure	1,000 Reindeer[a]		2,000 Reindeer[a]		3,000 Reindeer[a]	
	Low Mortality	High Mortality	Low Mortality	High Mortality	Low Mortality	High Mortality
End-of-Winter Herd						
Male Calf	160.1	158.8	320.2	317.7	480.4	476.6
Female Calf	160.1	158.8	320.2	317.7	480.4	476.6
1-Year Male	8.7	9.5	17.5	19.1	26.3	28.7
1-Year Female	65.7	70.3	131.5	140.6	197.3	210.9
2-Year Male	8.3	8.6	16.6	17.2	25.0	25.8
2-Year Female	62.4	63.2	124.9	126.5	187.4	189.8
3-Year Male	8.1	8.2	16.3	16.5	24.5	24.8
4-Year Male	8.0	8.1	16.1	16.2	24.2	24.3
Bulls	47.1	46.7	94.2	93.4	141.3	140.1
Cows	471.0	467.3	942.0	934.6	1,413.0	1,401.9
Total Head on Hand	999.5	999.5	1,999.5	1,999.5	2,999.8	2,999.5
Animals Slaughtered[b]						
Male Calf	135.3	117.5	270.7	235.0	406.0	352.6
Female Calf	78.3	56.7	156.7	113.5	235.0	170.3
1-Year Male						
4-Year Steer						
Bulls	8.0	7.9	16.0	15.8	24.0	23.8
Cows	61.2	60.7	122.4	121.5	183.6	182.2
Total Slaughtered	282.8	242.8	565.8	485.8	848.6	728.9

[a]Herd limit at end of winter.
[b]All slaughter takes place in November.

Because we have noted several problems and limitations of this linear programming model of Alaskan reindeer herds, our immediate plans are to update and improve the model. The present model may be too simple to represent adequately an Alaskan reindeer herd. However, the model can be improved easily. First the objective function can be expanded providing the herd owner with additional options in herd structure that could be considered for individual herd management objectives. Additional activities that could be added include the sale and purchase of live reindeer and the slaughter of reindeer of cohort groups other than those now included. Better estimates of carcass and velvet antler weights need to be incorporated. In addition, because velvet antler is not always of uniform quality, and since antler of differing grades sells for significantly different prices, inclusion of expected harvests of antler of various grades into the objective function is essential. Finally, the objective function can be improved with better estimates of production costs.

Improvements in the specification of constraints of the model are also needed. These include better data on calving percentages, improved estimates of annual mortality of all cohort groups (particularly calf mortality associated with summer antler harvesting), and modifications in land-ownership patterns or use designations. In addition, per-activity labor requirements for herding and handling and the management needs of alternative production activities should be included in the model. Unfortunately, for this paper, we were only able to make estimates of required slaughter labor. Next, seasonal forage requirements of reindeer should be a restriction to the model. This, along with estimates of available seasonal forage, should limit some activities. Also needed are reliable estimates of machinery and capital requirements of alternative activities. Finally, it would be useful to include measurable cultural conditions that may limit any of the model's activities.

These results should provide information that is useful to reindeer-herd owners in the management of their herds. They are useful in providing general directions under which herd owners might structure their herds but are not intended to be specific answers, primarily because of the limitations of the research noted previously. More importantly, however, these results cannot provide specific answers because each herd owner is subject to a unique set of problems and conditions which will never exactly match the situation assumed in the models.☐

Editor's Note: This article is largely a summarization of a technical paper by E. L. Arobio, W. C. Thomas, W. G. Workman, all of the Agricultural Experiment Station, entitled "Mathematical Programming for Considering Management Options in Alaska Reindeer Herding" and presented at the Second International Reindeer/Caribou Symposium held in Roros, Norway, September 17-21, 1979. For more information on linear programming as well as a more detailed description of the reindeer linear programming model the reader is referred to Arobio, et al., 1979; Agrawal and Heady, 1972; and Beneke and Winterboer, 1973. Photos by J. Stephen Lay, UAF Public Affairs.

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Plant Diseases – Potential Threat to Delta Barley

by

Jenifer Huang McBeath*

The Delta agricultural project is the first large-scale agriculture program sponsored by the state of Alaska. The purpose of this project is to develop a latent renewable resource into a productive economic and social activity that will strengthen Alaska's economy through diversification and reduce the cyclical, boom-bust nature of economic change. In the 1980 season, over 11,000 acres of the 60,000 acres of land sold in 1978 were in full production (Alaska Agricultural Action Council, 1980).

During the planning stage of the Delta agricultural project, great attention was paid to its economic feasibility and to agronomic aspects (Lewis et al., 1979; Lewis and Wooding, 1978). Questions such as the possible markets for the products and the cost of production and transportation were carefully considered. Many early-ripening varieties of crops were tested for their adaptability and productivity in the Alaskan environment. Disease problems were not taken into consideration at this stage. Both barley and rapeseed were recommended as crops suitable for cultivation in the Delta-Clearwater area (Alaska Agricultural Action Council, 1980). For several reasons barley remains the predominant crop in the Delta area—barley varieties mature earlier, they are easier to grow and easier to harvest, and farmers are more familiar with the crop.

Barley has been cultivated in the Delta Junction area since the 1950s. As a crop, barley is well established in this area. Unfortunately, many barley diseases have also become established in this environment. In the disease survey conducted in the 1979 and 1980 season, barley stripe and barley scald were found to be the most common disease in the Delta-Clearwater area (McBeath, 1980; Wooding and McBeath, 1979). Loose smut, barley spot blotch, net blotch and barley yellow dwarf virus disease are also common but to a lesser degree.

Barley Stripe

Barley stripe disease is caused by the fungus *Helminthosporium gramineum* (Dickson, 1956; Lenkel and Tapke, 1955; Shertleff and Bever, 1973). This disease is spread mainly by contaminated seeds. During seed germination, the stripe fungus in the contaminated seed grows and in-

Figure 1: A barley leaf blade displaying the tan-brown stripe characteristics of the disease.

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Figure 2: Erect, empty heads (caused by barley stripe infection) scattered among healthy barley plants.

vades the tissues of young barley seedlings. Seedlings infected with barley stripe display narrow, yellow to light tan stripes on the blade and sheath of a leaf (Figure 1). These stripes are parallel to each other and extend the entire length of the blade. As the tissues grow older, the stripes turn dark brown in color. Splits often develop in the center and along the length of the stripes which give the leaf a shredded appearance. Barley stripe is a systemic disease; the growth of stripe fungus follows closely the growth of the diseased plant. Therefore, it is quite common to see a stripe-infected plant displaying yellow striping on the new leaves and dark brown striping on the older leaves.

Although spores (seed-like structures) are being produced continuously by this fungus during the growing season, barley stripe disease does not spread from one plant to another. At the time of flowering, when moisture is available, spores blown by wind to the head of healthy plants will germinate and infect the seeds. Stripe fungus over-winters in the seeds, however, it does no harm to the dormant seeds. Only when these contaminated seeds are sown in the next growing season, does the fungus become active and start the disease cycle again. *H. gramineum* can survive a long time in the contaminated seeds—there are reports of stripe fungus found to be still viable in the seeds after 5 years in storage (Nyvall, 1979). Losses caused by this disease are due to stripe-infected

Figure 3: New and old lesions caused by barley scald fungus.

Figure 4: Smutted heads of barley.

plants' producing empty heads (Figure 2) or sometimes failing to head altogether, and therefore no grain is produced. Barley stripe disease spreads most easily in cool and humid weather (Teviotdale and Hale, 1976).

Barley Scald

Barley scald is also a fungus disease; it is caused by *Rhynchosporium secalis* (Dickson, 1955; Lenkel and Tapke, 1955; Nyvall, 1979). Even though contaminated seeds, voluntary barley, and other hosts such as rye and bromegrass can all serve as a source of this disease, the major source is infected plant debris in the field. Barley scald fungus overwinters on crop residues. In the spring, under cool, humid conditions, *R. secalis* in the debris produces numerous spores which are blown by wind or splashed by rain onto healthy seedlings. These fungus spores then germinate and invade the healthy barley tissues, which results in the formation of large

Figure 5: Dark brown lesions with well-defined margin on barley leaves, the result of spot blotch infection.

Figure 6: Light brown lesions, caused by net blotch, on barley.

lesions on the leaves and sheath of the plant. Lesions caused by barley scald are oval or diamond shaped. Young lesions have a water-soaked appearance and are a bluish-green in color. As the disease progresses, the color of the lesions turns to brown and eventually to bleached straw, bordered by a brown margin (Figure 3). When moisture is available, scald fungus at these lesions (both new and old) also produces spores which will become new sources of this disease. In Delta, it is quite common to see barley scald spreading rapidly in the field after a few rains. When infection is heavy, photosynthesis of barley plants decreases drastically. Moreover, the scald fungus causes a further reduction in yield by the continued drawing of already impoverished nutrients from the reserve.

Loose Smut

Loose smut is caused by the fungus *Ustilago nuda*. This is a seed-borne disease

Figure 7: A yellow dwarf virus infected barley plant compared to a healthy plant at the same stage of development.

(Dickson, 1955; Lenkel and Tapke, 1955; Nyvall, 1979; Shurtleff, 1974). When seeds are in storage, loose smut fungus located in the embryo of these seeds remains dormant. Infected seeds do not show any outward symptoms, and germination is not affected. Loose smut is a systemic disease. Leaves of the smutted plant are a darker green with yellowish streaks and are more erect than healthy leaves. Generally these plants are well developed and compete vigorously for available moisture and nutrients in soil. Since these plants produce no grain and deprive other plants of nutrients, there is a double loss in terms of potential yield from the field. The smutted spikes emerge from the boot slightly earlier than the spikes on healthy plants. Spore masses instead of kernels are enclosed in fragile white membranes which soon rupture (Figure 4). The brown to dark-brown dusty spores are blown by wind over the field while the healthy plants are flowering. Spores of *U. nuda* which lodge in the susceptible barley flowers germinate when weather is cool and humid and infect the kernels. Loose smut fungus becomes dormant in the maturing seed and its development in the infected seed resumes with the germination and growth of the seedlings.

Spot Blotch

Spot blotch is caused by the fungus *Helminthosproium sativus* (Dickson, 1955; Lenkel and Tapke, 1955; Nyvall, 1979; Shurtleff and Bever, 1973). Both contaminated seeds and crop residue can serve as sources of this disease. Unlike barley stripe and barley scald, barley spot blotch prefers warmer environments. In dry, warm soil, spot blotch in the contaminated seeds frequently causes seedling blight, crown rot, and root rot. Since the weather in Delta is cool, spot blotch merely causes leaf symptoms. On leaves, spot blotch appears as dark brown lesions with well-defined margins (Figure 5). The size and shape of these lesions vary, and sometimes they coalesce to form large, dry blotches. Older lesions are olive colored. When moisture is available, *H. sativus* produces large numbers of spores which is then carried by wind to other parts of the plant or to other plants to start a new infection cycle. In Delta, losses caused by this disease are minimal.

Net Blotch

Net blotch is caused by the fungus *Helminthosporium teres* (Dickson, 1955; Lenkel and Tapke, 1955; Nyvall, 1979; Shurtleff and Bever, 1973). This fungus over-winters in seeds and infected barley residue. *H. teres* also thrives in cool and humid weather. When environmental conditions are favorable, spores are produced in abundance in the spring from contaminated seeds and from infected crop residue. These spores are borne by wind to healthy seedlings where they start the infection. New infections occur so long as the weather remains cool and moist. In the Delta area, the symptomatic display of net blotch is quite similar to spot blotch except lesions caused by net blotch do not have definite margins (Figure 6). Sometimes, faint, dark brown, net-like patterns can be detected in these blotches. Net blotch on barley became more common in the 1980 season. Although crop losses caused by this disease are now minimal, there is no guarantee they will remain so in the future.

Barley Yellow Dwarf Virus Disease

Barley yellow dwarf virus disease (BYDV) is the only virus disease of barley found so far in the Delta area (McBeath, 1980). BYDV is transmitted by aphids (Herbert and Well, 1977). When an aphid feeds on a diseased plant, it becomes a carrier of this disease. Later, as the aphid feeds on healthy barley, BYDV particles are infected into the plant through the mouthpiece of the aphid. BYDV multiples in barley cells, causing the disease. BYDV also thrives in cool weather.

When BYDV infection occurs at an early stage of plant development, barley plants develop excessive amounts of tillers and are extremely stunted. The leaves show striking yellowish green blotches (Figure 7). Root development of these plants is very poor and limited, and no spikes may emerge. When BYDV infections occur at the later stage of barley development, they cause leaf-yellowing symptoms, limited spike development, and reduced kernel formation and filling, all of which result in reduction in yield. At present, yield loss due to BYDV infection is quite low.

Conclusion

For the farmer, a significant reduction in productivity frequently makes the difference between profit and loss. Plant diseases not only cause a reduction in yield, but may also result in a lower quality of grain produced. An epidemic of disease on barley can effect quality through lower test weights and reduced protein contents.

Presently, barley scald and barley stripe are two diseases of some importance (McBeath, 1980; Wooding and McBeath, 1979). Both diseases thrive in cool, humid weather—typical of weather conditions in the Delta area in some years. In the past, diseases such as scald, stripe, spot blotch, and net blotch have been effectively controlled by treating seed with fungicides containing mercury compounds. However, because use of mercury in fungicides has been banned, controlling these diseases has come to present a serious problem.

One distinct advantage is that Alaska is at the threshold of agricultural development. If we are careful in disease management, we may not have to face the problems caused by their presence on a large scale. For instance, seeds sown on isolated, newly cleared land in 1979 were certified seeds. Except for a few cases of stripe and spot blotch infection, barley plants were quite healthy. However, in the 1980 season, many farmers used seeds produced from the land without proper treatment, and the number of stripe as well as scald infected plants increased significantly (McBeath, 1980).□

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Rust Disease on White Spruce in Alaska

by

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White spruce (*Picea glauca* [Moench] Voss) is the most important commercial tree species in interior Alaska; white spruce stands cover approximately 12.8 million acres and form the tallest forests along the large rivers (Hutchinson, 1969). In the past, white spruce in the interior was used almost exclusively for the construction of cabins and other buildings, bridges, corduroy roads, and the like (Viereck and Little, 1972). Increasingly, white spruce has been sought in the international market; export of white-spruce timber and chips to foreign countries, especially Japan, has increased in recent years, enhancing its economic value.

Witches' broom (*Chrysomyxa arctostaphyli* Diet.), needle rust (*C. ledicola* Lagerh.), cone rust (*C. pirolata* Wint.), and bud rust (*C. woroninii* Tranz.) are diseases commonly found on white-spruce trees. For example, in 1978 approximately 30,000 acres of white spruce near Ruby, north of the Yukon river, were found to be heavily infected with needle rust (Figure 1). A needle-rust epidemic was reported the same year in Dillingham in southcentral Alaska (USDA, Forest Service, 1979). In 1980, needle-rust infestation was again observed on white spruce in large areas of the interior and Kenai peninsula. Needle rust of epidemic proportions was also found in the Susitna Valley, Seward Peninsula, and in southwest Alaska. Along the Kuskokwim river, especially the stretch of 320 miles between Bethel and Stoney river, spruce trees were so heavily infected with rust that the orange-colored spores released from the infected tree not only covered the surface of other vegetation but also changed the color of many rivers and lakes. Cone rust is also prevalent in spruce stands in Alaska. In a 1970 seed production study, cone rust was observed not only on the north and south slopes of the Alaska range but also covered all of interior Alaska as far north as the Dietrich river valley at Wiseman (Zasada et al., 1978). In the fall of 1978, an outbreak of white spruce cone rust was observed near Tyonek. In the fall of 1980, a heavy infestation of cone rust was observed in many spruce stands around the Palmer area, on the Kenai peninsula, and at Valdez.

Effective disease management is an essential part of good forest management. Since rusts, as a group, are the most widespread diseases found on white spruce, recognizing and understanding them is the first step in disease management.

Symptomatology and Infectious Cycle of White Spruce Rusts

White spruce rust diseases are caused by rust fungi. These rusts have a very complex life cycle; in order to complete their life cycle, not only white spruce but also an alternate host, unrelated to white spruce, is needed. Spruce rust fungi generally have five spore stages. At each stage, spores (seed-like structures) of distinct form and function are produced. Spermogonia (pycnia) and aecia are the two spore stages that occur on white spruce trees.

Witches' Broom Rust

The alternate host of spruce witches' broom is bearberry (*Arctostaphylos uva-ursi* [L.] Spreng.) (Peterson, 1961). Witches' broom is the only spruce-rust disease known to be able to perpetuate itself on spruce. Once the broom has become established, the infection reappears every year. Histological studies have shown the presence of rust mycelium (a tangled mass of thread-like structures which compose the body of the fungus) in the meristemic tissue of the unopened bud on the broomed branches; this is one indication that this rust overwinters in the mycelium form.

This rust attacks the spruce trees primarily on the trunk, causing an abnormal proliferation of branches (Figure 2). Both internodes and needles on these broom branches are shorter than normal. From the end of June until early August, the sporulating aeciosori on the needles colors the whole broom a striking orange. By the end of August, needles fall from the broomed branches; the broom then has a naked, dead-looking appearance and is frequently mistaken for a bird or squirrel's nest.

The development of spermogonia is synchronized with that of the host tissue. In mid-May, tiny, yellow spermogonia appear in the stomata region of the needle as buds on the broomed branches unfold. In approximately 14 days, spermogonia mature and turn light orange in color. Each spermogonium produces tiny, colorless spores called spermatia, which are exuded from the sori (a small, blister-like lesion) as a shining drop. These exuded drops express a strong, sweet odor, characteristic of spermogonia of all spruce rusts. Spermogonia of witches' broom usually remain active for approximately 5 to 7 days and then gradually shrivel into tiny black scars (Figure 3). A period of 14 days passes before the emergence of the next stage of the disease's development, aecia on the needle. Sori associated with aecia are bright yellow in color, surrounded by a white membrane called peridium. When mature, many orange aeciospores are produced from these sori (Figure 3). Aeciosori usually remain active until early August for a total of 5 weeks. By late August, these needles have shriveled and fallen from the broomed branches (McBeath, 1978a). Witches' broom rust depletes the nutrients from the spruce tree, but it does not cause the death of the tree directly. These trees that are heavily infected with witches broom rust seem to be more subject to winter kill.

Needle Rust

Needle rust is an annual rust; infection has to be renewed every year from rust on labrador-tea (*Ledum decumbens* [Ait.] Lodd., *L. groenlandicum* Oeder.). The rust overwinters on labrador tea in mycelium form on the previous year's leaves (Figure 4).

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Figure 1: An aerial photograph of a needle rust infected spruce forest near Ruby.

In early summer, under favorable environmental conditions, spores are disseminated from labrador tea to the tender, succulent, new spruce needles. Small yellow flakes at the stomata region of these needles are the first sign of infestation. As the discolored area gradually expands, a slight hypotrophy of the infected tissue also occurs. The spermogonia at the stomata region of the needle reach their sporulating stage in early July.

Peridia-clad aeciosori start to emerge from the stomata region in mid-July. By late July, massive reddish-orange aeciospores are released. Aeciosori remain active for another 3 or 4 weeks. The infected needles then gradually shrivel and eventually fall from the branches. When the infection is light, new shoots still sprout from these branches. However, in the event of heavy infection (80-100%), the branch remains bare throughout its life (McBeath, 1978b) (Figure 5). Needle rust not only depletes the nutrient but also reduces the reserves of the tree by causing loss of needles in fall. Whether this disease also reduces the ability of these trees to survive the winter is still unclear.

In 1978, another needle rust disease on white spruce was found near Tyonek. The symptom display of this rust was very similar to the needle rust caused by *C. ledicola*. However, scanning electron and light microscopic studies showed that the aeciospores of this needle rust were smaller and the ornamentation of the surface of the spore was also different. The economic importance of this rust is still not clear.

Cone Rust

Wet-looking cones are usually the first indication of cone-rust infestation. In early July, yellow spermogonia appear on the scales of the new cone. The cones are covered with slimy exudates which give them the wet appearance. In late July, large aeciosori appear at the dorsal (outer) side of the scale (Figure 6). The signs of infection become more obvious

Figure 2: Abnormal proliferation of branches on a spruce tree caused by witches' broom rust.

in the aecia stage; the cone is covered with powdery bright yellow aeciospores. Aeciospores also fill the spaces between the scales (Figure 7). The scales of infected cones open prematurely and give the cones an 'old' look. When it rains, these cones absorb moisture more rapidly and develop a water-soaked appearance which can be recognized readily (McBeath, 1978c).

Seed produced from infected cones are considerably lighter in weight (approximately 1/2 the weight of healthy seeds), but they are no different in size. The seed coat of these seeds is light in color (yellow to light brown) (Figure 8). Seeds are also very fragile and vulnerable to mechanical forces, partially due to poorly developed seed coats. Cone rust has a devastating effect on spruce-seed production. The mortality rate is almost 100% for seeds produced from severely affected cones. In cones with only minor infections, the number of viable seeds produced is also considerably decreased (McBeath, 1979c).

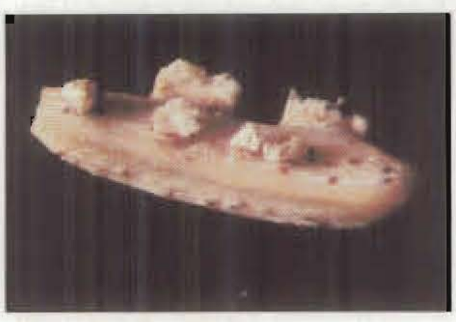

Figure 4: Needle rust on Labrador-tea.

Figure 3: A witches' broom infected spruce needle (12X).

The alternate host of cone rust is wintergreen (*Pyrola grandiflora* Radius., *P. secunda* L.) (Savile, 1950, 1955).

Bud Rust

Of all the spruce rust in Alaska, bud rust is the least known. In the past, bud rust was believed to attack only needle buds (Kuprevich and Transhel, 1957; Savile, 1950). However, our recent findings indicate that bud rust can also attack female cone buds of spruce trees. The rust attacks primarily the terminal leaf buds; but occasionally it also infects one or two lateral buds (Figure 9). Bud-rust infection becomes visible in late May when buds of spruce trees start to unfold. Instead of the normal green young shoots, the infected shoots are bright yellow in

Figure 5. Needle rust infected spruce. The twig on the left shows the present year's infection; only the current year's needles are infected. The twig on the right was heavily infected with needle rust in the previous year; the branches are bare and no new shoots have sprouted from them. Both samples were collected at the same time.

Figure 6: Rust infected cone on white spruce.

Figure 7: A dissected rust infected cone.

Figure 8: Seeds extracted from white spruce cone infected with cone rust compared to healthy seeds.

color and severely stunted (McBeath, 1979a; Savile, 1950, 1955; Ziller, 1974).

Small spermogonia are found exclusively at the tip region of the needles. Aecia primoidia, seen as long, yellow streaks beneath the four bands of stomata, give the needle a distinctive yellow color. By early June, aeciosori emerge from the host tissue. Later, the white peridial wall cracks and releases many bright yellow aeciospores. The aeciospores remain active until mid-July; then the infected needle becomes dehydrated (McBeath, 1979b).

Frequently, one or two of the lateral buds produce shoots: some were healthy looking, but more often they were small and twisted. Neeldes on the abnormal branches fell in autumn.

On flowers, bud rust attacks mainly female cones. Clusters of spermogonia appear in late May on the dorsal (outer) side of the scales of the infected cones. After sporulation, these spermogonia shrivel and turn to small black dots. Aeciosori then appear. Bright yellow aeciospores are released from the mature aeciosori later, permitting easy recognition of the infected cones (Figure 10). Bud rust aeciosori are located on both dorsal and ventral (inner) sides of the

Figure 9: Needle bud infected with bud rust fungus.

scale. Bud rust can stunt the growth in seedlings. Because no viable seeds are ever produced from bud rust-infected cones, this disease can also reduce seed production.

The alternate host of bud rust is believed to be labrador-tea (Kuprevich and Transhel, 1957; Savile, 1950, 1955).

Spruce rusts are obligate parasites. Since they do not cause the immediate death of the infected trees, spruce-rust diseases have largely been ignored in the past. Given the increasing economic value of white-spurce forests, more intensive methods of forest management such as assessing the losses caused by various diseases, may be necessary in the future.

Figure 10: Rust infected female cone bud.

To date, the geographic distribution of spruce rusts in Alaska is still not fully known; information provided from outbreaks of needle and cone-rust diseases indicates that the distribution of these diseases must be quite wide. Since these rusts can also cause diseases on black spruce and Sitka spruce, their economic value as well as their impact on the Alaska ecosystem may be quite significant.□

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The Persistence of the Herbicides 2,4-D and Picloram in Alaskan Soils North of Latitude 60°

by

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The herbicides 2,4-D (2,4-Dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-Trichlorphenoxy acetic acid) have been used for right-of-way brush control in Alaska since the 1950s (A.R.R. and D.O.T.) and contributed to economical maintenance of the margins of local airports, highways, and railroads.

However, since 1970, the public has associated both these compounds with Agent Orange and Agent Blue, used as defoliants in the Vietnam War. In addition to having this negative image, 2,4,5-T contains the toxic contaminant, TCDD (2,3,7,8 tetra-chloro-dibenzo-p-dioxin) or "dioxin," that in military formulations was allowed to exceed 200 parts per million (ppm). In 2,4,5-T produced for domestic use, TCDD is not allowed to exceed 0.5 ppm (Council for Ag. Science and Tech., 1978). Unfortunately, due to the complex manipulation of chlorine atoms required to produce the herbicide, it seems unlikely that the contaminant will be reduced to zero. In 1979 2,4,5-T was banned by the U.S. Environmental Protection Agency (EPA) except for a few specialized uses.

2,4-D is not known to contain TCDD (Council for Ag. Science and Tech., 1978). It is being studied for contaminants by the EPA (1980), the manufacturer and many universities but none of its byproducts and intermediate metabolites seem to be in a class with the toxicity of TCDD. It is 2,4-D that, in various formulations, is considered the herbicide of choice for brush control in Alaska. Because of their chemical relationship and the similarity of the two names, 2,4-D is not always distinguished from 2,4,5-T by citizens concerned with the harmful effects of the latter compound.

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Figure 1: Spraying the right-of-way of the Alaska R.R. near Wasilla. The truck is adapted to ride on rail or highway and a boom may be fitted to spray both sides of the track.

Picloram is a compound whose acute oral toxicity to mammals is in the same range as table salt (Thompson, 1979). A safe and effective brush-control agent, it is often mixed with other herbicides. In this class is TORDON 101 [R] used by both the Alaska Railroad and the Alaska Department of Transportation (DOT) for right-of-way brush control. The usual mix of TORDON 101 contains 10.2% picloram, 39.6% 2,4-D, and 50.2% inert ingredients. The accepted formulation for Alaska is one gallon of concentrate in 99 gallons of water applied at sprayer speeds that result in an application rate of one to four pounds of active ingredients (ai) per acre.

THE USE OF PHENOXY HERBICIDES IN ALASKA

The major users of phenoxy herbicides in Alaska are the U.S. Forest Service, the Alaska Railroad and (until 1978) the Alaska Department of Transportation (Bleicher et al., 1980). To a lesser extent, these compounds are used by the Federal Aviation Agency for airport and navigation aid maintenance, the military for grounds and service road brush control, and private corporations to control unwanted plant growth around industrial sites. Alaska's farmers may use 2,4-D to control perennials and woody plants in small grain crops. The "D" compound is often the active ingredient in weed-control mixes for home-garden use.

Many Alaskan organizations have expressed concern for the effects of the phenoxy herbicides on human and animal health and, in 1977 and 1978, bills were introduced into the Alaska State Senate to forbid or restrict the use of 2,4-D and 2,4,5-T within the state (1977). In an analysis of these bills submitted to the legislature on March 14, 1977, the Department of Environmental Conservation opposed the legislation. The 1977 bill was not reported out of committee, nor was a 1978 revision.

On May 11, 1978, the governor wrote to the commissioners of the Departments of Environmental Conservation and Transportation and Public Facilities directing: ". . . that the (departments) jointly present . . . a plan for testing (phenoxy) herbicides during this summer period so that some definitive decision can be made regarding their use or non-use within the State." At the same time DOT's Division of Highways was directed to refrain from right-of-way spraying until the study was complete.

METHOD

Experimental design parameters used in our testing of these herbicides are as follows:

- To work mainly with the herbicide TORDON 101, a mix of 2,4-D and picloram used for right-of-way spraying by many state and federal agencies,
- To set plots in three areas of the state: interior Alaska, southcentral and southeast Alaska,
- To sample soils and analyze for pesticide residues at periods of approximately two hours, two months, and one year after application of a label-recommended dosage.

The herbicides were to be applied at the rate and dose recommended by the manufacturer. Spray equipment and chemicals were to be provided by the Alaska Division of Highways. Although their spray program was not affected by the governor's order, the management of the Alaska Railroad offered to support in part the studies detailed in this paper.

The experimental plots selected in 1978 were located along seldom-used service roads on the Anchorage and Fairbanks International Airports. In cooperation with the Alaska Railroad, a study site was located along the main track at mile 162 near the town of Wasilla. All sites had no history of being treated with herbicides. The U.S. Forest Service was unable to schedule

Figure 2: The Anchorage airport Tordon 101 efficacy test plot, one month after application. Plus 80% of the vegetation has browned-out but there has been no leaf drop.

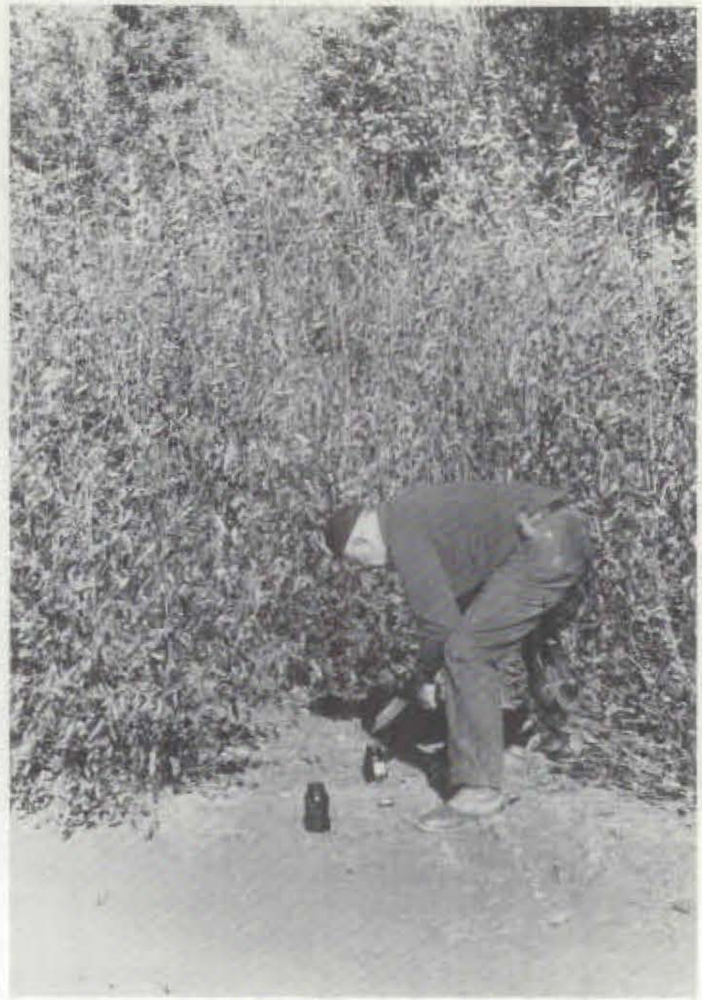

Figure 3: The author digging a soil sample from the Tordon 101 plot illustrated in Figure 2. After an interval of one year kill is 100% on brush and leaf drop is almost total although the location is sheltered from the wind.

a test in southeast Alaska in either 1978 or 1979. Division of Highways crews and spray equipment were assigned to the airport plots. The sprayer used by the railroad is shown in Figure 1.

Prior to spraying, controls were taken at the test site. At three locations to be treated in 1978 and the one location sprayed in 1979, holes were dug to a depth of 8 inches at three randomly selected sites and a soil mix placed within a single glass container. All controls proved negative for phenoxy herbicides when analyzed by gas chromatography.

Post-application samples were taken from an 18-inch square of soil not protected by vegetation. A soil mix was transferred to a glass container from the top 1 inch of soil and from the 6-to-8-inch level (except for the initial collection when the deeper sampling was omitted). This was done once along a line at a right angle to the center line of sprayer movement at distances of 5, 10, and 15 feet at two locations set approximately 100 feet apart. Thus the test lines in 1978 were replicated twice and the soil samples twice for the first sampling and four times for the second and third. In 1979, the samples were a mix of soil dug from the surface to the 8-inch level at locations 5, 10, and 15 feet from center line along a single, right-angle line. As there were no replications, the area from which the soil mix was collected was increased from 18 square inches to 36 square inches. The glass containers were 1- or 2-pint amber, screw-top, xylene washed, wide-mouth laboratory jars. Soil samples were frozen within 3 hours of collection and shipped frozen to the Department of Environmental Conservation's Douglas laboratory for transshipment to an EPA-approved, commercial laboratory. Department sample custody procedures were observed throughout the study.

The first TORDON 101 application was made at Mile 162 of the railroad right-of-way on June 9, 1978, and was sampled

Figure 4: Close-up of dessicated alder leaves one week after Ammate-X application to 1978 Anchorage airport Plot (4)-(4).

Figure 5: The author inspects the 1978 Anchorage airport Ammate-X test plot after one year. Note the total leaf drop and the absence of grass.

Table 1

	Fairbanks 10-ft. swath	Anchorage 20-ft. swath	Mile 162 20-ft. swath
2,4-D	1.55 lb/A ai[1]	1.70 lb/A ai	1.55 lb/A ai
picloram	0.395 lb/A ai	0.433 lb/A ai	0.395 lb/A ai

[1]Pounds per acre of active ingredient.

at 2 hours, 14 days, and 75 days. On July 18, 1978 an application was made by Division of Highways personnel at Fairbanks International Airport. Soil samples were collected at 2 hours, 23 days, and 51 days. A third plot was established at Anchorage International Airport on August 1, 1978 in cooperation with DOT staff in the southcentral region of the Division of Highways. Soil samples were collected at 2 hours, 16 days, and 43 days. For all applications of TORDON 101 the concentrate was mixed at a rate of 1 gallon in 99 gallons of water. All three spray rigs use piston pumps powering boom and nozzle attachments but for our tests the herbicide was applied through hand-held pressure hoses used for spot spraying.

An analysis of our 1978 data demonstrated that the sampling intervals on all our plots were too far apart to more than indicate the presence or absence of pesticide residues at the end of Alaska's summer season. We then decided to concentrate our 1979 efforts on a single plot and sample it for soil residues at intervals frequent enough to provide results amenable to graphic representation. A plot was applied in cooperation with the Alaska Railroad on a section of right of way near the village of Eklutna, 30 miles north of Anchorage. The swath was 26 by 200 feet and the soil samples were collected and processed as described above. In 1979, single, 1-year samples were collected from the Anchorage and Fairbanks airport plots.

RESULTS

In our experimental design, the swath was calculated to be 50 feet for all herbicide applications. However, because the fixed boom and nozzle arrangements of the three sprayers to be used were different, we had each cooperator spray the plots with a hand-held hose. By an analysis of the residues recovered from the soil samples taken at 5-, 10-, and 15-foot intervals across the swath, it was evident that the spraymen in Fairbanks and Anchorage used very different techniques to obtain a swath. In Fairbanks, the majority of the herbicide was applied within 5 feet of the road, while in Anchorage the application reached to 15 feet and beyond. We were forced to estimate the swath width from the subsequent vegetation kill: 10 feet in Fairbanks, 20 feet in Anchorage, 20 feet at railroad mile 162 (1978) and 20 feet at Eklutna (1979).

Corrected for swath width and rig speed, the dosages applied to the three 1978 plots are shown in Table 1. These dosages are within the range recommended for brush control with 2,4-D (1/4 to 4.0 lbs. of active ingredient per acre) and for picloram (1/4 to 8.0 lbs. of active ingredient per acre).

Table 2, lists the detectable mean recoveries of 2,4-D and picloram from eighty-three 1978 soil samples, recorded in parts per million (ppm) and sampled at time intervals of approximately 1 day, 2 weeks, and 6 weeks. At 2 and 6 weeks the samples were divided into high and low (1 inch vs. 6 to 8 inch) samplings. The object of this was to determine the relative extent at which the two herbicides migrated through the soil.

The 1979 Eklutna soils were taken across the swath 5, 10, and 15 feet from the center line of sprayer travel and were a mix dug from a 1-inch to an 8-inch level. The three samples were not replicated. The first soils were taken 1/2 hour after spraying and thereafter at intervals of 24 hours, 48 hours, 3 days, 4 days, 5 days, 6 days, 17 days, and 30 days. These were frozen, shipped, and analyzed as were the 1978 soils.

Table 2: Mean recoveries of herbicide in parts per million (ppm) from soils taken in 1978 in Anchorage, Fairbanks and on the Alaska Railroad.

Plot location	2,4-D Time	2,4-D Mean recovery high	2,4-D Mean recovery low	Picloram Time	Picloram Mean recovery high	Picloram Mean recovery low
FIA[1]	2 hours	3.98	—	2 hours	0.972	—
	23 days	0.254	0.062	23 days	0.230	0.050
	51 days	0.111	0.033	51 days	0.043	0.031
ANC[2]	24 hours	0.874	—	24 hours	0.224	—
	15 days	6.48	0.313	15 days	0.362	0.004
	43 days	0.558	0.079	43 days	0.005	0.010
RR[3]	2 hours	0.870	—	2 hours	0.056	—
	14 days	ND[4]	ND	14 days	ND	ND
	74 days	ND	ND	74 days	ND	ND

[1]FIA: Fairbanks International Airport.
[2]ANC: Anchorage International Airport.
[3]RR: The Alaska Railroad, mile 162.
[4]ND: No detectable residue.

CONCLUSIONS

Public concern about the use of phenoxy herbicides in Alaska to control brush along railroad and highway rights of way lies mainly in three areas: (1) Will the applications damage gardens, bees, and wild berries? (2) Does the pesticide appear in drinking water? and (3) Is there a buildup in the soil after repeated applications to the same locations?

Careful planning and a sensitivity to the homeowner's concerns about pesticide use can eliminate problems in the first area. This study was not designed to investigate water contamination by herbicides, but, in answer to the last question, it must be concluded from the data that there is a small but detectable residue present in the plots at the end of the short Alaskan summer.

From samples taken on day 51 in Fairbanks in 1978, the mean recovery of 2,4-D was 0.111 ppm at 1 inch and 0.033 ppm between 6 and 8 inches. In Anchorage, residues were (after 43 days) 0.558 ppm at 1 inch and 0.079 ppm between 6 and 8 inches. There was no detectable residue in the railroad plot after 2 hours. Picloram residues at the end of the 1978 season were: Anchorage 0.005 ppm (high) and 0.010 ppm (low); Fairbanks, 0.043 ppm (high) and 0.031 ppm (low). One year samples, taken in July 1979, showed a picloram residue of 0.020 ppm from the Anchorage plot, no detectable residue from the Fairbanks plot, and no detectable residues of 2,4-D from either plot.

While it was gratifying to learn there was no buildup of the phenoxy compound from the 1978 studies, we, in view of a measurable 2,4-D residue found at the end of that growing season, were anxious to determine exactly how long the components of TORDON 101 persist during a single season. With the cooperation of the Alaska Railroad, a TORDON 101 test plot was established on a railroad siding near the village of Eklutna in Southcentral Alaska. As the railroad's spray rig is able to move on track or highway, the plot was placed along a dirt service road a few yards west of the main line. Mix, speed, pressure, and applicating technique duplicated, as nearly as possible, those used at Mile 162 in 1978. Picloram residues detected from the 1979 soil samples indicate there is a measurable residue of slightly less than 1/2 part per million present at day 18 and a mean recovery from the 30-day samples of 0.1 ppm. There were no detectable 2,4-D residues after 2 days. The mean residues of the 2,4-D samples taken across the swath were:

Table 3: Mean residue recoveries of 2,4-D across the Eklutna swath.

Sampling time	Mean recovery (ppm)
1/2 hour	0.033
24 hours	0.60
48 hours	0.03

Our efforts to determine the relative extent to which the two components of TORDON 101 migrate through the soil were unsuccessful as cost factors precluded taking total soil samples from the surface to the 8-inch level. We can only conclude that the data in Table 2 demonstrate that a measurable amount of herbicide migrated to the 8-inch level within 1 month of application. However only picloram showed a higher concentration at 8 inches than at the 1-inch level: 0.01 ppm as compared to 0.005 ppm after 43 days in the Anchorage airport plot.

DISCUSSION

Our 1978 data suggest that only a small phenoxy residue remains in the soil at the end of Alaska's short summer and that none is present after 1 year. However, an analysis of our raw data led some readers to express concern that an application of herbicides applied at the best time to be effective in our climate (mid-May through mid-June) would inject a chemical into the total environment when nontarget plants, beneficial insects, and animals are developing most rapidly. Twenty days after the 1978 applications of picloram soil residues exceeding 0.003 ppm were found in all samples. For the herbicide of major concern, 2,4-D, there was also a substantial 1978 soil residue on day 43 in Anchorage (mean recovery 0.319 ppm) and in Fairbanks (mean recovery 0.072 ppm). This was contradicted in 1979 by Eklutna data that revealed no 2,4-D soil residues after 2 days and a picloram soil residue below the limits of detectability on day 30.

In Alaska's variable and often severe climate, very little that happens can be separated from the weather. The late spring and summer of 1978 in both Anchorage and Fairbanks were relatively dry, Table 4, but during the 1979 sampling period there were numerous days of heavy precipitation. "Heavy rain" was recorded during the 48-hour sampling, "heavy rain" on the third day, "intermitten showers" on the fifth and sixth sampling and rain almost every day between the sixth and seventeenth day of sampling. When the 1-month sample was taken it was "raining."

Table 4: Rainfall (in inches), measured in Anchorage and Fairbanks during July, August, and September, 1978 and 1979.[1]

Year	Anchorage	Fairbanks
1978:		
July	1.78	1.19
August	0.54	1.24
September	2.16	0.98
1979:		
July	3.84	–
August	1.56	–
September	2.73	–

[1] U.S. Department of Commerce: National Weather Service; Anchorage, Alaska.

In the 1978 soil samples, Anchorage and Fairbanks airports, the percentage of soil moisture ranged from a high of 26.55 per cent to a low of 5.47 per cent. The mean percentage of soil moisture of seven Fairbanks samples was 9.90 per cent and of 16 Anchorage samples, 20.54 per cent. This approximates the difference in summer rainfall between the two areas in a "normal" season. However there are Alaskans who cannot remember a normal season since the gold rush and no correlation between soil moisture and residue recovery could be determined from the data.

Only very small residues of 2,4-D and picloram remain in our soils after the Alaskan growing season, but much higher residues were detected in the weeks when plant growth is greatest. Fortunately as spring right-of-way herbicide applications will kill berry plants before fruiting, it is unlikely that harvesters will ingest pesticide through this route. However, work by Woodward (1979) suggests that concentrations of picloram above 0.006 ppm inhibit trout-fry growth. In view of this and the data on the persistence of picloram presented here, precautions taken in Alaska to provide a buffer zone of 100 feet between sprayed vegetation and lakes and streams should be maintained and even increased to 300 feet in streams that are known producers of salmon fry. Picloram residues from the 1979 soil samples, indicate that there is a residue of slightly less than 1/2 part per million present at day 18 and shows a mean recovery from the 30-day samples of 0.1 ppm. As picloram was recovered from the airport plots after 1 year, applicators using this compound should keep in mind that enough of the pesticide may persist from season to season to cause substantial plant damage, in particular to delicate and valuable ornamentals.

Evaluated on the basis of the data presented here one must conclude that Alaskans living north of latitude 60° north are exposed to no greater danger of a year-to-year buildup of 2,4-D residues in their soils than are the citizens of the other 49 states. Greater caution must be used when planning to apply picloram for it has been demonstrated that a recommended dosage applied to the same area year after year may result in soil residues that are harmful to desirable plants. However it must be observed that picloram's oral toxicity to mammals (LD50) is 8200 milligrams per kilogram (Thompson, 1979)—several times safer than table salt.□

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Responses of Arctic Tundra to Intensive Muskox Grazing

by

Jay D. McKendrick*

Tundra is a rangeland vegetation, and as such can only satisfy basic human needs when its forage and browse resources are converted into animal products. Except for certain wild berries and, perhaps, peat as a fuel, the tundra offers man little survival and comfort other than a habitat for his animals. It is true that tundra has significant value in piquing modern human interests and in pleasing the eye as the alternating seasons vary the landscape, but those values can be appreciated only after fundamental creature comforts have been gratified. Conversion of tundra range resources into animal products occurs naturally with the free-roaming caribou, ptarmigan, and other indigenous fauna of the Arctic. Consequently, man's harvest of tundra products has been dependent upon his "capturing" the tundra-harvesting animal. Thus, hunting has been the arctic rangeland husbandry practiced by arctic dwellers for millenia.

As their economy has become more cash based, arctic people have become increasingly dependent upon imported food, clothing, fuel, and other necessities of life. Such dependency creates an uncomfortable degree of vulnerability and has prompted renewed interest in self-sufficiency (Dearborn, 1979). Reindeer were brought to Alaska in the late nineteenth century to alleviate Eskimo starvation, as caribou numbers were declining. This relatively short pastoral history with reindeer herding and its accompanying research is the major source of experience from which technology for tundra range management can arise.

The recent introduction of muskox farming has added a totally new dimen-

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Table 1: Provisional plant species list for the Unalakleet Muskox Farm

FORBS	GRASSES, SEDGES, AND RUSHES
Aconitum delphinifolium spp. delphinifolium	Agrostis trinii
Adoxa moschatellina	Arctagrostis latifolia
Anemone narcissiflora sibirica	Beckmannia erucaeformis
Antennaria friesiana	Bromus tectorum
Arnica frigida	Calamagrostis canadensis
Astragalus alpinus alpinus	Calamagrostis lapponica
Campanula uniflora	Carex bigelowii
Cardamine pratensis ssp. angustifolia	Eriophorum vaginatum vaginatum
Castilleja elegans	Festuca brachyphylla
Chrysosplenium tetrandrum	Festuca brachyphylla
Cornus suecica	Hierochloe alpina
Corydalis pauciflora	Luzula multiflora
Descurainia sophioides	Phleum pratense
Dryopteris dilatata	Poa arctica
Epilobium latifolium	Trisetum spicatum
Equisetum arvense	
Equisetum silvaticum	**SHRUBS**
Lupinus arcticus	
Lycopodium annotinum	Alnus crispa
Mertensia paniculata Eastwoodae	Betula nana
Minuartia arctica	Betula (hybrid?)
Oxytropis nigrescens	Diapensis lapponica
Pedicularis Kanei spp. Kanei	Dryas octopetala
Pedicularis labradorica	Empetrum nigrum
Phlox sibirica sibirica	Ledum palustre spp. decumbens
Pinguicula villosa	Loisleuria procumbens
Polemonium acutiflorum	Oxycoccus microccus microcarpus
Polygonum Alaskanum	Rubus arcticus arcticus
Polygonum bistorta spp. plumosum	Rubus chamaemorus
Polygonum viviparum	Ribes triste
Potentilla palustris	Salix arctica crassijulis
Potentilla villosa	Salix glauca
Saxifraga punctata spp. Nelsonniana	Salix lanata
Stellaria crassifolia	Salix ovalifolia
Tofieldia coccinea	Salix phlebophylla
Trientalis europaea arctica	Salix planifolia spp. pulchra var. pulchra
Trifolium hybridum	Spiraea beauverdiana
Valeriana capitata	Vaccinium uliginosum
Viola biflora	Vaccinium vitis-idaea
Viola epipsila	
TREES	
Betula papyrifera var. humilis	Populus balsamifera
Picea glauca	Populus tremuloides
Picea maraiana	

Table 2: Average values for 13 soil characteristics from three plant communities at the Unalakleet Muskox Farm.

Textural Class	≤2 mm Fractions (%) Sand	Silt	Clay	Fraction (% >2 mm)	O.M.[1] (%)	Total (%) N	P	Available (ppm) N	P	K	Ca	Mg	pH
					Mat and Cushion Tundra								
Clay Loam	23.1	47.3	29.6	32.7	23.1	.185	.027	19.3	3.9	109	192	78	4.78
					Tussock Tundra								
Silt Loam	11.2	66.7	22.0	1.9	30.1	.226	.040	22.1	5.7	137	345	159	4.66
					Tall Shrub (alder)								
Silty Clay Loam	33.0	47.7	19.3	11.0	53.9	.480	.048	64.5	5.5	299	2189	319	4.59

[1]O.M. = organic mater, N = nitrogen, P = phosphorus, K = potassium, Ca = calcium, Mg = magnesium.

sion to tundra range management. The tundra ranges may never have supported grazing pressures as great as those at the Unalakleet Muskox Farm. This enterprise, started in 1976, is a valuable demonstration, providing experimental experiences for tundra range research. Prior to this activity, tundra range management was primarily aimed at maintaining climax or near-climax plant communities with special emphasis on protecting lichens, as those plants were the prime winter range forage for reindeer. Some results of the two-year study reported here suggest other management approaches may be possible for these ranges. Knowledge and experiences are paramount to proper management of tundra ranges and sustaining of the resources while meeting human needs in the Arctic.

THE TUNDRA RANGE

There are five major vegetation types on the Muskox Farm: tussock tundra, shrub tundra, mat and cushion tundra, tall shrub, and conifer forest (classifications were based on the system by Viereck and Dyrness, 1980). See the provisional plant species list (Table 1) for a characterization of the flora for the vicinity.

Tussock tundra occurs generally on the midslopes of this undulating landscape. It has an open aspect and consists of cottongrass (*Eriophorum vaginatum*) tussocks with another sedge (*Carex bigelowii*), heath shrubs, mosses, and several lichens occupying interstices among the tussocks. At least two willows (*Salix arctica* and *S. ovalifolia*) occur sparingly throughout the tussock tundra. Tussock tundra soils of the root zone are acidic, silt loams, generally free of stones and are nearly one third organic matter (Table 2). Due to the large accumulation of insulating organic matter in this climatic zone, these soils remain permanently frozen except for the surface active layer, which thaws each summer. Permafrost prevents water percolation and causes these soils to remain nearly saturated. Gleying (development of a grey color due to the presence of reduced iron) is common near the bottom of the active layer.

The shrub tundra occupies an intermediate position between tussock tundra and tall shrub. Due to its height of about 1.5 meters (5 feet) or less, it presents a somewhat more open aspect compared to the tall-shrub type.

Table 3: Respective areas of five plant communities in the three range units at the Unalakleet Muskox Farm at the time the farm was being fenced, July, 1976. In addition to these areas, approximately 3.5 ha (9 acres) are devoted to nongrazing uses at the headquarters site.

Plant Communities	Range Units (ha) East	Center	West	Total	Percent
Tussock tundra	21	10	19	50	27.9
Mat and cushion tundra	3	9	10	22	12.3
Shrub tundra	9	19	8	36	20.1
Tall shrub	10	19	19	48	26.8
Conifer forest	1	1	21	23	12.8
Total	44	58	77	179	

Table 4: Stocking rates for two range units during the first three years at the Unalakleet Muskox Farm and the respective basal cover and species composition percentages[1] in tussock tundra for those two units and adjacent ungrazed tussock tundra outside the perimeter fence in September, 1979.

	Year	Range Units Center		West		Outside	
Stocking rates[2]	1977	0.49 (1.21)[3]		no data available		0	
	1978	0.37 (0.91)		0.38 (.94)		0	
	1979	0.56 (1.38)		0.79 (1.95)		0	
		Cover	Composition	Cover	Composition	Cover	Composition
Sedges:							
Carex bigelowii		2.5	10.9	4.4	12.8	2.2	5.7
Eriophorum vaginatum		2.6	8.2	2.4	6.3	2.8	8.1
Totals		5.1	18.2	6.8	19.1	5.0	13.8
Shrubs:							
Ledum decumbens		4.0	9.4	6.0	11.7	5.9	10.8
Empetrum nigrum		1.5	4.9	1.1	3.1	1.8	4.8
Betula nana		1.4	2.3	1.9	3.2	2.0	3.4
Vaccinium vitis-idaea		3.0	8.4	4.3	10.1	3.8	7.7
Vaccinium uliginosum		1.9	3.9	0.8	1.9	1.9	4.0
Rubus chamaemorus		0.5	1.1	0.4	1.3	0.7	1.5
Arctostaphylos alpina		0.1	0.1	0.0	0.2	0.1	0.2
Salix sp.		—	—	0.9	0.1	—	—
Totals		12.4	30.1	14.5	31.6	16.2	32.4
Cryptogams:							
Mosses		17.7	19.9	18.6	22.5	15.4	16.7
Lichens		24.5	31.6	20.1	26.8	32.0	32.8
Liverworts		—	—	0.0	0.1	0.0	0.1
Totals		42.2	51.5	38.7	49.4	47.4	49.6

[1]Obtained according to the walking point method described by Owensby (1973).
[2]ha/AUM (acres/AUM).
[3]Palmer and Rouse (1963) reported stocking rates of 0.87 acres/AUM in the Fairbanks vicinity.

The dominant species are dwarf birch (*Betula nana*) and Labrador tea (*Ledum palustre* spp. *decumbens*). Other shrubs include blueberry (*Vaccinium uliginosum*) and crowberry (*Empetrum nigrum*). The latter species is called blackberry by the natives at Unalakleet. Their "crowberry" is *Arctostaphylos alpina* or alpine bearberry to the botanists. Various willows (*Salix* sp.) may also appear sparingly within the shrub tundra. Several forbs and grasses may also occur in this type as well as lichens. Mosses generally cover the soil and "bury" the lower lateral limbs of the shrubs, which then root adventitiously. No soils data were obtained from this type, but soils are probably intermediate between the tussock-tundra and tall-shrub soils in most features.

Mat and cushion tundra occurs on the tops of ridges and hills. It consists of low-growing plants and, therefore, has an open aspect. Alpine bearberry, crowberry, alpine-azalea (*Loiseleuria procumbens*), and prostrate forms of dwarf birch are the dominant vascular plants with a dense cover of lichens among the shrubs. The flora is quite varied in this type, containing several grasses, legumes, members of the pink (*Caryophyllaceae*) and sunflower (*Compositae*) families, and two or three prostrate willows. Soils are acidic clay loams that are quite stony and lower in organic matter and mineral nutrients than either the tussock tundra soils or tall shrub (Table 2).

Relief allows for surface drainage, but the large accumulations of lichens tend to hold moisture on these sites. Also the fine texture of the less-than-2-mm soil fraction contributes to the overall moisture-holding capacity. Even so, the mat and cushion sites are undoubtedly the driest of all those in the vicinity. The extent of root penetration and thickness of the active layer was not explored during this study.

The tall-shrub type consists of dense stands of alder (*Alnus crispa*) and/or willows (mostly *Salix planifolia* spp. *pulcha* var. *pulchra*) and is usually confined to the drainage ways and along streams. Exceptions occur where the tussock and shrub tundras have been removed down to mineral soil by excavation or erosion. In the absence of intense muskox grazing on such mineral soils, seedlings of alder readily establish, creating dense thickets. Examples of that process can be seen readily along roads and trails around the abandoned U.S. Air Force site northeast of Unalakleet. Other shrubs occurring in such situations are spirea (*Spirea beauverdiana*) and sometimes dwarf birch along the edges.

Fireweed (*Epilobium angustifolium*), starflower (*Trientalis europea*), fern (*Dryopteris dilatata*), bluejoint reedgrass (*Calamagrostis canadensis*), holygrass (*Hierochloe alpina*), horsetail (*Equisetum sylvaticum*), clubmoss (*Selaginella* sp.), woodrush (*Luzula multiflora*), and several other plants occur in the understory of this range type. The richness of the understory undoubtedly contributes in part to the remarkable forage-production capacity when the tall shrubs are removed. Soils under the tall shrubs are acidic, silty, clay loams—usually stony. They are rich in organic matter and mineral nutrients (Table 2), another factor contributing to their forage-production capacity. Rooting depth and permafrost relations were not examined in this type.

The conifer-forest community occurs in the valleys; and, in the Muskox Farm vicinity, south- and east-facing slopes are the most common sites for this type. Further east, away from the coast, trees become more abundant, and the conifer forest becomes more prevalent. Understory vegetation consists of shrubs, forbs, grasses, and mosses. The mix varies with the openness of the tree canopy. In open stands, shrub tundra forms among the trees. Soils were not examined in this vegetation type, but it is reasonable to speculate that the active layer is deeper here than in the tundra communities.

THE MUSKOX FARM

In order to relate the observations and data for this range study to other locations, it is necessary to know the area of the Muskox Farm, the respective areas of the ranges being grazed, and the rela-

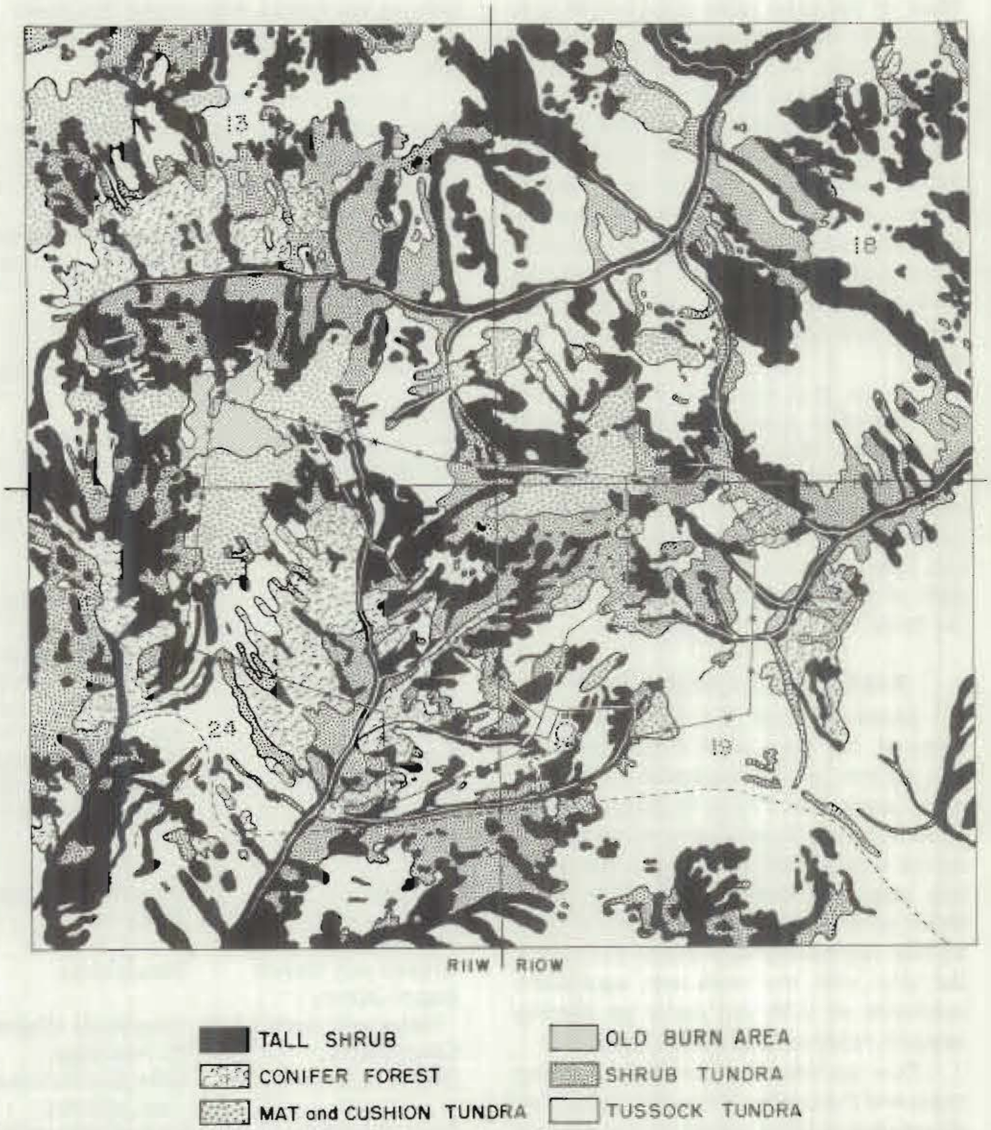

Figure 1: A vegetation map of the four sections of land near Unalakleet, Alaska, showing which part of each combine to comprise the Muskox Farm. Perimeter and cross fencing are shown. This map was created from color aircraft imagery obtained from the National Oceanic and Atmospheric Administration and from the U.S. Geological Topographic Series 1:63,360 scale Unalakleet (D-4) Quandrangle map.

tive amounts of vegetation types on the farm. In the absence of any surface survey information, areas of the range units were calculated from weight data of a map. A map of the Muskox Farm (Figure 1) was created on drafting film from aerial photography. Next, the range units of the farm were cut out and weighed on an analytical balance and compared with the weight of a section of film from the map representing 259.2 ha (640 acres). All calculations were based on the averages of three weighings.

The Muskox Farm is about 3.7 km (2.3 miles) inland from Norton Sound on the West Coast of Alaska (162° 45′ E, 63° 54′ N). It is northeast of and visible from the village of Unalakleet. Elevations range between 45 and 180 meters (147 and 590 feet). Climate is strongly influenced by the nearby Norton Sound. Portions of the three range units on the farm (Figure 1) lie in four sections, 13 and 24 of Township 18 S, Range 11 W and 18 and 19 of Township 18 S, Range 10 W Kateel River Meridian. Total area for the three range units is about 179 ha (442 acres). Approximately 3.5 ha (9 acres) is devoted to corrals and the headquarters site. The perimeter and cross fences were constructed in 1976 and 1977. At the time of our range study there were 129 adult muskoxen and 20 calves on the farm.

A dot grid was superimposed onto the vegetation map of the Muskox Farm to estimate the relative percentages of area occupied by the various vegetation types. Table 3 lists the vegetation types on the three range units of the farm. Tundra vegetation dominates, amounting to 60% of the area, with tall shrub and conifer forest making up the remainder.

RANGE USE BY MUSK OXEN

Stocking rates for the first three years at the farm were calculated from the records at the headquarters for the three range units (Table 4). Stocking data were not determined during either winter or the spring qiviut-combing season when hay was fed. Animal units (AU) were based on the beef cattle standard of 11.8 kg/day (26 lbs/day) dry matter consumed per day with the muskoxen equivalent estimated at 0.38 AU based on feeding research reported by Palmer (1944).

Due partially to the high stocking levels and the habits of this animal species, all vegetation types within the range units were used. It was common to observe the animals feeding upon a variety of plants during the course of a few hours. They browsed on willow and alder, grazed on sedges and fed upon lichens during the normal course of their daily feeding in the summer. During winter, the animals preferred the higher elevation and seemed to avoid much of the lower-lying tussock tundra, even though it was free of snow in places.

Table 5 shows some of the variety of plants acceptable to muskoxen as feed. It was most significant to note the ready acceptance of alder twigs. Palmer (1944) listed alder among the plants eaten by muskox at the Fairbanks farm. Apparently, this is the one ruminant species that feeds readily upon alder. Moose are known to take alder sparingly but preferring willow, birch, and aspen.

In winter, muskox preferred the ridge tops that produce mat and cushion tundra as a winter range. Presumably all plants were fed upon, due to the heavy grazing pressures, which forced the animals to eat plants that, under less harsh circumstances, may have been unacceptable.

Because there was insufficient winter range, hay was fed during portions of the winters. Table 6 shows estimates of the hay needs to feed the muskox herd adequately during those feeding periods. Annually, the farm needed to provide about 640 AUM. In 1978, about 28% of that had to come from a stored feed base. By September of 1979, as much stored feed was used as had been used during the entire year of 1978 when the manager had attempted to protect the range resource base from overgrazing. Hay for supplemental feed was not grown locally. Until 1979 it was shipped from the state of Washington. In 1979, hay grown in southcentral Alaska was used for part of the winter feed.

RANGE REACTION TO MUSKOX GRAZING

This study focused on the tussock and mat cushion tundra vegetation types and conducted primarily in the center range unit; males in the east unit were too dangerous during the rut, and we did not want to disturb the females with calves in the west unit. Sample plot data (Table 7) portrayed the range in 1978 as being quite productive, with a standing crop at the end of the growing season of about 4300 to 4700 kg/ha (3800 to 4200 lb/

Table 5: Relative acceptance of several plant species hand plucked and fed to a male muskox in the center range unit, 20 September 1978.

Range Plant		Animal Acceptance		
Common Name	Latin Name	Eaten	Eaten Sparingly	Refused
Graminoids:				
Sedge (green)	Carex bigelowii	X		
Sedge (senesced)	Carex bigelowii	X		
Ticklegrass	Agrostis scabra			X
Bluejoint reedgrass	Calamagrostis canadensis	X		
Forbs:				
Cloudberry	Rubus chamaemorus	X		
Arctic bramble	Rubus arcticus	X		
Alaka wild rhubarb	Polygonum alaskanum	X		
Fleshy starwort	Stellaria crassifolia	X		
Starflower	Trientalis europaea	X		
Horsetail	Equisetum arvense	X		
Fern	Dryopteris dilatata	X		
Jacob's ladder	Polemonium acutiflorum	X		
Club moss	Lycopodium annotinum		X	
Shrubs:				
Crowberry	Empetrum nigrum	X		
Alder	Alnus crispa	X		
Dwarf birch (twigs w/o leaves)	Betula nana		X	
Bog blueberry (twigs w/o leaves)	Vaccinium uliginosum			X
Lingonberry	V. vitis-idaea		X	
Diamond leaf willow	Salix planifolia spp. pulchra var. pulchra	X		
Beauverd spirea	Spiraea beauverdiana	X		
Sprawling Labrador tea	Ledum palustre ssp. decumbens			X
Lichens:				
Reindeermoss	Cladonia sp.	X		

acre). Those values are somewhat deceiving, in that they contain the accumulations of lichen, woody plant growth, and the standing dead sedge leaves from several years. Palmer and Rouse (1945) found in 1922 that the standing lichen crop in a tussock tundra south of the present Muskox Farm amounted to 5763 kg/ha (5140 lb/acre). Lichen cover ranged between 50-80%, browse between 10-15%, and sedge between 10-15% in their survey. Thus, the current findings agree with the figures of nearly six decades ago.

The annual growth of forage and browse could not be estimated without excluding the current grazing pressure. It appeared as if grazing had significantly reduced lichens and shrubs in the tussock tundra during the 1976-1978 grazing period. Lichens and unidentifiable fragments (mostly small pieces of shrubs and lichens) were significantly reduced in the mat and cushion tundra community. The stocking levels in 1978 and 1979 visibly reduced plant canopy cover in all types. However, the basal cover and species composition data indicated that the plant population in the tussock tundra was not significantly altered. There was a trend toward increases in the sedges, possibly at the expense of some shrubs, lichens, and mosses. That is the normal reaction to overgrazing in this region according to Palmer and Rouse (1945).

Figure 2 shows examples of how tussock tundra responded to overgrazing and trampling disturbances. Unless the the soil base was destroyed, the most noticeable response was an increase in annual growth of sedges. It appeared that the grasses and sedges of the mat and cushion tundra likewise increased their growth while lichen and shrubs declined with grazing pressure (Table 7). Several factors probably account for those changes, but increased mineral nutrient cycling and warming of the soil are probably primarily responsible. Removing certain lichens may also release mycorrhizal fungi (Brown and Mikola, 1974), thus increasing the uptake of phosphorus and other minerals by higher plants.

Palmer and Rouse (1945) interpreted the advance of trees into the tundra as a sign that the tundra was yet unstable and not at climax. In the absence of heavy grazing, tussock tundra follows tree and shrub communities in the plant successional sequence. Palmer and Rouse (1945) noted that heavy grazing by reindeer increased shrub growth. That has not been the case at the Muskox Farm during its short history. Possibly the browsing nature of muskox averted the shrub invasion, which occurred when reindeer overgrazed such types. Also, animal trampling in the heavily stocked muskox range units prevented shrub seedling establishment.

Palmer and Rouse (1945) concluded that shrubs were the most aggressive invaders onto barren sites and that sedges did not respond in a similar fashion. They also noted that lichens recovered readily on moist, open sites where vascular plant competition was low. They concluded that severe use, probably less than that at the present Muskox Farm, would cause soil erosion and require 20 to 30 years for recovery. Conclusions by Palmer and Rouse (1945) were based on their observations of reindeer grazing and clipping and scraping of vegetation in exclosures.

Annual herbaceous (nonwoody) production increased remarkably on tussock tundra that was destroyed in a corral (Figure 3) at the Muskox Farm. Although that site was heavily manured, further increasing soil fertility and providing seeds from the hay, the response indicates that the potential for annual forage production is still much greater than that of the undisturbed tundra. Thus, annual range production for graminoid life-forms might be substantially improved under certain conditions of heavy grazing.

The response of the tall shrub type to heavy grazing has been ultimately the loss of alder (Figure 4). The death of alder due to browsing probably had beneficial effects on the understory vegetation, however, that could not be measured while the animals were using the range. Certain locations, outside the range units where alder was removed, were sampled to evaluate the annual forage production. Figure 3 shows a substantial response in forage production occurred below a corral where runoff fertilized an ungrazed grass stand. There the standing crop of tall, bluejoint reedgrass averaged about 8000 kg/ha (3.6 t/acre). In another location, where the alder were removed and no soil fertilization occurred, forage production averaged about 1700 kg/ha (0.75 t/acre). The response by bluejoint reedgrass was also quite visible (Figure 4). These were not isolated instances. Wherever the alder were removed to construct the perimeter fence, substantial forage production occurred.

Table 6: Stocking rates and calculated forage used by muskoxen on the three range units at the Muskox Farm for 1978 and January through September of 1979. Quantities of hay needed for periods when animals were not on the ranges were also estimated.

	Range Units (ha/unit)				
	East (44)	Center (58)	West (77)	Total	Estimated Hay Needs
1978:					
AUM[1]	108	156	202	466	177 (AUM)
Calculated kg/ha used	881	965	942		63,543 (kg)
1979 through September:[2]					
AUM	92	103	97	292	176 (AUM)
Calculated kg/ha used	751	637	452		63,184 (kg)

[1]AUM = Animal-unit-month = 359 kg forage. One 227 kg (550 lb) adult muskox is approximately 0.38 animal units according to feed requirements given by Palmer (1944).
[2]This period does not include the winter period for 1979 which would require hay for the animals.

Table 7: Standing crop (kg/ha)[1] of range plants in the lichen and sedge tundra vegetation types on grazed (inside pastures) and ungrazed (outside pastures) sites in the center pasture of the Muskox Farm at Unalakleet in 1978.

	Tussock Tundra			Mat and Cushion Tundra		
	Ungrazed	Grazed		Ungrazed	Grazed	
	Sept.	June	Sept.	Sept.	June	Sept.
Green sedges	130 ab[2]	250 b	50 a	0	30	0
Dead sedges	1600	1400	1130	230	70	80
Lichens	2390 b	1100 ab	920 a	4250 b	4600 b	1740 a
Shrubs and forbs	1670 b	950 a	1410 ab	1980	1220	1510
Unidentifiable fragments[3]	1200 b	570 a	660 ab	1570 b	790 ab	1350 a
Total	6990 b	4270 a	4170 a	8030 b	6710 ab	4680 a

[1]kg/ha x 0.892 = lb/a.
[2]Means followed by the same letter within a row within a vegetation type are not different at the 5% level of probability.
[3]Frgaments of plants that were too small for hand separation were listed as unidentifiable. This category was mostly bits of lichens and debris from shrubs.

Figure 2-A: A typical, ungrazed, tussock tundra community, consisting of an assemblage of lichens, sedges, and ericaceous shrubs with an understory of mosses.

Figure 2-B: Trampling (vehicle traffic in this instance) can kill the vegetation of a tussock tundra. The first seedlings to reinvade such areas in the Unalakleet uplands are sedges, *Carex bigelowii* and *Eriophorum vaginatum*, as in the wheel tracks along the Muskox Farm's perimeter fence in this photo. New sedges in these tracks are approximately three years old.

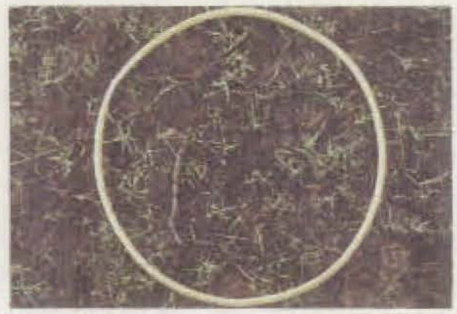

Figure 2-C: Severe trampling and grazing by muskoxen around corrals and salt blocks kills all plants. Even under such harsh treatments, the native sedge, *Carex bigelowii* established seedlings as in this photo of a 0.1 m^2 circular plot.

The growth responses of both introduced grasses, clover, and native grasses and sedges on these disturbed sites clearly demonstrates the potential for local hay production in this region. Even though the coastal climate's influence causes the formation of tundra vegetation, typical of the Arctic further north, the presence of trees and plants' responses to disturbances hints at the potential for greater vegetation production in the Unalakleet vicinity.

The latitude at Unalakleet is approximately that of Healy, Alaska, which lies between Palmer and Fairbanks, two communities known for their agricultural production capacities. Unalakleet citizens produce successful gardens inland a few miles from their village, providing adequate soil fertilization and weed control are practiced. There is equal potential for forages and grain crops.

TWO POSSIBLE RANGE MANAGEMENT APPROACHES

If the range-management objective in this region is to achieve maximum annual forage and/or browse production for muskoxen, then initially overgrazing these ranges may be an approach. Maintaining such subclimax conditions would necessitate judicious use with intermittent protection. Mat and cushion tundra would have to be either fenced separately if preserved or left available if sacrificed under such a system. Alder stands may be eliminated and their understory vegetation would increase its production of forage.

Such a system would require winter feeding during periods when the range feed is unavailable, particularly if the mat and cushion type is either sacrificed or too scarce for the herd size. Feeding hay on the snow-covered range would be preferable to feeding in corrals, because the mud and muck of corrals creates an undesirable habitat for both man and beast.

If the range management objective is to maintain climax plant communities, grazing intensities would have to be much less than those of the present Muskox Farm. Stocking rates of one-tenth to one-fourth of those at the Unalakleet farm might align with that objective. Under such a system, supplemental winter feeding could be eliminated, if either enough mat and cushion tundra or other suitable winter range types are available. Both abundance of winter range and carrying capacities of winter and nonwinter ranges would have to match the stocking rate to maintain climax range communities.

Costs and returns for the two alternatives would dictate in part the muskox rancher's management choices. Fencing and haying are expensive inputs for the intensive option. The partial retrieval of those costs might lie in the qiviut crop. If there is freedom to market muskox breeding stock in Alaska, that would also offset part of the expenses in an intensively managed muskox farm.

The open-range option would have lower overhead and initial investment costs. But the returns may also be quite low because: 1) females would usually breed only in alternate years because of their nursing calves as opposed to the early weaning of calves under intensive stocking which allows females to breed annually; 2) losses to predators may be greater than where animals are more closely guarded; 3) slaughtering meat animals would be more difficult on the open range than the slaughter of animals that can be easily corralled, and 4) the qiviut crop would be less easily harvested from open ranging animals. Management tools, such as drift fences, roundups, castration, selective breeding, partial supplementation in winter, range riding, salting, and other techniques could be used to overcome the limitations of open ranging muskoxen.

Figure 2-D: Once the trampling and grazing factors are removed from a severely damaged tussock tundra, remarkable vegetation invasion can occur, as in this corral at the Unalakleet Muskox Farm. This former quagmire has been protected for almost two growing seasons, and is shown here with a lush cover of native and introduced plants including: *Carex bigelowii*, alsike cover, timothy, foxtail barley, bluegrasses, several mustards, fireweed, lambsquarter, and knotweed.

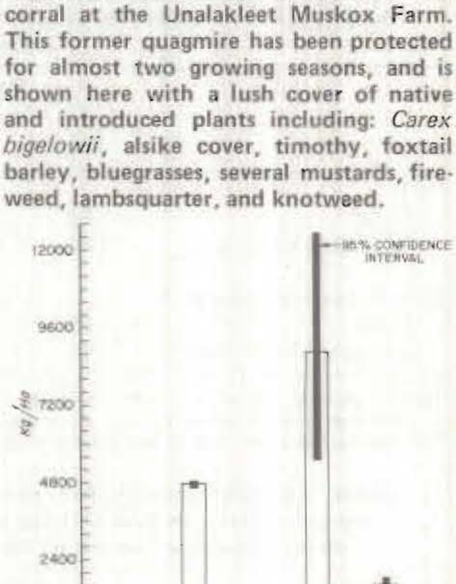

Figure 3: Comparisons between sedge tundra and tall shrub range types in terms of their 1979 standing crops of sedge and grass forage in September. The natural sedge tundra was ungrazed. Production in the corral occurred with protection from grazing for the entire growing season following total destruction of the natural vegetation. Grass in the fertilized site was influenced by nutrients in runoff from the corral.

CONCLUSIONS

Muskoxen have a wide-ranging palate that includes not only the sedges and lichens of the tundra but also forbs, grasses, and shrubs. Therefore, they appear to be adapted to climax as well as subclimax tundra range vegetation. This offers some advantage over caribou and reindeer which are adapted primarily to climax ranges. Under heavy concentrations, muskoxen would probably compete with other indigenous ungulates such as caribou and moose. In terms of a meat source produced from tundra ranges, perhaps muskoxen have some advantages over free-roaming caribou, making such competition an acceptable alternative. Burch (1977) concluded that "muskoxen are sedentary creatures whose distribution is relatively constant throughout the annual cycle. . ." as opposed to the highly migratory caribou. Hence, the harvesting phase of open-ranged muskoxen would probably be easier than with caribou on a year-round basis.

Muskoxen are effective as a biological control of alder when confined and stocked appropriately high. Because muskoxen are unable to maneuver in deep snow they could be used as biological controls on alder only during snow-free seasons in some parts of Alaska.

Tussock tundra and tall shrub vegetation types annually produce more herbaceous forage following disturbance by heavy grazing. Lichens are probably the first life forms removed under heavy grazing either by consumption or trampling by the animals. Sedges and grasses increase their production following heavy grazing. Fertilizing enhances such production.

Highpoints of the landscape are preferred by muskoxen during winter even though other areas may be snow free. During winter, grass hay can be fed to muskoxen, and they survive quite well. Under the current conditions of the Muskox Farm at Unalakleet, annual hay need for each adult muskoxen is about 450 kg (1000 lbs). That would provide feed for about 100 days per year. Considering each reproducing adult is worth $8,000 to $12,000, the cost of 1,000 pounds of hay is a reasonable investment if animals could be marketed for breeding stock. In terms of either qiviut or meat production the costs of feeding hay in tundra regions should be considered carefully. Ranging the animals as much as possible to minimize hay costs would be most economical. The most limiting nutrient needs to be determined, i.e. protein, energy, etc.

Continuous stocking rates of .3 to .5 ha/AUM are probably excessive considering long-term, range-management objectives. However, such stocking rates may have merit as a method of shifting the range into a lower successional and probably more productive stage for grasses and sedges.

Some important questions concerning muskox range management are: 1) What are appropriate stocking rates for various range use objectives? 2) How effective is rotation grazing with respect to those range objectives? 3) What are the production levels of range sites that have been overgrazed and pushed to a lower successional stage? 4) Can the animals be open-ranged and still managed for qiviut as well as meat? and 5) what are the economic considerations for the range-use options and for local hay production?

Figure 4-A: A typical unbrowsed tall shrub community outside the perimeter fence at the Unalakleet Muskox Farm.

Figure 4-B: Heavily browsed tall shrub community inside center range unit at the Unalakleet Muskox Farm. Much of the alder has been killed by the year-round browsing.

Figure 4-C: Tall shrub site from which the shrubs have been removed outside the perimeter fence at the Unalakleet Muskox Farm. When the shrubs are removed, tall grasses and other nonwoody species respond with lush growth.

Initially it was stated that experience in and knowledge of the management of tundra range are paramount for sustained use of its resources. That is true, but simply supplying those data will not guarantee that muskox ranching will come of age in Alaska's near future. Along with investing in that research, a concurrent support of the industry is required to ensure its success. Factors relating to social, economic, and political conditions may have at least as much effect on the viability of the muskox industry as do the biological constraints.□

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Alaskan-Developed Grass Varieties Coming into Use

by

Wm. W. Mitchell*

MOST GRASSES USED IN U.S. ARE INTRODUCTIONS

Because of the long lead time necessary to develop new varieties, plants most commonly used in newly settled areas are introductions. Alaska is no exception, but research at the Agricultural Experiment Station is making materials of northern origin available for use at northern latitudes. More emphasis has been placed on the potential of native plants in Alaska than elsewhere, probably because of its environmental constrictions. Three varieties of grasses indigenous to Alaska were recently released for revegetation purposes (Mitchell, 1979a).

Most of the important grasses used in the United States are introductions (Hanson, 1965). The chief interest in grasses throughout our history has been in forage types, though landscaping and conservation uses have increased in importance in our century. The early colonists found that the native plants which had sufficed for the wild game of eastern North America were inadequate for their introduced livestock (Ahlgren, 1956). Soon, they began growing forages with seed brought from Europe; this practice has continued, with concerted efforts being made today to obtain seeds from throughout the world.

Among the introduced grasses most important to the north-temperate-to-boreal regions, excluding cereals, are smooth bromegrass (*Bromus inermis*), timothy (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), orchardgrass (*Dactylis glomerata*), meadow foxtail (*Alopecurus pratensis*), creeping foxtail (*Alopecurus arundinaceus*), red fescue (*Festuca rubra*), redtop (*Agrostis alba*), creeping bentgrass (*Agrostis palustris*), crested wheatgrass (*Agropyron desertorum*), and quackgrass (*A. repens*). A number of these have been used for purposes other than or in addition to forage grasses. The last of these, though generally not used by design, is present in many forage fields and disturbed areas owing to its aggressiveness and persistence as a weed.

Interestingly, history repeated itself in the early efforts with grasses in Alaska. Difficulties encountered in working with native grasses and legumes for hay and pasture caused the Alaska Experiment Station to turn to introduced varieties (Irwin, 1945). The earliest trials commenced about 1902. Although Alaskan latitudes are considerably north of the likely origins of the grasses then available, their broad range of adaptability permitted a measure of success with some of the introductions. Ecotypical, or varietal, differences within species are important to possible ranges of application (Klebesadel *et al.*, 1964; Mitchell and McKendrick, 1975), and over the course of the years continued trials have delineated the most reliable introductions for use in Alaska. The species that have been the most dependable in providing northern-adapted materials include smooth bromegrass, timothy, Kentucky bluegrass, red fescue, and meadow foxtail (Keller and Klebesadel, 1973; Mitchell, 1978a; Alaska Rural Development Council, 1977). Others that have had more limited applications include creeping foxtail, sheep fescue (*Festuca ovina*), creeping bentgrass, reed canarygrass (*Phalaris arundinacea*), and crested wheatgrass.

As revegetation needs increased, the species found best adapted for forage and pasture use and for turf plantings were the principal source of materials for revegetation uses. Where revegetation requirements occurred in or bordered on areas with agricultural histories, these materials often sufficed so long as proper varieties were used. But severe winters can injure or decimate even the better-adapted introductions (Klebesadel, 1977).

Growing conditions are not the criteria, however, which determine where construction and resource-extraction activities occur. With the advent of an arctic oil field and a pipeline transecting Alaska from the north coast to the south coast, environments hostile to even the better adapted, introduced plants were bound to be encountered. The time for a serious look at native plants was at hand.

RESEARCH ON NATIVE PLANTS

The Rockefeller Foundation funded a project in the late 1950s that aided in the collection of indigenous materials throughout Alaska, which were then established in nurseries at the Palmer Research Center of the Alaska Experiment Station. That funding continued into 1966. Thus, a base had been established for the research to be conducted on the oil field and pipeline project. The program had already produced some significant results in the development of the varieties 'NUGGET' Kentucky bluegrass and 'ARCTARED' red fescue (Hodgson *et al.*, 1971; Hodgson *et al.*, 1978) released in 1965. Both grasses display exceptional winter hardiness.

Nugget bluegrass was collected at Hope, a mining settlement on the Turnagain Arm southeast of Anchorage. Its origin prior to its establishment at Hope is not known. Nugget has been an outstanding performer as a turf grass. The true origin of Arctared also is unknown because of the circumstances of its collection. Its behavior definitely identifies it, however, with a north-latitude origin; Arctared most likely is an indigenous red fescue. It has proved to be superior to any of the introduced varieties of red fescue in most situations.

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The significance of these varietal releases was given emphasis in the early revegetation studies in the Prudhoe Bay oil field in which Arctared was the only entry of the commercially available materials that performed with any reliability (Mitchell, 1978a, b). Nugget bluegrass, the next best of the commercial cultivars, was marginal in performance. Tests at two alpine sites in interior Alaska also indicated the serious limitations of currently available cultivars. Results with certain native materials included in these tests indicated that they would be an asset to revegetation mixes for these tougher, environmental sites.

From trials conducted since 1969 (Mitchell *et al.*, 1974; Mitchell, 1978a; Van Cleve, 1975), it is evident that the most critical deficiency in plant materials available for revegetation purposes occurs under the severe conditions of the Arctic.

Three Native Varieties Released for Revegetation Uses

Three cultivars of native grasses have been released for commercial production that will greatly improve the revegetation mixes available for these more severe environmental situations. An intensive effort has been made to obtain material of arctic origin for use in the Arctic. The most success achieved to date has been with a small, tufted grass related to the familiar lawn grass, Kentucky bluegrass. The variety 'TUNDRA' glaucous bluegrass (*Poa glauca*) was developed from selective work based on bulk seed samples collected in the Arctic in 1969 and 1970 (Mitchell, 1979a). The parents were located during a botanical survey along the pipeline route (Mitchell, 1970) along the Sagavanirktok River in the vicinity of Sagwon, about 65 miles south of Prudhoe Bay. Sagwon was a main staging area used by companies involved in oil exploration and drilling in the foothill region of the Arctic prior to the Prudhoe Bay discovery on the north coastal plain.

Though not a common member of tundra communities, the plant looked promising because of its apparent ability to occupy disturbed ground and to produce a good amount of seed. When established in a spaced-plant nursery at Palmer, however, many of the plants grew in an extreme prostrate fashion, rendering it impossible for machine harvest of seed; further, a number exhibited signs of stress and failed to live beyond two years. Fortunately, plants of a relatively upright type were also evident, and eventually 23 plants of the upright type that persisted beyond three years were selected as the breeding stock for Tundra bluegrass.

Tundra bluegrass has grown vigorously and persisted well in all upland plots in which it was established in arctic trials; in mixed plantings on such sites, it has been the dominant component. Tundra is not well adapted to wet areas that become ponded for periods of time. This material of arctic origin commences growth earlier than other grasses in the trials and heads abundantly under arctic conditions. The early growth is grazed by caribou, but upon heading, the grass appears to become relatively unpalatable. Seed production in the second year of growth of Tundra bluegrass has ranged from about 300 lb/acre to an exceptional 1000 lb/acre, in one trial, in plantings at Palmer. Yields have declined in the following year; it appears difficult to maintain a seed-producing field beyond two harvest years. The grass is subject to the debilitating effects of fungal diseases, particularly powdery mildew, when grown in boreal regions. Such limitation in the performance of Tundra would appear to confine it to the Arctic for revegetation uses, where it is an excellent grass. Tundra currently is being applied by the Husky Oil Company in their revegetation efforts in the Naval Petroleum Reserve of the Arctic (Figure 1).

The variety 'ALYESKA' polargrass (*Arctagrostis latifolia*), also of indigenous origin, is another important addition to materials adapted for use in the Arctic and other tundra regions (Mitchell, 1979a). The variety is based on 27 collections of polargrass made through interior and western Alaska. The plants were grown in nurseries at Palmer for 7 to 10 years prior to being composited into a breeding block for the variety. No plants of arctic origin have been found suitable for inclusion in the breeding composite because of their extremely poor seed-producing ability. Components of Alyeska were tested in revegetation studies conducted along portions of the trans-Alaska pipeline route and in the Prudhoe Bay oil field. Polargrass has been one of the best performers in the arctic oil-field trials, persisting well under various conditions (Figure 2). Alyeska is complementary to Tundra bluegrass and Arctared fescue in its adaptations to the Arctic, being better suited than the other two to the low, occasionally ponded sites. It has been grazed readily by caribou and remains more palatable than Tundra bluegrass through the growing season.

Alyeska is most appropriate for the cooler, moist, growing regions, and may be expected to do well on tundra sites of that character along the west coast and in alpine regions. It is not well suited to dry sites or those subject to desiccating winds. It tolerates strongly acid soils and appears immune to snow mold. Thus, it may have application on difficult lowland, boggy sites, particularly if they are acidic and subject to disease problems. Seed yields in small-plot plantings of this grass at Palmer have ranged from about 80 to 450 lb/acre.

A third native grass variety that has been released for commercial production has wider application through the boreal, or forested region of Alaska than Alyeska. 'SOURDOUGH' bluejoint reedgrass (*Calamagrostis canadensis*) is based on 36 collections made through interior and southcentral Alaska (Mitchell 1979a). Bluejoint is probably Alaska's most abundant native grass, frequenting communities throughout mainland Alaska except in the Arctic, where it is rare to absent. It often dominates grassland communities in southcentral to southwestern Alaska.

Sourdough, a tall, leafy grass, is adapted to tundra and forested regions throughout Alaska for sites that are wet to moderately dry. Bluejoint, like polargrass, tolerates strongly acid soils and appears immune to snow mold, but endures drier sites than polargrass. Sourdough can be used in arctic revegeta-

Figure 1: Excellent first-year growth was achieved by a planting of TUNDRA bluegrass at an arctic drill site in the Naval Petroleum Reserve. Philip Smith, an environmental manager for Husky Oil Co., inspects the seeding conducted under his supervision. The variety TUNDRA was developed from material of glaucous bluegrass collected in the Arctic.

Figure 2: Research plots of polargrass, left, and bluejoint reedgrass, right, pictured entering dormancy in early September in the Prudhoe Bay, arctic oil field, maintained vigorous growth in their eighth year after establishment. The grasses have not been fertilized since 1975. These entries were combined with other Alaskan collections to form the breeding material for their respective varieties, ALYESKA polargrass and SOURDOUGH bluejoint reedgrass.

tion mixes, particularly for the foothills region. Bluejoint has shown good persistence under a variety of conditions in forested and alpine and arctic tundra trials (Figure 2).

Unfortunately, seed production of bluejoint offers some difficulties (Klebesadel *et al.*, 1962). Trial plantings indicate probable yields of 20 to 50 lb/acre, though production on some plots has equalled 100 lb/acre. The seed disseminates soon after ripening and is readily scattered by winds. Thus, its harvest requires alertness. Also, without preventive attention, a varying percentage of the crop may be lost to insect or fungal infestations, which produce the condition known as silvertop (or white top). Because of the extremely small size of the seed, low seeding rates of 5 lbs or less per acre can produce good stands.

Alyeska and Sourdough have low seedling vigor, as is often the case with native grasses. When seeded in mixes with other well-adapted grasses, lower seeding rates will better enable the development of the native grasses.

NATIVE SEEDS HELP MEET REVEGETATION NEEDS AND SPECIFICATIONS

Specific seeding specifications sometimes require or promote the use of native grasses for revegetation purposes. On Amchitka Island, the U.S. Fish and Wildlife Service specified that only perennial species identical to those indigenous to the region could be used for revegetation on Amchitka Island. Revegetation was necessary to cover disturbances created in conjuntction with the nuclear-testing program. Preliminary trials indicated that seed of only two species, red fescue and Bering hairgrass (*Deschampsia beringensis*), could be made available for the purpose (Mitchell, 1976). Appropriate material of red fescue could be obtained commercially, but the Bering hairgrass was necessarily hand harvested from native stands, with over 400 lbs supplied for the effort in this fashion.

Sourdough bluejoint and Bering hairgrass seed stemming from research at the Palmer Experiment Station also have been used successfully in a revegetation project in the Glacier Bay National Monument, fulfilling native-seed specifications.

The Alaska Fish and Game Department confronted the experiment station with a particular problem in providing seed for a waterfowl-habitat project in a tidal area, thus requring plants with salt-water tolerance. Bering hairgrass seed from a population source that occurs in the high-tide zone of some tidal flats in the upper Cook Inlet, again, supplied the answer. Bering hairgrass now occupies some islands constructed in the Westchester lagoon in Anchorage, affording cover for waterfowl.

Of possible significance to seed growers of Alaska is the performance of Alaska-source material of Bering hairgrass seed in revegetation trials in Iceland (Mitchell, 1979b). The superior performance of experimental seed lots provided the Icelandic researcher, Thorsteinn Tomasson, has culminated in the purchase of over one ton of seed by the Iceland Soil Conservation Service for more extensive trials. This seed was grown by the Alaska Plant Materials Center. Work is currently underway at the Palmer Research Center of the Experiment Station to develop a variety for commercial release.□

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Persistence and Movement of Agricultural Chemicals in Soils in the Delta-Clearwater Area

by

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

What happens to agricultural chemicals when they are applied to the cool soils of interior Alaska during farming operations? Are they rapidly broken down into nontoxic compounds by soil microorganisms, or is this process retarded by the cool soil temperatures? Do they present a threat of contaminating ground and surface water supplies in developing agricultural areas of Alaska? With the recent expansion of large scale farming in interior Alaska, these questions and many others continually arise concerning the fate of chemical fertilizers and herbicides when applied to cool soils particularly when permafrost is present (Permafrost is a phenomenon occurring in cold regions wherein subsurface layers of soil remain frozen year around due to poor drainage and large amounts of insulating organic matter on the soil surface). In 1979, with land clearing underway in the 60,000-acre Delta Agricultural Project, a cooperative study was initiated between the University of Alaska Agricultural Experiment Station and the United States Department of Agriculture Soil Conservation Service with assistance from the Environmental Protection Agency. The objective was to study the persistence and possible movement of fertilizers and herbicides over one cropping season when these chemicals were applied to soils in the Delta-Clearwater area.

EXPERIMENTAL PROCEDURE

In the spring of 1979, three sites were selected on three different soil series representing a cross section of the wide range of soils in the Delta-Clearwater area. Site No. 1 was selected on a Richardson silt loam. This site had been under cultivation for approximately 30 years, but was close to some of the newly cleared lands. It represented some of the most productive soils in the area. The Richardson series is characterized by approximately 4 feet of silt loam overlying very gravelly coarse sand. No permafrost was present at this site, and the water table was at a depth of approximately 15 feet.

Site No. 2 was selected on a Nenana silt loam soil. This site was located on land which had been cleared during the winter of 1978-1979 and was cultivated for the first time in the spring of 1979. The Nenana series is representative of a majority of the tillable soils in the Delta-Clearwater area and is characterized by a mantle of silty soil approximately 20 inches thick overlying very gravelly sand. Permafrost was present within a foot of the soil surface in the spring of 1979, at the beginning of this study. The bottom of the permafrost layer was measured at approximately 65 feet. The water table in this area is at approximately 160 feet.

Site No. 3 was selected to represent some of the poorest agricultural soils in the area. The surface soil was almost pure sand and was initially classified as a Beales soil. However, later core drilling revealed that there was a buried Nenana silt loam soil underneath with approximately 18 inches of sandy outwash on the surface. For this study, we identified this soil as simply "sand." This site was cleared in 1978 but was cultivated for the first time in 1979. It was relatively close to Site No. 2 and had similar permafrost and groundwater conditions.

Barley and rapeseed appear to be the two most promising crops for the Delta-Clearwater area. The herbicides most frequently used on these crops, 2,4-dichlorophenoxyacetic acid (2,4-D) and trifluralin (Treflan), were selected for use in this study. The herbicide 2,4-D is used on barley and other small grains for the control of broadleaf weeds. It is applied after the barley and weeds have emerged and kills only those weeds with which it comes in contact during the spraying operation. Treflan is a preplant, incorporated herbicide used for broadleaf weed control in rapeseed. It is sprayed on the soil before planting and is worked into the soil with a tillage implement. In this study, a disk was used. Treflan stays in the soil and continues to kill germinating weeds until it is broken down by soil microorganisms. The fertilizers used for production of barley and rapeseed in the Delta-Clearwater area are nitrogen, phosphorus, and potassium. In this study, fertilizers in the form of urea, treble superphosphate, and potassium sulfate were broadcast prior to planting and incorporated with a single disking operation. No top-dressing was used.

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As soon as the three sites were identified in the spring of 1979, a series of soil cores was taken to a depth of 4 feet at each site. Two-inch diameter cores were taken using a Giddings hydraulic soil probe (Figure 1). The soil cores, an example of which is shown in Figure 2, were divided into 6-inch increments to a depth of one foot and 1-foot increments thereafter. These samples were analyzed for fertilizers and herbicides to determine what was present in the soil prior to beginning the study.

A normal rate of application for each of the two herbicides was determined to be one pound of active ingredient per acre. A normal rate of fertilizer application for these soils was determined to be 100 lb/acre nitrogen, 50 lb/acre P_2O_5, and 50 lb/acre K_2O. The study was designed so that each crop received fertilizer at a zero, normal, and four times normal rate in combination with the normal rate of herbicide; and herbicide at a zero, normal, and four times normal rate in combination with the normal rate of fertilizer. At each site, barley and rapeseed were randomly planted in six main plots. Each plot was split into five subplots, each of which received one of the five treatments described above and shown in Table 1.

Table 1. Herbicide and fertilizer treatments applied to barley and rapeseed plots

Barley				Rapeseed			
2,4-D (lb a.i./a.)[a]	fertilizer (lb/acre) N	P_2O_5	K_2O	Treflan (lb a.i./a.)[a]	fertilizer (lb/acre) N	P_2O_5	K_2O
0	100	50	50	0	100	50	50
1	100	50	50	1	100	50	50
4	100	50	50	4	100	50	50
1	0	0	0	1	0	0	0
1	400	200	200	1	400	200	200

[a]Pounds of active ingredient/acre.

After the plots had been planted and all fertilizers and herbicides applied, a furrow was plowed around each subplot. A typical ditched subplot is shown in Figure 3. A 1-gallon glass jar was buried in the lowest point of the furrow to catch a sample of runoff water which might flow off the plot during a rain. Only one rain was of sufficient intensity to cause any surface runoff. This occurred during early August; immediately afterward water samples were collected from the jar at each plot. The samples were frozen to preserve them for fertilizer and herbicide analyses. At the same time, water samples were collected from an area of natural vegetation nearby to compare their quality with those from the test plots.

In the fall, following the harvest, replicated soil cores were taken from each subplot. The cores were divided into 6-inch increments to a depth of 1 foot and 1-foot increments for the remaining portion. Soil samples for herbicide analyses were immediately frozen following collection and were shipped together with water samples to Raltech Scientific Services, Inc., Madison, Wisconsin. All soil samples for fertilizer analyses were frozen and delivered, again with water samples, to the state soil-testing lab at Palmer, Alaska. These samples were analyzed for ammonium and nitrate forms of nitrogen, total available phosphorus, and total exchangeable potassium.

RESULTS

Analyses of the soil samples collected in the spring prior to beginning the study showed no traces of 2,4-D or Treflan at any of the sites. The fertilizer nutrients—nitrogen, phosphorus, and potassium—were present in moderate amounts at all sites. This would be expected because these elements occur naturally in the organic and inorganic components of any soil. The Richardson soil, because it had been under cultivation for approximately 30 years, showed slightly higher amounts than did the Nenana or sand sites. This is largely due to the fact that Richardson is a deeper soil, had possibly accumulated fertilizer residues from past years, and had been cleared long enough to allow much of the natural organic matter as well as past crop residues to decompose and release the nutrients. The Nenana and sand sites were newly cleared, allowing little time for decomposition of organic matter.

No Treflan or 2,4-D was found in runoff water samples from either the Richardson soil or the sand. Traces of both herbicides were found in runoff water samples from the Nenana soil. These traces were slight, however, amounting to less than 0.5 ppm (part per million) in each case. The Nenana soil site was in a low area and had become completely flooded by water during the rain. The traces of herbicides found were most likely the result of sheet erosion of clay particles carrying the herbicides from the plots.

Nitrate and ammonium forms of nitrogen in the water collected from the plots at all sites were highly variable and averaged less than 1 ppm in concentration. Differences between sites were not significant. By comparison, approximately 0.5 ppm of nitrate and ammonium was found in runoff water from natural vegetation. Although levels of nitrate and ammonium slightly higher than 1 ppm were sometimes found in water from the more heavily fertilized plots, the results were not consistent. Total available phosphorus in the water samples from the plots at all sites averaged 0.07 ppm as opposed to 0.48 ppm from natural vegetation. There were virtually no differences among sites. Application rates did not appear to affect the concentrations of phosphorus in the runoff water at any site. Exchangeable potassium in the runoff water from the plots on the newly cleared land (Nenana and sand soils) did not differ significantly from potassium levels in water from the naturally vegetated area. All samples averaged about 1.6 ppm. Potassium levels in the runoff water from the Richardson soil were the highest, however, averaging 7.0 ppm. Again, the samples were highly variable and did not seem to reflect application rates. Several factors could have contributed to the higher potassium levels in the Richardson soil. The particular site on which the plots were located had been used as a dairy farm prior to its being cultivated for barley production. Manure contains high levels of potassium and there may have been some carryover. Richardson soils are the deepest of the soil types found in Alaska's interior. Potassium would not leach as readily through these deep soils as it would through the shallower Nenana and sand types. Further, potassium which had been applied during the time the land was cultivated could have remained in the soils also, contributing to the higher levels. The relatively small amount of applied potassium actually removed in grain would probably account in part for this.

Fall soil sample analyses showed very few traces of 2,4-D residues. Using instrumentation capable of detecting 2,4-D residue concentrations of greater than .02 ppm, traces of 2,4-D were found in only five of the 135 samples analyzed. All five of these samples came from the Nenana and sand soil types. The highest concentration found was 0.163 ppm. Treflan showed a considerably greater persistence than 2,4-D. Treflan residues were found in 34 of the 36 plots on which it had been applied at the three sites. Residues averaged 0.180 ppm on plots which had received the 1 lb a.i./acre application rate and 0.591 ppm on plots which had received the 4 lb a.i./acre application rate. All Treflan residues were found in the surficial 6 inches of the soil. No signs of leaching below that level were found.

Figure 1: The Giddings soil probe mounted on a 1¼ ton munitions truck being prepared to drill a deep core.

Figure 2: A view of a typical soil core taken in the silt-loam soils where project research was conducted.

Approximately 600 soil samples were analyzed for ammonium and nitrate forms of nitrogen, total available phosphorus, and total exchangeable potassium from the fall sampling period. A summary of the results of these analyses is shown in Figures 4, 5, 6, and 7. The figures indicate an average for the three sites. These results show fertilizer application rate had very little effect on fertilizer nutrient levels below the 6-inch depth. When fertilizer was applied at four times the normal rate, considerable residues were found in the surficial 6 inches as would be expected.

During this first year of cultivation of the newly cleared lands, the soils warmed up considerably allowing the permafrost level to recede below a depth of 14 feet where it was not detectable in cores taken with the hydraulic soil probe. The hydraulic soil probe used was unable to penetrate below this depth due to concentrations of coarse gravel in the soil profile. This warming of the soil allowed some nutrient release from decomposition of buried organic matter, particularly on the sand site where there was a buried Nenana soil layer. This layer had a high organic content which would account for a higher nutrient level at its location below the surface. The layer varied among subplots. In general, the nutrient release from buried organic matter at the Nenana and sand sites may account for some slight nutrient level increases between the spring and fall sampling periods.

Figure 3: Each subplot was surrounded by a ditch to catch runoff water. The ditches were dug after the plots were seeded using a small one-bottom mold board plow pulled by a garden tractor.

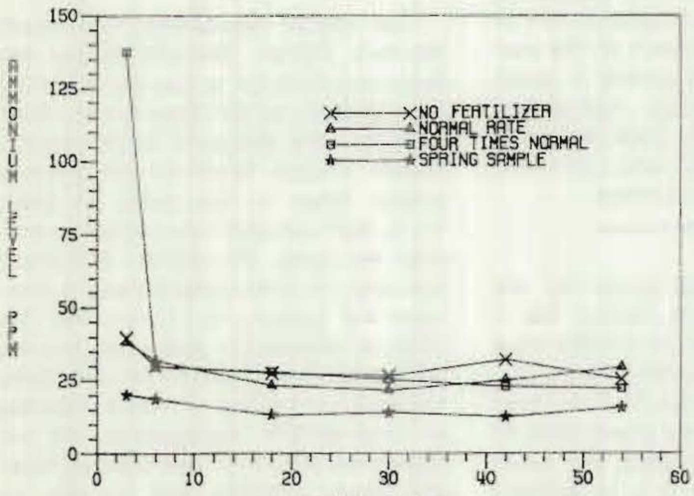

Figure 4: Average Ammonium Level of Rapeseed and Barley Plots with Sites Averaged.

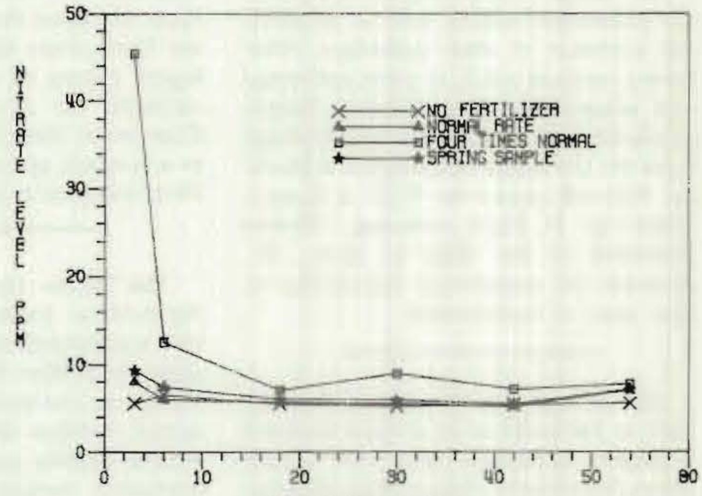

Figure 5: Average Nitrate Level for Rapeseed and Barley Plots with Sites Averaged.

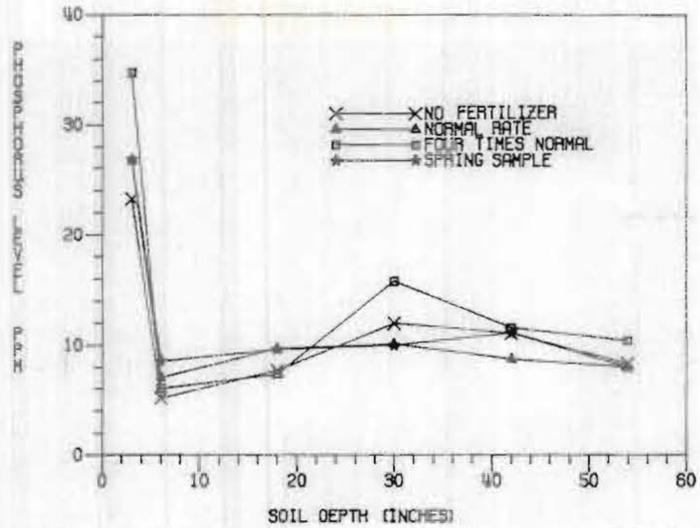

Figure 6: Average Phosphorus Level for Rapeseed and Barley Plots with Sites Averaged.

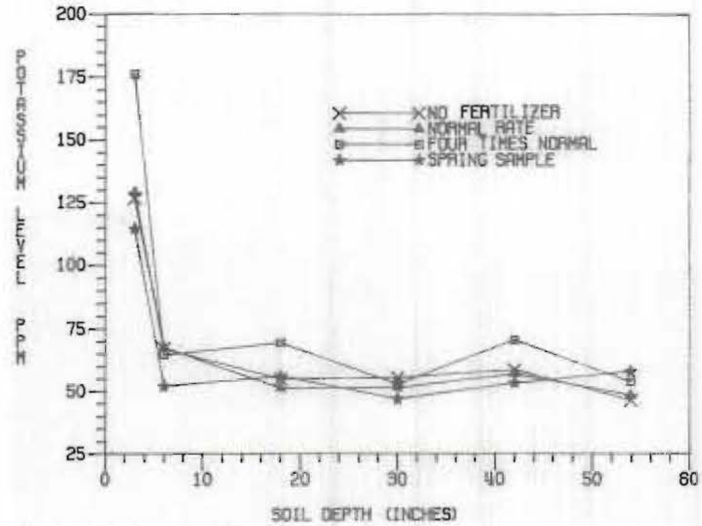

Figure 7: Average Potassium Level for Rapeseed and Barley Plots with Sites Averaged.

CONCLUSIONS

It must be recognized that this study reflects only one cropping season in a field environment that is undergoing change. However, several observations can be made based on these results. The average annual precipitation for the Delta-Clearwater area is only 11.5 inches. Recent work by William Alan Braley (master's degree candidate, Institute of Water Resources, University of Alaska, Fairbanks) in the Delta-Clearwater area showed that barley and rapeseed use almost all the available water leaving very little potential for leaching.

Some fertilizer nutrients may be released from organic matter in the soil as the soils warm after clearing. However, this release would be slow. Braley's studies show that during the warm summer season when decomposition is occurring, the net moisture movement in the soil is upward rather than downward, thus moving these nutrients into the crop root zone rather than down toward the groundwater table.

Agricultural herbicides showed no signs of leaching downward in the soil. Since these herbicides are chemically attracted to particles of clay and organic matter in the soil, very little movement would be expected. That practically all of the 2,4-D disappeared by the end of the growing season was expected. It was applied to the surface of the plants and soil where warm temperature allows it to degrade. Treflan, on the other hand, was incorporated into the soil where temperatures are lower. Even given this fact, the degradation rate was slower than expected. Other studies at Fairbanks have shown these same results. In the Fairbanks studies, as much as 50% of the Treflan remained in the soil in the spring a year following application. Further work is needed in this area, particularly where the herbicides are incorporated into cool soil.□

NOTES

The Agricultural Experiment Station is pleased to announce the addition of several new staff members in a range of study areas and assigned to several of our research locations.

Dr. Jenifer Huang McBeath has joined the experiment station staff as an assistant professor of plant pathology. After having received a B.S. in plant pathology and entomology from National Taiwan University and an M.S. in plant pathology from the University of California at Davis, Dr. McBeath earned the Ph.D. at Rutgers University in plant pathology. Widely published in her field of study, Dr. McBeath has contributed two articles to this issue of *Agroborealis*

Dr. Jeffrey S. Conn has joined the staff at Fairbanks as an affiliate assistant professor associated with the United States Department of Agriculture, Science and Education Administration—Agricultural Research. Dr. Conn received a Ph.D. in August of 1980 from North Carolina State University in botany. He also holds a B.S. in wildlife ecology and an M.S. in biology from the University of Arizona where, as a graduate research assistant, he also worked in remote sensing of natural resources. In addition, at North Carolina State, Dr. Conn did post-doctoral work in the Horticulture Department on the ecological aspects of weed control in apple orchards. At the Alaska Agricultural Experiment Station, Dr. Conn will serve as a research agronomist who will study the control and biology of weeds.

The Homer Research Center for the Agricultural Experiment Station has a new superintendent: Dr. An Peischel who comes to us from Kansas State University. At Kansas, she received her Ph.D. in range animal nutrition from the Department of Animal Science and Industry. Her other credentials include: an A.S. in agribusiness and economics from Pennsylvania State University; a B.S. in animal industries from Southern Illinois University; and an M.S. in animal industries, also from Southern Illinois University, having concentrated her studies there on monogastric nutrition.

The Alaska Agricultural Experiment Station's Palmer Research Center has been commissioned to map and inventory the vegetation of the Upper Susitna River Basin for the proposed Susitna Hydroelectric Project. Work on this 2.5-year project began in the spring of 1980. Three staff members were added to conduct the work. Dr. William B. Collins, instructor in range management, is managing the project. Dr. Collins has five years of experience with deer and elk habitat and diet research at Utah State University and brings to Alaska expertise in range-wildlife management. He has experience also with free-roaming horse and burro nutrition and impacts on ranges of the western states. Dr. Collins has a B.S. in range management from Brigham Young University and M.S. and

Ph.D. degrees in range science from Utah State University.

Dorothy (Dot) J. Helm, range field and laboratory technician, is the botanical and plant-ecology specialist assigned to the vegetation sampling and plant-community analysis phase of this project. She will soon receive her Ph.D. from Colorado State University in range science, where her dissertation research was in determining optimum vegetation sampling techniques. She has research experiences with soils and vegetation ranging from alpine tundra to the sagebrush grass. Ms. Helm has a B.S. in mathematics from the University of Delaware; a M.S. in mathematics (computer science) from the University of Michigan; and a M.S. in range science (quantitative ecology) from Colorado State University. Her programming capabilities are very important to this project.

David Laneville, drafter, is responsible for the final mapping phase of this project. Mr. Laneville has prior experience with the Prudhoe Bay oilfield development and the Alaska Department of Transportation. He studied business and math in college and has vocational training in civil engineering, surveying, soil testing, and drafting. His skills with building have been needed in preparing the facility which houses the staff and equipment assigned to this project.

The Palmer Research Center has benefited greatly by acquiring this new talent. Their creation of vegetation maps for the study region is being done to not only fulfill the objectives of the proposed hydroelectric project but also to provide Alaska with maps and vegetation resource information that has heretofore been unavailable. In addition to mapping and characterizing vegetation/habitat units occurring in the Upper Susitna Basin, the research team will investigate what effects reduced river flow may have on the succession of floodplain vegetation and associated moose habitat. If the proposed hydroelectric project is installed, river flow downstream from the dam will be kept fairly constant, thus discontinuing seasonally high flows. Some researchers have hypothesized that high water acts as a disturbance which keeps vegetation in serial stages most preferred by moose for feeding areas. This aspect of the study will also provide information usable beyond the needs of the feasibility study; much is expected to be learned about moose requirements and habitat management alternatives.

The Alaska Agricultural Experiment Station is providing a staff member, Dr. Jay D. McKendrick, to serve with Mr. W. I. "Bob" Palmer as Governor Jay Hammond's designee to the Staff Advisory Council of the Subcommittee on Range Resource Management for the National Governors' Association. Governors John V. Evans of Idaho and Bruch King of New Mexico are cochairmen of the subcommittee, which is composed of fourteen governors and has received endorsement from several groups, i.e. the National Cattlemen's Association, environmental organizations, and Federal land-management agencies as a vehicle to resolve conflicts surrounding uses of public rangelands in the western states. The Bureau of Land Management and U.S. Forest Service are two Federal agencies that have been cooperating most closely with the subcommittee on their various investigations. Dr. McKendrick chairs one of the six taskforce groups formed to focus on specific problems: that charged with identifying conflicts between Federal land statutes, policies, and regulations. The committee has prepared resolutions for the National Governors' Association on: coordinated resource management, predator control, wildlife management, and the desertification study by the Bureau of Land Management.

Dr. James V. Drew, Dr. John D. Fox, and Mr. Anthony Gasbarro participated in the second International Workshop on Forest Regeneration of Northern Latitudes in Sweden and Finland during August, 1980. Workshop sessions were held at the Swedish University of Agricultural Sciences in Umea and at Hallnas, Sweden. Forest scientists from several northern countries studied Scandinavian forest research to determine techniques applicable for the regeneration of white spruce in Alaska and the Yukon Territory. Swedish research in forestry was studied at the Institute for Forest Improvement in Savar, the Forest Nursery at Piparbole, and the Experiment Forest of Svartberget. Studies of northern forestry in Finland included observations of timber harvesting on the Vaasa archipelago and review of research at the Forest Field Station and Arboretum at Hyytiala, and the Haapastensyrja Tree-Breeding Station.

Dr. A. L. Brundage, Professor of Animal Science at the Palmer Research Center of the University of Alaska, accepted a temporary assignment at the University of Illinois as visiting professor in the Department of Dairy Science during the 1980 spring semester. His primary responsibility was to teach a graduate-level course in quantitative genetics. The course was cross-indexed in biology and included: the mathematical theory of the genetics of quantitative traits: properties of random-mating populations; estimates of repeatability, heritability, and genetic correlation; genetic results of selection; selection methods; correlated response; and selection for more than one trait. In addition to his teaching responsibilities, Dr. Brundage provided some statistical consulting services in support of the dairy-science research program at Illinois. During this time, he retained full responsibility for the dairy research program in Alaska and maintained close contact with his office in Palmer.

Dr. Brundage was also selected to participate in the 17th Annual International Stockmen's School at Tucson, Arizona in January. He was one of 88 guest professors presenting an intensive series of lectures to livestock producers in a continuing-education program sponsored by the Agriservices Foundation and the University of Arizona. The school included simultaneous sessions concentrating on general cattle, beef cattle, cow-calf operations, cattle finishing, dairy cattle, horses, sheep and goats, and one of general interest. Dr. Brundage presented two lectures in the session of general interest, "The genetics of a population, wishful thinking vs. probability" and "Selection index theory and its use in animal breeding."

Dr. Alan Jubenville, associate professor of land resources management, is the recipient of an Andrew J. Mellon Foundation Grant designated for travel for the purpose of professional improvement. Dr. Jubenville will use his grant monies to visit a number of universities and agencies in order to assess the state of the art in environmental interpretation during the spring semester of 1981.

The revegetation of coal spoils is the subject of a research effort for which funding has been renewed by the Office of Health and Environmental Research of the Department of Energy. Coinvestigators working on the project the areas on which each is concentrating his study efforts are: Dr. Wm. W. Mitchell, principal investigator, working with plant materials and their application; Dr. George Mitchell, working on soil problems; and Dr. Jay D. McKendrick working on native plant communities and related fauna.

Continued on page 66

News and Comment:

Combines were operating in the fields on the Delta Project by early September. The scene is quite different from the previous September when black spruce and moss covered these same areas which are now producing feed grains for use in Alaska and in other parts of the world.

Delta Agricultural Project - Success or Failure?

by

Robert Pollock
Executive Director
Alaska Agricultural Action Council

Occasionally I have been asked about the success or failure of the Delta Agricultural Project. I have also heard that success must be demonstrated prior to continued progress.

To make a judgment on the success of the project after only 24 months of actual development (since the original land sale) would be premature. The U.S. agricultural industry was developed over a period of 200 years and Alaska's agricultural industry is just beginning to expand. On the other hand, as a demonstration of agricultural development and identification of problems that must be solved in establishing an agricultural industry, the Delta Agricultural Project is a success.

In only two years, vegetation on nearly 54,000 acres has been knocked down, 34,000 acres of this has been piled into berms, and one-third of the entire project is ready for production. Although there have been problems and questions, individual, private entrepreneurs, with the help of state support and loan financing, have proved that they can clear large acreages efficiently.

The Delta Project has proven its ability to produce grain yields beyond the expectations of even the most ardent agriculturalists. Commercial barley fields have recorded yields averaging better than 70 bushels per acre. Its quality has withstood scrutiny by the United States Department of Agriculture Federal Grain Inspection Service and the state's livestock producers.

Because of the Delta Agricultural Project, primary data can now be used in an economic assessment of a grain-producing industry in interior Alaska. In the past, most economic studies had to be based on assumptions from sources outside of Alaska. With facts and figures from actual farm operations near Delta Junction, it can now be said that the economic feasibility of grain production is very real—although it is also very dependent on the continued growth of the industry.

In addition to substantiating many of the agronomic and economic claims of early supporters, Alaska's agricultural development is beginning to have a definite impact on the state's

The Alaska Farmers Cooperative elevator is handling most of the 6,500 to 7,000 tons of grain harvested in the Delta Junction area during the 1980 season. It has a current capacity of 10,000 tons and will continue to be a key handling facility in the area.

Commercial barley fields yielded as high as 70 bushel to the acre. Windbreaks 1/4 mile apart are required on all Delta Project farms and are visible to the right and left of this barley field.

economy. The estimated employment supported directly by agriculture near Delta Junction exceeds 150 people. The indirect employment is much greater and only beginning to develop to the point that it can be assessed. Moreover, the ability to buy "Alaskan grown" food supplies of better quality and at competitive prices is starting to emerge. Also, the Delta Agricultural Project demonstrates that Alaska can professionally manage and develop its agricultural resources.

Even though the Delta Agricultural Project has demonstrated Alaska's agricultural potential, it has also identified some obstacles to further development. If Alaska's agriculture is to achieve the same relative stability of the industry in the lower 48 states, a sufficient land base must be available to create the economies of scale so vital to agriculture. Marketing, transportation, processing, and production facilities that are critical for even the first phase of agricultural development cannot become cost efficient and competitive until certain critical volumes are reached.

Production by itself is useless. Livestock producers in the state now have access to local feed supplies at prices more favorable than ever before, but the industry cannot expand until the need for slaughter and processing facilities is filled. Even if the livestock industry were to grow and expand, it would probably still not require the volume of feed that must be demanded in order to support the infrastructure of the grain industry. The counterpart to the livestock feed market, then, is to export Alaska's grain, but this option will not be viable until competitive transportation facilities are available. Competitive pricing of Alaska's grain supplies on the world market will encourage the livestock industry in Alaska.

If Alaska's agriculture is to continue developing, one additional segment must be given considerably more attention: agricultural research. Nobody ever said that starting an agricultural industry above 64 degrees latitude would be easy or without problems, but without adequate professional research into cultural practices, genetically adapted varieties, marketing, and many other areas, the chances of success are greatly reduced.

The answer to the question mentioned at the start of this commentary is "yes, the Delta Agricultural Project has successfully demonstrated the potential of Alaska's agriculture." On the other hand, the further development of the potential will not occur accidentally, any more than the progress of the last two years was accidental. Only with the continued support of the state in administration, development financing, and facility construction; the continued cooperation of the many agencies, each vital in their own area of expertise; and most of all the perseverance of the private entrepreneur doing the actual farming, will Alaska's agricultural development continue successfully.□

The Delta Project is shown using color infrared photography at an altitude of 63,000 feet. The clearly defined, redder areas indicate crops growing in the Delta Project and on older lands near Delta Junction. The greenish areas are lands on which the trees have either been removed or knocked down but no crops planted. The distance from the Tanana River (left in photo) to the Gerstle River (first to the right in photo) is approximately 38 miles.

NOTES: Continued

Dr. William G. Workman and Edward L. Arobio have received a grant from the Alaska Department of Natural Resources to conduct a study of potential fee-setting mechanisms applicable to the use of state-owned land for livestock-grazing purposes. The study focuses on those procedures best suited to Alaskan grazing situations and on meeting specific criteria set forth by the Department of Natural Resources, thus providing the state with viable options for calculating livestock-grazing fees.

Dr. Keith Van Cleve, Director of the Forest Soils Laboratory (AES) is on sabbatical leave this year in England. He is examining the techniques of nutrient analysis used at Merlewood Research Station's Institute of Terrestrial Ecology at Grange-over-Sands in Cumbria, England.

Principal investigator, Dr. James V. Drew, heads a team of researchers studying the effects of various tillage systems in interior Alaska. The two-year project is being funded principally by the United States Department of Agriculture, Science and Education Administration. Substantial areas of new lands are being cleared in interior Alaska for the production of barley and rapeseed. The behavior of these soils under a variety of conservation tillage systems is not yet known. The unique soil-temperature and photoperiod conditions of interior Alaska do not permit the direct transfer of data obtained at more southerly latitudes. This research is aimed at determining the effect of several tillage systems for the production of barley and rapeseed on soil loss; soil temperature and moisture regimes; soil organic matter, pH, nitrogen, phosphorus, and potassium; crop-disease populations; yields of barley and rapeseed; and costs, inputs, returns, and energy requirements. The data derived from this study will be evaluated in order to determine the best management practices for the conservation of soil and water in this area of Alaska.

HAPPY BIRTHDAY

Cooperative Extension Service Celebrates its 50th New Year

The Experiment Station's partner in making research available to the public, the Cooperative Extension Service, is celebrating its 50th New Year in Alaska.

The Extension Service began providing practical information to Alaskans while the farmers of the Matanuska Colony were still in tents. Before the parcels were allotted or the ground broken, Extension Agents were helping the new settlers adapt to a demanding climate. Today Extension agents are still helping new settlers as well as the oldtimers manage their resources better, use research results more effectively, and enjoy life.

Under the Land-Grant University concept, the University of Alaska has the charge to not only conduct research that can be applied to Alaska's problems, but also to make the knowledge garnered from research available to the people in Alaska in a form that can be easily understood and readily applied.

The Extension Service has the charge to be the outreach arm of the university specifically as it relates to practical information in the subject areas of agriculture, Marine Advisory Program and Fisheries Extension, natural and community resource development, local government education and assistance, human development and home management, nutrition, housing, and 4-H and youth programs.

The Extension system of noncredit, informal education utilizes workshops, meetings, television, radio, newspapers, computers, newsletters, publications and face-to-face, one-to-one assistance. The Extension Service takes education to Alaskans wherever they live within the limits of the resources available.

The Experiment Station is looking forward to many more years of partnership with the Extension Service. In fact, we hope to cooperate more fully than ever before in providing the knowledge that will help to develop a strong and growing agriculture in Alaska.

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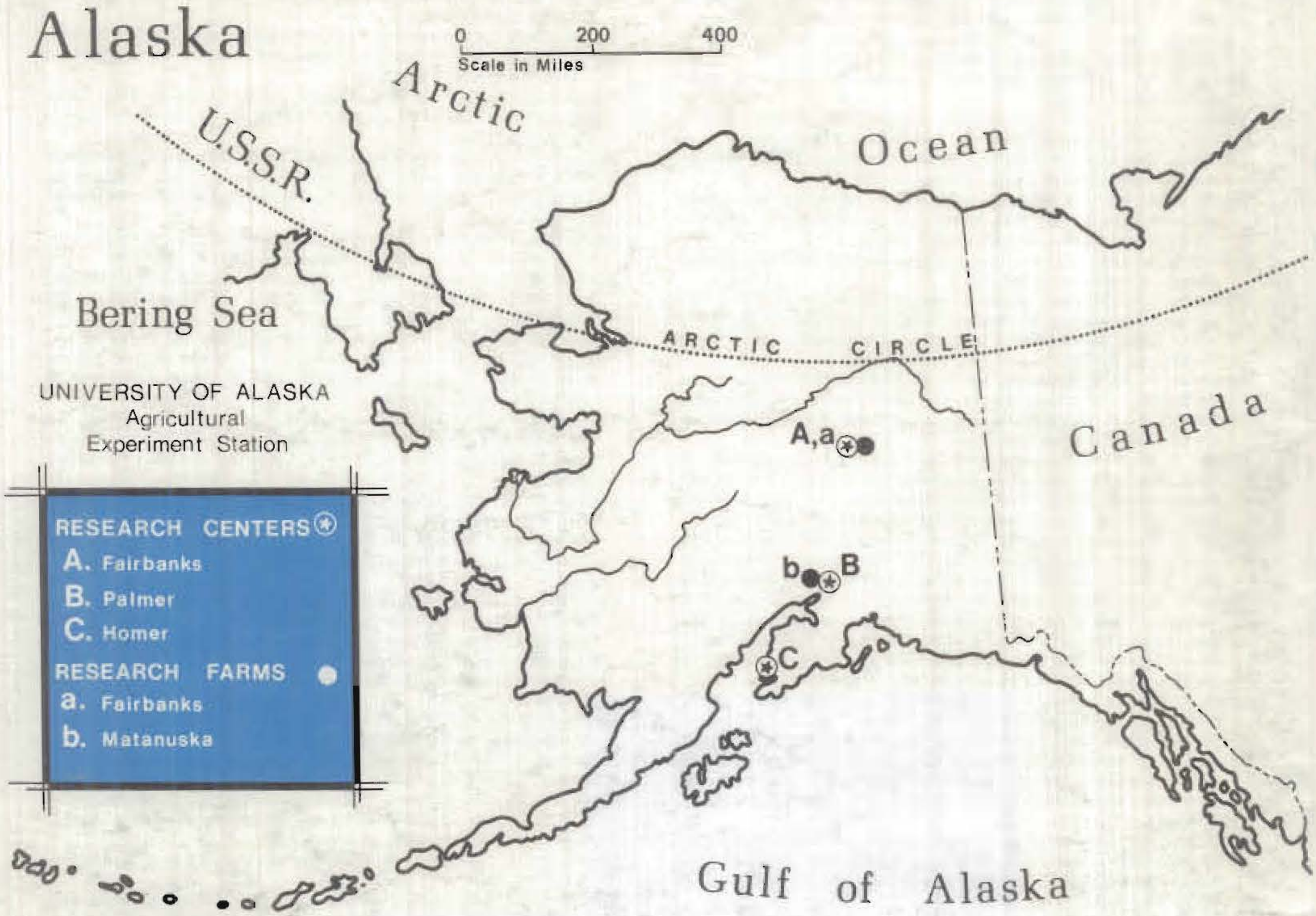

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