Agroborealis

Volume 15, January/1983

Agricultural Experiment Station
University of Alaska

From The Director's Desk

Since the turn of the century, research at the Alaska Agricultural Experiment Station has focused on the needs of Alaska's agriculture. This has resulted in improved varieties and cultural practices for crop production, new animal-breeding and management systems for livestock production, and research for the management of forest lands. In addition, it has provided research results in agricultural economics for the expansion of Alaska's agricultural industry.

The goal of Alaska's agricultural development is to place 500,000 acres of new land in crop production by 1990. This schedule is designed to reduce the problems of limited agricultural land in private ownership, small and scattered farms, costly supply and marketing systems, and inadequate financing that have hampered Alaska's agricultural development in comparison with other states. Equally important are new initiatives in agricultural research.

Traditionally, agricultural research has been carried out by state agricultural experiment stations in the nation's land-grant universities. To this end, the Hatch Act of1887 authorized the direct payment of Federal funds on a formula basis to establish agricultural experiment stations in each state. Additional legislation increased the Federal authorization, and the McIntire-Stennis Act of 1962 provided Federal funds for forestry research.

Subsequent legislation extended authorization for Federal payments to agricultural experiment stations in Alaska, Hawaii, and Puerto Rico. Today the states themselves carry a major share of the fiscal responsibility for agricultural research.

Nationally, the annual rate of return per tax dollar invested in agricultural research is 30 to 50 percent. This is higher than the before-tax rate of return for investments in other segments of the economy.

When agricultural research and extension are integrated in the land-grant university system, they have proved to be an unbeatable combination to support the successful development of agriculture. The involvement of U.S. land-grant universities in underdeveloped countries through Title XII of the Federal Foreign Assistance Act of 1961 indicates that effectively supported and integrated agricultural research and extension have been the most successful system of research and education for agricultural development.

The success of agricultural development in Alaska is closely related to new research and technology that can be implemented in that effort. New research is needed:

- to develop small grain varieties with improved agronomic characteristics for Alaska;
- to improve engineering designs for harvesting, drying, and storing small grains under Alaskan conditions;
- to reduce losses of crops from weeds, diseases, and insects;
- to improve animal health and nutrition;
- to improve marketing for Alaskan agricultural commodities.

This issue of *Agroborealis* reports some research in progress at the Alaska Agricultural Experiment Station to improve the production of crops and livestock in Alaska and to protect Alaska's agricultural and forest resources.

James V. Drew

James V. Drew, Director

Agroborealis

January/1983 **Volume 15**

Agricultural Experiment Station
School of Agriculture and
Land Resources Management
University of Alaska

Agroborealis is published under the leadership of the AES Publications Committee: J. V. Drew, A. L. Brundage, L. J. Klebesadel, J. D. McKendrick, A. Jubenville, and S. H. Restad. Please address all correspondence regarding the magazine to: Mayo Murray, Managing Editor, Agricultural Experiment Station, University of Alaska, Fairbanks, Alaska 99701.

Managing Editor . . . . .Mayo Murray
Composition. . . . . . Melanie Hassebroek

Printed by United Graphics, Seattle, Washington.

Agroborealis is published by the University of Alaska Agricultural Experiment Station, Fairbanks, Alaska 99701. A written request will include you on the mailing list. The Agricultural Experiment Station at the University of Alaska provided station publications and equal educational and employment opportunities to all without regard to race, color, religion, national origin, sex, age, physical handicap, or veteran status.

Table of Contents

ABOUT THE COVER . . . *Good farming practices yielded 75 bushels of barley per acre for Delta Junction farmer Barney Hollembaek. This September photograph was taken on Hollembaek's Tract O farm on the Delta I project.* Photo by Cathy Warren.

Figure 1. Conservation-tillage research plots in the Delta-Clearwater area of interior Alaska.

Conservation–Tillage Research in Interior Alaska

A Progress Report

By

Carol E. Lewis*

INTRODUCTION

The loss of soil on agricultural land through erosion by wind and water is an increasing concern worldwide. Conservation-tillage methods which reduce soil erosion are being developed and applied in many areas. In temperate as well as northern environments, conservation tillage requires use of new systems of soil management which differ from traditional techniques.

*Associate Professor, Resource Management, Agricultural Experiment Station, Alaska.

Field operations which leave crop residues on the surface as crops are planted and weeds are controlled help reduce soil erosion. Crop residues anchored to the soil surface protect the soil from wind and water erosion. The fewer operations used in reduced tillage mean a larger area can be covered than with more intensive cultivation techniques. Farmers using reduced tillage must manage their operations in a timely manner and must understand the use of new systems and their effects on crop yields.

Tillage in traditional soil-management systems has been used to prepare the soil for seeding as well as to control weeds, insects, and diseases. Conservation-tillage systems must perform these functions and may also provide moisture conservation by leaving crop residues on the soil surface. These residues provide physical protection from wind and water erosion, reduce evaporation loss, and trap and hold snow during winter months.

Conservation-tillage systems use equipment capable of seeding into a soil surface which has not been cleanly tilled. These systems range from those using some tillage to those which use no tillage but depend more on the use of pesticides for weed, insect, and disease control.

Some disadvantages of conservation-tillage systems include reduced soil temperatures in spring and increasing problems with weeds and diseases. Thus, there is a requirement for greater management ability (Bentley et al., 1978; Oldenstadt et al., 1982; Pidgeon and Ragg, 1979; Stobbe, 1979; Zentner and Lindwall, 1978).

SOIL CONSERVATION NEEDED AT DELTA

Increasing agricultural development for small-grain production in the Delta-Clearwater area of interior Alaska has highlighted the need for conservation of the silt-loam soils of the area. In addition, conservation of soil moisture is important in view of the area's low average annual precipitation of 11.5 inches.

Traditional soil management includes removal of the straw in the fall following harvest. The soil is disked two or three times in the spring to incorporate residues and prepare the seedbed after fertilizers are applied. Intensive disking in the spring results in an enormous loss of soil moisture and increases the vulnerability of the soil to wind erosion. Moreover, seed germination may be 3 to 4 weeks late due to lack of moisture. Late germination will delay harvest and result in a higher probability of losses from frost and snow.

In 1980, the Agricultural Experiment Station in cooperation with the U.S.D.A. Soil Conservation Service began conservation tillage research in the Delta-Clearwater area. In view of cool soil conditions, a short growing season, and the long daylength in interior Alaska, the results of soil-conservation tillage research at lower latitudes may not be applicable. Although research involving a 3-year cropping sequence is not yet complete, the first 2 years of study have yielded useful information.

STUDY DESIGN

Conservation tillage research was established in 1980 in the Delta-Clearwater area on Nenana silt-loam which had been farmed for 15 years. The site is nearly level and well drained. The soil consists of silt-loam, approximately 12 inches in depth, overlaying coarse sand and gravel. Straw residues remaining following the production of barley the previous year were approximately 900 lb/a. Since the site is nearly level, there is little hazard for water erosion. However, the wind-erosion hazard is moderate to severe (Schoephorster, 1973).

Production systems within the experiment (Table 1) were established on plots approximately .25 acre in size (Figure1). The tillage systems used in the study were: 1) maximum till (chisel plowing and two diskings prior to planting), 2) minimum till (one disking prior to planting), and 3) no-tillage (no tillage treatment). A 3-year rotation (barley-rapeseed-fallow) and continuous barley (barley+) were used. The barley plots were

Table 1. Crop Management Systems Used in the Delta-Clearwater Study.[a]

Barley on rape stubble	No-Till	Spring broadcast fertilizer, seed barley, spray Paraquat, spray 2, 4-D
	Min-Till	Spring broadcast fertilizer, disk once, plant barley, spray 2, 4-D
	Max-Till[b]	Fall chisel with 2" twisted points, spring broadcast fertilizer, disk twice, plant barley, spray 2, 4-D
Rape on fallow	No-Till	Spring broadcast fertilizer, plant rapeseed, spray Paraquat, spray TOK/RM
	Min-Till	Spring broadcast fertilizer, disk once, plant rapeseed, spray TOK/RM
	Max-Till[b]	Fall broadcast fertilizer, spring spray Treflan, disk twice, spring plant rapeseed.
Fallow[c] on barley stubble	No-Till	Spray Roundup or Paraquat, as needed
	Min-Till	Spray Roundup or Paraquat, chisel with 16" sweeps as needed.
	Max-Till[b]	Fall chisel with 2" twisted points, disk as needed.
Barley+ on barley+	No-Till	Spring broadcast fertilizer, plant barley, spray Paraquat, spray 2, 4-D
	Min-Till	Spring broadcast fertilizer, disk once, plant barley, spray 2, 4-D
	Max-Till[b]	Fall chisel with 2" twisted points, spring broadcast fertilizer, disk twice, plant barley, spray 2, 4-D

[a]Although fall operations were specified, frozen ground conditions following harvest prevented them from being accomplished. As a result, these operations have been performed in spring.
[b]Early freezing in 1979 and 1980 prevented fall fertilization and tillage.
[c]Paraquat was used in 1980. Because of unsatisfactory control of grass, Roundup was used in 1981.

seeded at a depth of 1.5 to 2 inches with a Haybuster double-disk opener, no-tillage drill. The no-tillage rapeseed plots were also seeded with the Haybuster no-tillage drill to a depth of approximately .5 inch. A Brillion seeder was used to seed the minimum- and maximum-tillage rapeseed plots also to a depth of .5 inch.

'Galt' barley treated with Vitavax was seeded at 72 lb/a. 'Candle' rapeseed was seeded at 6 lb/a.

Nitrogen (N) as urea was broadcast on one-half of each plot and as ammonium nitrate on the remaining half. In the 3-year rotation plots, N as urea was broadcast at a rate of 163 lb/a of 46-0-0 (75 lb/a N); ammonium nitrate was broadcast at 220 lb/a of 34-0-0 (75 lb/a N). The barley+ plots received an additional 25 lb/a N as urea or ammonium nitrate per ton of residue present at planting time. Phosphorus (P) was banded in the row with the seed in all plots at the rate of 100 lb/a of 11-51-0 (11 lb/a N, 51 lb/a P_2O_5). Potassium (K) was broadcast on all plots as K_2SO_4 at the rate of 100 lb/a of 0-0-51 (51 lb/a K_2O).

Figure 2. Plots are direct combined, using a plot combine. Samples are collected, bagged, and tagged in the field.

Weed control was accomplished in the barley and barley+ plots using 2, 4-D in combination with tillage when maximum- and minimum-till systems were used. Paraquat in combination with 2,4-D was used on the no-tillage barley and barley+ plots. Treflan was used on the maximum-tillage rapeseed plots. TOK, a post-emergent herbicide, was used on minimum- and no-tillage rapeseed. No herbicides were used on the maximum-tillage fallow plots. Paraquat or Roundup was used with the minimum- and no-tillage fallow systems.

METHODS

In the spring of 1980 prior to fertilization, soil samples were taken in 2-inch increments to a depth of 6 inches. The plots were then fertilized and tilled according to the schedule of operations in Table 1. Residue on the barley plots averaged 900 lb/a. Thus, an additional 11 lb/a of N was added to the barley+ plots. The barley was planted on May 20 and 21. The herbicide Paraquat was used on the minimum- and no-till fallow plots.

A good stand of barley was obtained in approximately three weeks. The rapeseed was slow to emerge and resulted in a poor stand. Consequently, on June 27 the rapeseed was re-seeded with a cyclone seeder. Because of this late planting, the rapeseed failed to mature prior to killing frost.

A light snow on September 2, followed by cool, wet weather, delayed harvest. On September 29 and 30, a 4 x 20-foot strip was harvested from each barley plot (Figure 2). Late harvest and frozen ground prevented any fertilization or tillage in the fall.

In the spring of 1981, soil samples were again taken in 2-inch increments to a depth of 6 inches. The plots were fertilized and tilled according to the schedule in Table 1. Residue on the minimum- and maximum-tillage barley+ plots average 1,760 lb/a. As a result, 22 lb/a additional N were applied. Residue on the no-tillage barley+ plots averaged 2,400 lb/a requiring 30 lb/a additional N. Rapeseed was seeded on May 10, and barley on May 20. Roundup rather than Paraquat was used on the minimum- and no-tillage fallow plots to obtain a better control of perennial grasses.

A frost on August 15 damaged the crops. Barley was harvested on September 15, and rapeseed on October 1.

The soils were sampled following the harvest. The samples were taken in 2-inch increments to a depth of 6 inches.

PRELIMINARY RESULTS

Analyses of the 3-year rotations and the continuous rotation used in the tillage study will be completed in 1982; preliminary results for 1980 and 1981 and yields for 1982 are reported herein.

Average monthly temperature and precipitation during May through September of 1980 and 1981 were compared to 17-year averages (Table 2). Minimum temperatures were consistently higher in 1980 and 1981 than the 17-year averages. Maximum temperatures varied from higher than average in the spring of 1980 and 1981 to lower than average in the fall of those years. While May and July were lower in precipitation in 1980 compared to the average, precipitation was higher in the fall. The largest percentage of precipitation for 1981, on the other hand, occurred in July.

Table 2. Average Temperatures (°F) and Average Precipitation (in) from May through September 1980 and 1981 in the Clearwater Area

MONTH	MINIMUM TEMPERATURE			MAXIMUM TEMPERATURE			PRECIPITATION		
	1980	1981	17-YR AVG	1980	1981	17-YR AVG	1980	1981	17-YR AVG
MAY	34.5	35.6	29.8	64.1	65.4	59.6	.66	1.33	1.40
JUNE	41.9	41.3	40.3	67.5	69.6	69.0	1.93	1.72	2.12
JULY	46.9	45.0	43.6	71.7	66.1	71.5	2.10	4.68	2.56
AUGUST	41.1	40.5	40.3	66.9	65.5	67.9	2.35	1.27	1.76
SEPTEMBER	30.5	31.4	26.0	52.5	53.1	56.0	1.73	.82	1.40

	1980	1981	17-YR AVG
Last Spring Killing Frost	May 19	May 22	May 25
First Fall Killing Frost	Aug 24	Aug 17	Aug 25
Estimated Days in Harvest Season[a]: August 15-October 31	27	21	34

[a]The number of days in which harvesting was presumed possible assumes the first day in each time block of three days was a drying day in which no harvesting was possible.

SOURCE: D. M. Quarberg, Cooperative Extension Service, University of Alaska, Delta Junction, Alaska.

Table 3. Soil Surface Residue (lb/a) and Soil Aggregation (%) Results for Fall After Harvest 1980 and 1981[a]

TILLAGE METHOD AND ROTATION		SURFACE RESIDUE		SOIL AGGREGATION[b]	
1980	1981	1980	1981[b]	1980	1981
		Maximum Tillage			
Barley[d]	Fallow	1516	384	---[e]	33.9
Rapeseed	Barley[c]	1574	3834	---[e]	25.3
Fallow	Rapeseed	0	4564	2.9	34.5
		Minimum Tillage			
Barley[d]	Fallow	1554	662	4.8	38.3
Rapeseed	Barley[c]	1813	3350	3.2	29.5
Fallow	Rapeseed	614	3145	2.2	23.2
		No-Tillage			
Barley[d]	Fallow	3588	936	4.8	53.3
Rapeseed	Barley[c]	2427	3652	3.6	65.3
Fallow	Rapeseed	1334	3440	3.7	43.9

[a]In 1979, surface residue averaged 900 lb/a for the entire study area and soil aggregation averaged 9.5%.
[b]Percent of soil aggregates greater than .84 mm in diameter. The .84 mm diameter is the standard diameter used to determine the erodibility coefficent in the wind erosion equation. When about 75% of the surface soil clods or aggregates are stable and greater than about .84 mm in diameter, wind erosion is minimized, even if surface crop residues are absent (Woodruff and Siddoway, 1965).
[c]Values shown are for spring, 1982, prior to tillage. Early freezing and snow prevented measurements from being taken in the fall of 1981 after harvest.
[d]Barley and barley+ were averaged in 1980 and 1981.
[e]No measurements taken. Ground was frozen after harvest.
SOURCE: R. Boyer, USDA Soil Conservation Service, Delta Junction, Alaska.

Table 4. Total Available Nitrogen (N), Spring and Fall, 1981 (ppm)

CROP ROTATION		NO-TILL		MINIMUM TILL		MAXIMUM TILL	
1980	1981	SPRING	FALL	SPRING	FALL	SPRING	FALL
Rapeseed	Barley	38.7	24.4	42.3	33.1	49.1	32.2
Barley+	Barley+	50.7	32.6	52.1	35.4	52.8	38.2
Fallow	Rapeseed	59.2	35.2	62.9	31.7	133.8	37.7
Barley	Fallow	43.2	46.0	54.3	43.8	52.1	62.9

Table 5. Total Phosphorus (P), Spring and Fall, 1981 (ppm)

CROP ROTATION		NO-TILL		MINIMUM TILL		MAXIMUM TILL	
1980	1981	SPRING	FALL	SPRING	FALL	SPRING	FALL
Rapeseed	Barley	19.9	34.3	21.3	31.8	22.6	30.0
Barley+	Barley+	20.5	31.9	24.3	39.7	19.1	37.1
Fallow	Rapeseed	18.9	27.1	21.4	20.0	17.4	17.7
Barley	Fallow	17.6	27.5	23.8	34.0	19.5	24.2

In the fall of 1980, crop residues from barley ranged from 1516 lb/a to 3588 lb/a depending on the tillage system. Residues from rapeseed ranged from 1574 lb/a to 2427 lb/a. Crop residues present on the 1981 barley and rapeseed plots were greater than those in 1980 for all tillage treatments. Barley residue increased an average of 1500 lb/a, rapeseed residue an average of 2000 lb/a (Table 3).

Soil aggregation was not affected by tillage treatments in 1980. In 1981, however, aggregation of the soils in the no-tillage plots was greater than that for soils which received minimum and maximum tillage (Table 3).

Soil samples taken in the fall of 1980 showed an available N level of 45 parts per million (ppm), an available P level of 27 ppm, and an available K level of 97 ppm. Total available N was again measured in the spring and fall of 1981. Because there was only a slight difference between the two N sources, the values shown in Table 4 are an average for ammonium nitrate and urea. The average available N in the spring was approximately the same for all tillage treatments: 48 ppm for cropped plots. The spring no-tillage fallow plots had 59 ppm available N, the minimum-tillage 63 ppm, and the maximum-tillage 134 ppm. In the fall after harvest, there was again little difference in the amount of N available in the cropped plots. The average was 33 ppm. The no-tillage fallow plots showed a slight increase of 3 ppm of available N, the minimum-tillage a decrease of 10 ppm, and the maximum-tillage an increase of 10 ppm. In the spring and fall of 1981, available P and K were also measured (Tables 5 and 6). There was little difference in P between 1980 and 1981. The level of K had increased slightly for all tillage treatments.

The soil pH and organic matter were measured in the spring and fall of 1981. There was little difference in pH among tillage treatments in spring and again in fall (Table 7). The average pH, however, increased from 5.73 in spring to 6.36 in fall. Only soils

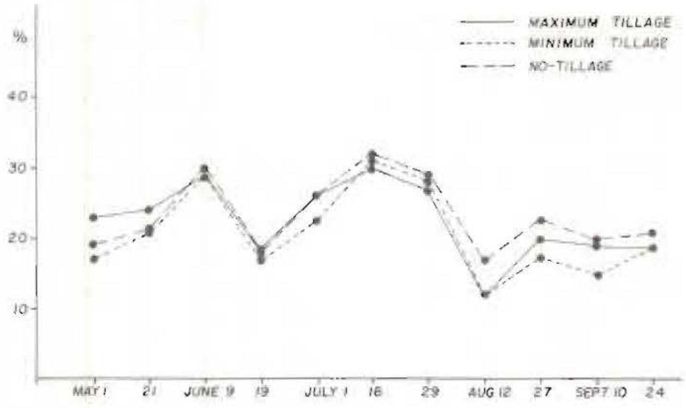


Figure 3. Per cent soil moisture for barley plots.

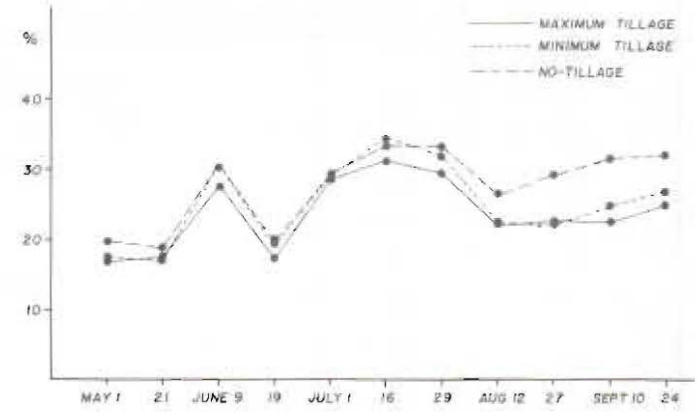


Figure 4. Per cent soil moisture for fallow plots.

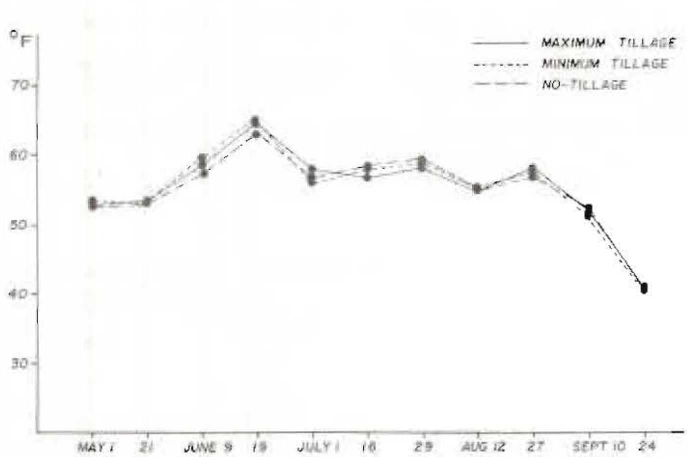


Figure 5. Soil temperature for barley plots.

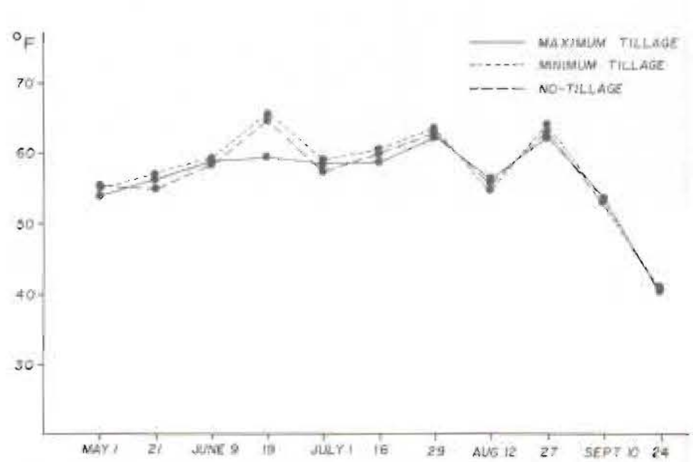


Figure 6. Soil temperature for fallow plots.

in the maximum-tillage rapeseed and fallow plots decreased in organic matter (Table 8). Differences from spring to fall were slight for all tillage treatments.

The various tillage methods had little or no effect on soil moisture and temperature in 1980. The accumulation of crop residues was evidently not great enough to influence these variables. More pronounced effects were noted on soil moisture in 1981 but not soil temperature. Figures 3 and 4 show the effects of tillage on soil moisture. The barley in rotation and the fallow plots were used as examples. The no-tillage plots had the highest soil moisture in the latter part of the season. The effect of tillage on soil temperature in 1981 is illustrated in Figures 5 and 6. Although there were variations in temperature with respect to tillage in midseason, no tillage treatment affected soil temperature more than another overall.

No-tillage plots in 1980 produced higher yields than the tilled plots (Table 9). Differences among tillage treatments were slight, however. The source of N had little effect on yield. In 1981, barley in rotation on the minimum-tillage plots yielded highest at 46 bu/a (Table 9). Barley+ yields did not vary by tillage method. Rapeseed yields were highest on the maximum-tillage plots. Again in 1981, source of N had little effect on yield.

In 1982, the source of N affected the yields of barley in rotation but not barley+ or rapeseed. Yields of barley in rotation which received ammonium nitrate were 10 bu/a higher than those on which urea was used when averaged over all tillage treatments. There was less than 1 bu/a difference in yields among tillage treatments for barley in rotation when ammonium nitrate was used. When urea was used, the no-tillage barley in rotation plots yielded the highest at 43 bu/a. Yields for barley+ differed little between maximum- and minimum-tillage treatment. Those for no-tillage were approximately 10 bu/a lower. Rapeseed yields were highest when planted using no-tillage.

DISCUSSION

The objective of conservation tillage research in the Delta-Clearwater area is to study soil-management systems which minimize soil and water erosion, are consistent with good weed control, maintain adequate soil moisture, and allow the soil to warm up early enough in the spring to produce satisfactory yields.

It was found that Paraquat would not adequately control perennial weeds in either the no-tillage or minimum-tillage fallow plots. As a result, Roundup was used in 1981. The control was adequate at a rate of 2 qt/a. Tillage alone was satisfactory in the maximum-tillage fallow plots. A good control of perennial grasses was not obtained in the minimum- and no-till-

Table 6. Total Potassium (K), Spring and Fall, 1981 (ppm)

CROP ROTATION		NO-TILL		MINIMUM TILL		MAXIMUM TILL	
1980	1981	SPRING	FALL	SPRING	FALL	SPRING	FALL
Rapeseed	Barley	156.4	135.3	126.2	146.8	118.7	122.0
Barley+	Barley+	136.6	154.9	122.3	135.5	123.0	120.1
Fallow	Rapeseed	105.7	110.0	116.3	114.2	150.2	77.1
Barley	Fallow	116.2	158.2	113.7	150.8	113.7	109.4

Table 7. pH Spring and Fall, 1981.

CROP ROTATION		NO-TILL		MINIMUM TILL		MAXIMUM TILL	
1980	1981	SPRING	FALL	SPRING	FALL	SPRING	FALL
Rapeseed	Barley	5.84	6.37	5.79	6.39	5.77	6.45
Barley+	Barley+	5.69	6.34	5.82	6.39	5.72	6.25
Fallow	Rapeseed	5.74	6.33	5.78	6.45	5.48	6.24
Barley	Fallow	5.84	6.25	5.78	6.36	5.66	6.17

Table 8. Total Soil Organic Matter, Spring and Fall, 1981 (%)

CROP ROTATION		NO-TILL		MINIMUM TILL		MAXIMUM TILL	
1980	1981	SPRING	FALL	SPRING	FALL	SPRING	FALL
Rapeseed	Barley	2.63	3.40	3.00	3.52	3.26	3.46
Barley+	Barley+	2.99	3.01	3.14	3.70	2.94	3.72
Fallow	Rapeseed	2.90	3.33	3.11	3.80	3.18	2.77
Barley	Fallow	2.96	3.30	2.84	2.90	2.97	2.73

Table 9. Yield Summary for Barley, Barley+, and Rapeseed for 1980, 1981, and 1982 (bu/a)

Tillage Method	Fertilizer Source	1980			1981			1982		
		B	B+	R	B	B+	R	B	B+	R
Maximum Till	Am. Nitrate	34.9	35.3	a	44.4	39.6	15.1	48.2	53.1	10.8
	Urea	38.2	33.3		43.0	43.1	13.7	33.9	62.5	12.7
Minimum Till	Am. Nitrate	30.7	28.6	a	49.3	42.1	11.0	47.9	56.6	13.3
	Urea	34.4	41.6		42.7	46.5	10.7	38.0	50.5	16.4
No-Till	Am. Nitrate	43.7	38.3	a	33.0	41.0	7.4	48.6	40.0	18.1
	Urea	35.1	46.0		36.4	41.6	5.6	43.0	41.0	15.8
Mean Values:										
Fert. Source:	Am. Nitrate	36.4	34.1		42.2	40.9	11.2	48.2	49.9	14.1
	Urea	35.9	40.3		40.7	43.7	10.0	38.3	51.3	15.0
Till. Method	Max. Till	36.6	34.3		43.7	41.3	14.4	41.1	57.8	11.8
	Min. Till	32.6	35.1		46.0	44.3	10.8	43.0	53.5	14.9
	No-Till	39.4	42.2		34.7	41.3	6.5	45.8	40.5	17.0

[a]Not harvested in 1980.

age barley plots when Paraquat was used. The herbicide 2,4-D adequately controlled broadleaf weeds in barley as did Treflan and TOK in the rapeseed.

Two important factors for conservation of soil and water resources are residue cover and soil aggregation. In the fall of 1979 after harvest, residues averaged 900 lb/a. In both 1980 and 1981, residues increased for all crops and all tillage operations. However, residues were greatest where tillage operations were not performed.

In the fall of 1980, there was little difference in soil aggregation among all tillage treatments. The average was 3.6%. After harvest in 1981, the percentage of aggregates had increased for all tillage treatments. The no-tillage showed the greatest increase with an average of 54.2%. Since increased surface residue and soil aggregation reduce soil erosion by wind and water, the measurements indicate that a no-tillage system would be most effective in terms of soil conservation.

Soil moisture and temperature in 1980 were not affected by different tillage systems. This is not surprising in view of the low amount of residue present from the 1979 crop. Residue increased in 1980, particularly on the no-tillage plots. This increase in residue more than likely explains higher moisture levels in no-tillage plots. In 1981, the no-tillage barley and fallow plots had the highest soil moisture, particularly toward the end of the growing season. The effect of increased residue on soil temperature was not as evident. Although some differences were recorded in midseason, they were not consistent enough to provide evidence that one tillage treatment had more effect than another.

Soil analyses in 1980 and 1981 indicate that there was a substantial carryover of total N from fall to spring. This was particularly evident in the spring of 1981 for the maximum-tillage plots which were fallowed in 1980. The 1980 rapeseed plots which were to be cropped to barley in 1981 had the least available N in the spring of 1981 for all tillage systems, the highest of which was for maximum-tillage. Highest available N was in the 1980 fallow plots which were to be cropped to rapeseed in 1981. The highest, again was for maximum till. By fall, soils in all cropped plots showed an average of 33 ppm available N with differences of approximately ±10 ppm for all crops and tillage systems.

Yield response to tillage method is one of the most important factors to the farmer. In 1980, yields among the tillage treatments were highly variable. Although no-tillage plots produced the highest barley yield, conclusions should not be drawn favoring no-tillage from a yield standpoint. In 1981, minimum-tillage plots produced the highest barley yield. Yields from barley+ plots showed no response to tillage treatments. Rapeseed yields from the maximum-tillage plots were highest. In 1982, no-tillage barley exhibited the highest yields as did no-tillage rapeseed. Barley+, however, had the highest yields when maximum-tillage was used.

These preliminary results indicate that no-tillage produces surface residue and soil aggregation more favorable to conservation of soil and water than minimum or maximum tillage. In the case of barley in rotation, minimum tillage as well as no-tillage produced the highest yields. A minimum-tillage system also produces surface residue and soil aggregation conducive to soil and water conservation. Barley+ plots in 1982 performed best under maximum tillage, the system least conducive to conservation of soil and water. Yields of rapeseed have shown no response pattern. The 1982 results do indicate, however, that there may be some years in which reasonable yields can be obtained for rapeseed using a conservation-tillage system. □

REFERENCES CITED

Bentley, C. F., J. M. Crepin, and K. W. Domier. 1978. No-tillage grain production in the Edmonton region. *Agriculture and Forestry Bulletin 1*(1):17-25.

Oldenstadt, D. L., R. E. Allan, G. W. Bruehl, D. A. Dillman, E. L. Michalson, R. I. Papendick, and D. J. Rydrych. 1982. Solutions to environmental and economic problems (STEEP). *Science 217*:904-909.

Pidgeon, J. D., and J. M. Ragg. 1979. Soil, climatic and management options for direct drilling cereals in Scotland. *Outlook in Agriculture 10*:49-56.

Schoephorster, Dale B. 1973. Soil Survey of Salcha-Big Delta area, Alaska. USDA-SCS, U.S. Government Printing Office, Washington, D.C.

Stobbe, E. H. 1979. Tillage practice on the Canadian prairie. *Outlook in Agriculture 10*:21-26.

Woodruff, N. P., and F. H. Siddoway. 1965. A wind erosion equation. *Soil Science Society of American Proceedings 29*:602-608.

Zentner, R. P. , and C. W. Lindwell. 1978. An economic assessment of zero tillage in wheat-fallow rotations in Southern Alberta. *Canadian Farm Economics 13*(6):1-6.

Soil Moisture and Temperature as Influenced by Fall and Spring Tillage Systems

By

Roger Boyer*

INTRODUCTION

Soils in Alaska, when not protected by vegetation, are highly erodible by wind and water. However, adequate soil-conservation practices exist to control erosion at or below levels acceptable for long-term agricultural productivity. In such areas as Delta Junction, where wind is the principle erosion force, measures designed to cope with this factor must be implemented on agricultural land. Windbreaks have long been recognized as one of the traditional methods of controlling soil erosion caused by wind. Conservationists agree that windbreaks alone, unless spaced very close together, are not adequate to control erosion (Craig and Turelle, 1964), and that the required close spacing is often not convenient for the farmer with large equipment.

A further complicating factor at Delta Junction is the recorded variability of the wind's direction. Winter winds blow down the Tanana Valley from the southeast to the northwest and summer winds come out of the Alaska Range down the Delta River from south to north. Further complicating this is the abrupt change of directions that can take place in spring and fall. To adequately protect the soil throughout the year, windbreaks, even if spaced closely, should ideally be designed in a grid – a pattern which would be unacceptable to farmers.

Another method of controlling wind erosion is to manage the crop residue (stubble) such that a portion remains on the soil surface for protection against the force of the wind. This practice has earned widespread acceptance by farmers in many different areas. Residue management has been shown to be very effective in controlling both wind and water erosion and in conserving soil moisture (Onstad and Otterby, 1979; Skidmore et al., 1979; Woodruff et al., 1972). In order to practice residue management, the number of tillage operations must be reduced or a type of tillage must be used that leaves part of the residue on the surface. Reducing the number of operations will also conserve energy and reduce costs.

Soil moisture and temperature are two critical factors for crop production that are presumed to be affected by tillage at Delta. Two types of tillage systems are employed there. One consists of fall disking with another disking in the spring just prior to seeding and packing. The other system deletes the fall disking. This latter system is a form of crop-residue management because the stubble is left standing over winter. Since 1978, we have been endeavoring to determine the effects that fall and spring tillage and spring-only tillage (conservation tillage) have on soil moisture and temperature.

*District Conservationist, USDA, Soil Conservation Service, Delta Junction, Alaska.

METHOD

Soil-moisture data were determined by collecting core samples of soil to a depth of 6 inches. Moisture was assumed to be the difference between the wet and air-dried weight of the sample. Soil temperatures were measured with a soil thermometer at 1.5-inch and 3.5-inch depths. All data were collected at midday, at 2-week intervals between soil thaw-out in the spring, and continued until the fall soil freeze-up occurred. Barley fields which were fall tilled and spring tilled (fall-tilled fields) and those that were just spring tilled (spring-tilled fields) were studied. No attempt was made to determine grain yields, as this would be influenced heavily by farmer management (seed variety, planting method, planting date, rate of fertilizer application, etc.).

RESULTS

Rainfall

Rainfall during the 1978 and 1979 growing seasons was lower than the long-term average, while the 1980 and 1981 seasons were average or slightly higher (Quarberg, 1982). Air temperatures were average for 1978 and 1979, and slightly cooler than average for 1980 and 1981.

Soil Moisture

Soil-moisture content in spring-tilled fields was higher 74% of the time. During the period of seed germination (May 1 through June 15), spring-tilled fields were higher in moisture content 94% of the time. The only two sample periods in which fall-tilled fields were higher in moisture content were during high rainfall periods in 1980 and 1981. Over the four-year period, the moisture content of the soil during the germination period averaged 4-12% more for spring-tilled (Table 1) than for fall-tilled fields. This is especially significant because average moisture in the fall-tilled fields was sometimes near the wilting point, i.e., barley could not have germinated. As the season progressed, the differences between spring- and fall-tilled fields decreased (Figure I). This seemed to be related to summer rains. It is interesting to note that, throughout the summer, the average moisture-content level of spring-tilled fields was equal to or higher than that of the fall-tilled fields, except for the July 1 period.

Table 1. Soil Moisture in the Top 6 Inches of Soil (%)

Date of Sample	Fall Tillage					Spring Tillage				
	1978	1979	1980	1981	Average	1978	1979	1980	1981	Average
4/15			18		18			20		20
5/1	20	15	12	36	21	21	29	17	64	33
5/15	14	9	11	23	14	23	13	36	15	22
6/1	19	8	9	20	14	22	13	16	28	20
6/15	12	13	11	34	18	23	19	10	34	22
7/1	9	19	18	33	20	19	22	18	33	18
7/15	8	7	10	31	14	17	13	8	40	20
8/1	8	19	10	32	17	11	25	11	37	21
8/15	12	6	8	28	14	14	12	10	26	16
9/1	15	24	21	29	22	10	24	19	36	22
9/15	10	14	19	30	18	11	14	20	41	21
10/1	16	8	24	36	21	13	8	21	41	21
10/15		10			10		15			15

Table 2. Soil Temperatures at 1½-Inch Depth in Degrees Fahrenheit

Date of Sample	Fall Tillage					Spring Tillage				
	1978	1979	1980	1981	Average	1978	1979	1980	1981	Average
4/15			54		54			54		54
5/1		68	50	57	59		63	48	45	52
5/15		77		59	68		68	43	57	55
6/1	68	91	81	68	77	66	82	77	68	73
6/15	72	75	81	70	75	72	72	81	64	72
7/1	75	77	72	57	70	77	79	75	55	72
7/15	73	77	86	70	77	70	75	77	68	73
8/1	81	68	73	61	72	75	68	68	61	68
8/15	77	79	70	64	73	70	73	70	66	70
9/1	63	52	68	59	61	61	52	63	59	59
9/15	63	61	48	50	55	61	59	48	50	55
10/1	34	50	52	39	43	37	52	52	34	45
10/15		34			34		34			34

Table 3. Soil Temperatures at 3½-Inch Depth in Degrees Fahrenheit

Date of Sample	Fall Tillage					Spring Tillage				
	1978	1979	1980	1981	Average	1978	1979	1980	1981	Average
4/15			37		37			36		36
5/1		48	37	43	43		41	36	32	36
5/15		52		45	48		50	32	46	43
6/1	54	61	59	59	59	50	57	55	57	55
6/15	59	54	57	63	59	59	54	59	59	57
7/1	61	59	64	52	59	61	57	64	52	59
7/15	64	66	63	63	64	63	63	63	61	63
8/1	66	63	61	57	63	65	63	61	59	63
8/15	63	63	59	61	61	59	61	57	63	61
9/1	54	48	54	54	52	54	48	52	54	52
9/15	52	50	45	46	48	46	50	46	48	48
10/1	37	45	45	36	41	45	37	45	34	41
10/15		34			34		34			34

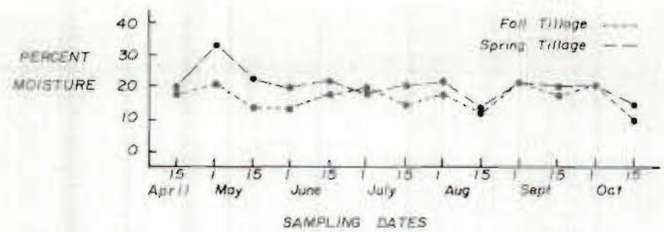


Figure 1. Per Cent Soil Moisture for Fall and Spring Tillage. Values are Averages for 1978-1981 Data.

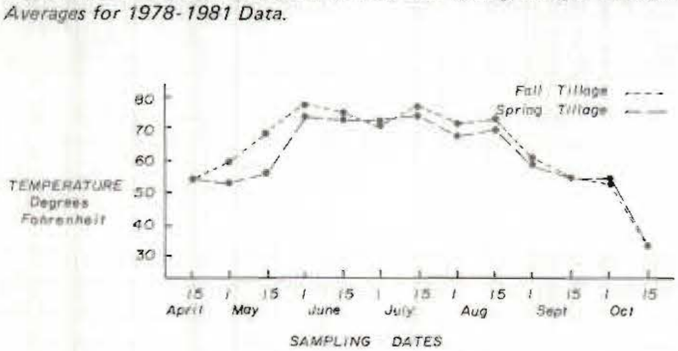


Figure 2. Soil Temperatures at the 1½-Inch Depth for Fall and Spring Tillage. Values are Averages for 1978-1981 Data.

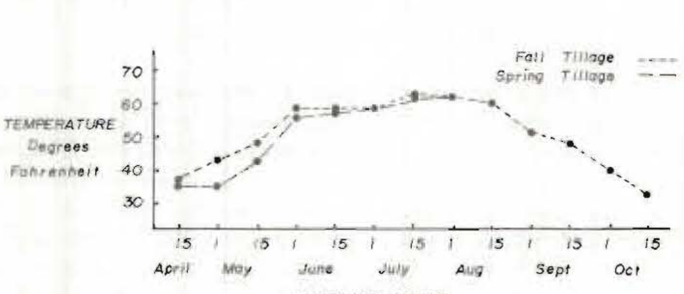


Figure 3. Soil Temperatures at the 3½-Inch Depth for Fall and Spring Tillage. Values are Averages for 1978-1981 Data. NOTE: From August 1 to October 15, Average Temperatures Were the Same.

Soil Temperature

Soil in fall-tilled fields tended to be warmer early in the spring and throughout the summer at the 1.5-inch depth than did spring-tilled fields (Table 2). Temperatures at the 3.5-inch depth tended to be more uniform, with fall-tilled fields being somewhat warmer (Table 3). Spring-tilled fields were a little warmer at this depth later in the fall. A direct comparision, by depth, between the two tillage systems is shown in Figures 2 and 3.

DISCUSSION

Tillage systems that conserve soil and soil moisture, reduce energy consumption, and ensure proper crop production are the ultimate goal of both the farmer and soil conservationist. A spring-only tillage system is highly desirable in that it has the potential to accomplish all of these objectives

Spring-only tillage allows full soil cover throughout the winter by crop residue and, after spring disking, leaves 50% of the residue to protect the soil prior to crop emergence. Spring tillage also helps conserve the precious soil moisture because the soil is disturbed less. Spring tillage tends to result in soil temperatures which are cooler than fall-tilled fields. In this study, no spring-tilled fields had temperatures too low for proper seed germination (above 40°F).

Bauer and Kucera (1978) compared several types of tillage systems in North Dakota for producing spring wheat. They obtained very similar results to those shown here. Spring tillage increased soil moisture and reduced soil temperature slightly.

During times of less-than-average rainfall, spring-tilled fields maintained moisture levels above the wilting point for barley (13%), while fall-tilled fields often fell below this level, thus causing stress on the crop. In years with above-average rainfall, only a slight, if any, advantage existed for spring tillage.

The major benefit of the spring-tillage system was the soil protection provided by the standing stubble. The standing stubble traps snow and effectively protects the soil from wind erosion. Wind erosion could also be prevented by a chisel plow operation in the fall. Chisel plows only reduce the surface residues by about 25% for each pass, versus 50% for a disk (see Figures 4, 5, and 6). It is unlikely that any fall tillage method would be equal to or better than fall chiseling for moisture conservation, as water storage increases proportionally with the amount of crop residues (Greb et al., 1970; Black and Siddoway, 1979).

It is assumed that small grains produce about 80 pounds of residue per acre per bushel of grain produced. Thus, a 50-bushel crop will yield about 4,000 pounds of residue. The U.S. Soil Conservation Service Standards and Specification call for 1,500 pounds per acre of small-grain straw for adequate protection of silt-loam soils from wind forces.

Crop residues have also been shown to be effective in reducing runoff and water-caused erosion (Onstad and Otterby, 1979). Even though surface residues may have a negative effect on soil temperatures, they can increase soil-moisture storage. Also, Black (1973) found that, as the amount of residue increased, the erodibility of the soil by wind decreased.

Most farmers at Delta till in the spring even if they have tilled the previous fall, and disking is the common method of spring seed-bed preparation. After fall and spring disking, only about 1,000 of the original 4,000 lbs/acre of stubble remain (75% total reduction). Soil Conservation Service Standards indicate that this amount is inadequate and recommend 1,500 lbs/acre of stubble to protect the soil from wind erosion until the growing grain crop provides enough cover to protect the soil. Along with the reduction of residue, disking in the fall also

Figure 4. Crop residue, left on the field in the fall, traps large amounts of snow over the winter.

Figure 5. A direct comparision of fall chisel plowing (left) and no tillage (right). Note the greater amount of residue and snow in the nontillage area. However, the chisel-plowed area has a very rough soil surface. Both conditions provide good protection against wind erosion.

Figure 6. A direct comparison of fall disking (left) and no tillage (right). Note the greater amount of residue and snow in the nontillage area.

tends to flatten the standing straw, thus eliminating most of the capacity for snow entrapment and moisture conservation.

A chisel-plow operation (25% reduction) in the fall would leave 3,000 pounds of residue. Followed in the spring by a disk (50% reduction), there would still be 1,500 pounds of residue left, enough to protect the soil. Chisel plows also tend to leave more straw standing upright (Skidmore, 1977), which helps to catch and hold snow (Aase and Siddoway, 1980). Presently no data exist for Delta concerning soil moisture following fall chisel plowing. Research needs to be conducted on this tillage practice. However, there are only one or two chisel plows in the Delta area at this time, and the large amounts of woody trash remaining on the newly cleared fields precludes their use.

One additional point should be made. Disking twice in the spring, a practice that has been common in Delta, leaves only 1,000 pounds of residue (50% reduction for each pass), not enough to protect the soil. These two spring operations could also result in a rapid loss of soil moisture conserved over winter and, in the absence of spring rain, could delay germination and maturity of the crop.

No-till systems are increasing in other farming areas of the U.S. and Canada. Such systems afford good control of soil erosion and also effectively conserve moisture (Deibert et al., 1978). Currently the University of Alaska Agriculture Experiment Station is researching this concept at Delta. Lewis (1983) found little significant difference in soil moisture and temperature between minimum tillage (one disking), maximum tillage (chisel plowing, plus two diskings), and no tillage (using herbicide for weed control). However, no-till had the highest grain production and definitely resulted in the greatest protection of the soil.

SUMMARY AND CONCLUSIONS

Fall-tillage and spring-tillage systems were investigated to determine their effects on soil moisture and temperatures. Spring tillage conserved more moisture in the surface 6 inches of soil and increased the probability of rapid seed germination. Fall-tilled ground tended to be slightly warmer, but spring-tilled fields were adequatlely warm for seed germination. Spring tillage has a substantial soil-conservation advantage because the standing grain stubble is left on the field over the winter for protection against wind erosion.

Taking into consideration field conditions (woody trash) and the lack of equipment (chisel plows), the best currently known system for seed-bed preparation, crop production, and soil conservation appears to be spring disking with no previous fall tillage. This tillage practice conserves moisture, prevents soil loss by wind, and conserves costly energy by reducing the number of trips across the field. □

REFERENCES

Aase, J.K., and F.H. Siddoway. 1980. Stubble height effects on seasonal microclimate, water balance, and plant development of no-till winter wheat. *Agricultural Meterology 21*(1):1-20.

Bauer, A., and H.L. Kucera. 1978. Effect of tillage on some soil physicochemical properties and on annually cropped spring wheat yields. North Dakota State University Agricultural Experiment Station. Bulletin 506. 102 pp.

Black, A.L. 1973. Soil property changes associated with crop residue management in a wheat-fallow rotation. *Soil Science Society of America Proceedings 37*(6):943-946.

Black, A.L., and F.H. Siddoway. 1979. Influence of tillage and wheat straw residue management on soil properties in the Great Plains. *Journal of Soil and Water Conservation 34*(5):220-223.

Craig, D.G., and J.W. Turelle. 1964. Guide for wind erosion control on cropland in the Great Plains states. U.S. Department of Agriculture, Soil Conservation Service. 104 pp.

Deibert, E.J., E. French, B. Hoag, and R. Nowatzki. 1978. No till: North Dakota research emphasis. *Farm Research 35*(4):3-7.

Greb, B.W., D.E. Smith, and A.L. Black. 1970. Water conservation with stubble mulch fallow. *Journal of Soil and Water Conservation 25* (2):58-62.

Lewis, C.E. 1983. Conservation-tillage research in the Delta-Clearwater area of Interior Alaska. *Agroborealis*, this issue.

Onstad, C.A., and M.A. Otterby. 1979. Crop residue effects on runoff. *Journal of Soil and Water Conservation 34*(2):24-26.

Quarberg, D. 1982. Climatological data for Delta/Clearwater. Mimeograph Report from Cooperative Extension Service, 9 pp.

Skidmore, E.L. 1977. Tillage research needed to reduce wind erosion. IN: Conservation Tilllage Research Progress and Needs. pp. 52-57. U.S. Department of Agriculture, Agricultural Research Service. ARS-NC-57.

Skidmore, E.L., M. Kumar, and W.E. Larson. 1979. Crop residue management for wine erosion control in the Great Plains. *Journal of Soil and Water Conservation 34*(2):20-24.

Woodruff, N.P., L. Lyles, F.H. Siddoway, and D.W. Fryrear. 1972. How to control wind erosion. Agricultural Information Bulletin No. 354. U.S. Department of Agriculture, 22 pp.

Planting and Fertilizing Options in Barley Production

By

Charles Knight*

INTRODUCTION

Spring planting time is a crucial period for Alaska's barley farmers. Given the short time during which the seed must be planted in order to reach maturity and Mother Nature's frequently uncooperative attitude at this time of year, farmers often find themselves with only 10 days to 2 weeks to plant thousands of acres of barley. Consequently, planting precision is often sacrificed for speed.

A common scenario of spring planting in interior Alaska could be described as follows: after the snow melts, fertilizer is broadcast on the fields while the ground is still frozen or as soon as the soil is dry enough to support equipment; fertilizer is incorporated as soon as possible with one or two disking operations; then barley is planted with a grain drill. If planting time is short due to wet weather, equipment failure, etc., the barley seed is broadcast with a fertilizer spreader and covered with a light disking operation followed by a packer. Occasionally this planting procedure works, but it is also time consuming, labor intensive, weather dependent, and highly susceptible to delayed seed germination and wind erosion.

PROBLEMS AND DILEMMAS

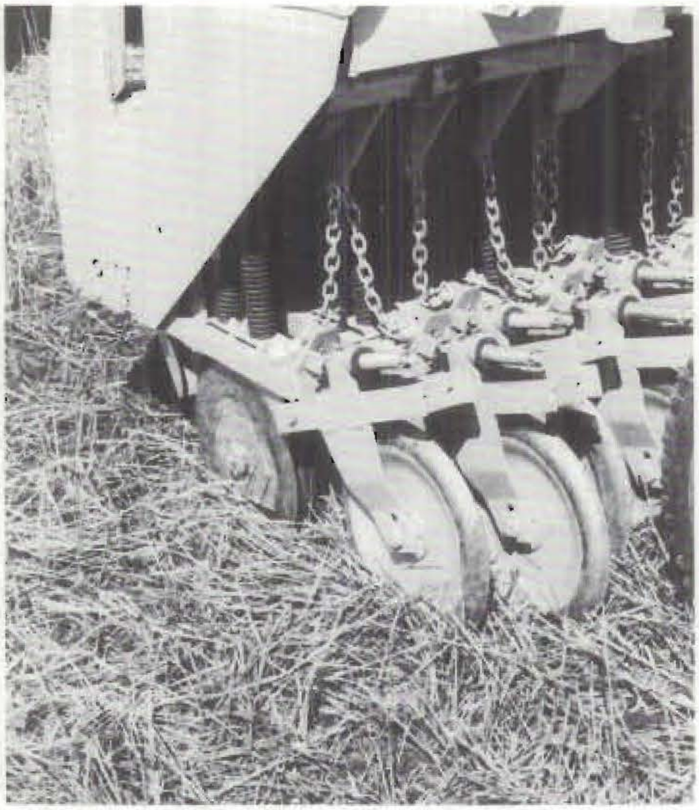
Danger of crop damage from early fall frosts can be greatly reduced if good seed is planted correctly, allowing the crop to get off to a quick start. Fertilizer, particularly phosphorus which moves very little in the soil, should be mixed down into the root zone and not left on the soil surface where it is unavailable for plant use. The fertilizer should be tilled into the soil as soon as possible following application to reduce possible nitrogen losses due to ammonia volatilization. Seed should then be planted immediately after the tillage operations before too much water has evaporated from the soil. Since water is lost by evaporation each time the soil is disturbed, and each field operation reduces the amount of crop residue on the soil surface, it is a real problem getting fertilizer properly incorporated and barley seeded with minimal losses of soil moisture and surface trash. If the field is worked enough to do a good job of incorporating the fertilizer, large amounts of surface trash and soil moisture have been lost leaving the field highly susceptible to wind erosion. Low soil moisture and a loose seedbed due to large amounts of incorporated straw may also delay seed germination and result in uneven crop emergence and delayed harvest.

If the farmer falls back on the broadcast method of seeding, he must expect to make certain sacrifices. If he broadcasts both the seed and fertilizer before tillage, he must decide whether to work the ground lightly and do a poor job of incorporating the fertilizer, or to till the soil vigorously, doing a good job of incorporating the fertilizer but burying a large portion of the seed so deeply that crop emergence will be sporadic, possibly resulting in a poor stand and delayed harvest. If the fertilizer is first broadcast and tilled into the soil, and then the seed broadcast and covered with a shallow tillage and packing operation, a large amount of energy has been expended getting the crop planted; considerable amounts of moisture and crop residues have been lost; and there is still no control of seeding depth to ensure uniform crop emergence.

One possible solution is to incorporate all of the fertilizer into the soil with a no-till planter and eliminate the preplant fertilization and tillage operations. Agricultural soils in interior Alaska have a very low clay content and, therefore, have very

Broadcasting fertilizer (above) is not only time consuming, but also costly. Fertilizer efficiency is greatly increased when it is applied in concentrated bands beneath the soil surface and near the seed row.

*Instructor, Agronomy, Agricultural Experiment Station, Fairbanks.



When planting through heavy crop residues in a no-till cropping system, the planter should slice through the surface trash and place seed and fertilizer in the moist soil with minimum soil disturbance.

few compaction and crusting problems (U.S.D.A., 1973). The only apparent benefits from tillage prior to planting are the destruction of perennial weeds and a possible increase in the warming rate of soils in the spring. Two years of research with various tillage practices in the Delta-Clearwater area have shown very little spring temperature differences in tilled and untilled soils and no apparent effect on barley germination.

Perennial weeds are usually found only in patches and are usually more effectively controlled with spot herbicide applications than by tillage. With the recent development of agricultural herbicides, many people have been questioning the need for preplant tillage. For this reason, farm equipment manufacturers have recently been designing minimum-till and no-till grain drills which, in one operation, can both plant seed and apply fertilizer into soil that has received little or no tillage since the previous crop. These drills place the fertilizer in a narrow band either in the row with the seed or in a separate band below or to one side of the seed.

Banding fertilizer with the grain drill offers many advantages over broadcast applications. Besides the time and expense saved by eliminating the fertilizer application and incorporation operations, fertilizer application rates can often be reduced by 20 to 25 per cent without reducing yields when using banded fertilizer (Loynachan et al., 1978). Some possible explanations for this more-efficient use of banded fertilizer include: 1) no lapse between fertilizer application and incorporation during which time nitrogen might be lost by ammonia volatilzation; 2) all of the fertilizer is placed in the root zone and none is left on or near the soil surface where it will remain unavailable to plant roots; 3) the narrow band is placed near the roots of the crop and is not uniformly spread between the rows where much of it might be used by competing weeds; and 4) the concentrated band of fertilizer makes contact with less soil and, therefore, is not as susceptible to being trapped by soil particles and held in a form unavailable for plant use.

There are also some disadvantages to banding fertilizers. Virtually all chemical fertilizers are salts with varying rates of solubility. Although plants need these salts for survival, an excess of soluble salts around a seed will draw water out of the seed and delay germination. It can also draw water out of the seedling roots after germination, causing the plant to wither and die. In interior Alaska, a normal annual fertilizer application for barley is approximately 400 pounds per acre. If all of these salts were banded in the row with the barley seed, severe root desiccation and stand reduction would be expected unless adequate rainfall were received to disperse the salts prior to seed germination. A good rule of thumb is that not more than 140 pounds per acre of fertilizer should be banded in the seed row with small grains (Loynachan et al., 1978). Of this 140 pounds of fertilizer, not more than 15 or 20 pounds should be nitrogen, as nitrogen fertilizers absorb water very rapidly and may release toxic amounts of ammonia in the area of the seedling.

PLANTING EQUIPMENT

The farmer is faced with several options in planting equipment. Ideally, it appears that he should use a heavy grain drill capable of penetrating untilled soil, maintaining a uniform seeding depth, and banding large amounts of fertilizer in a band that is either below or to one side of the seed row. Next, he must decide what type of furrow openers to select for making the rows for the seed and fertilizer.

There are two basic types of furrow openers for grain drills — disks and hoes. There are several variations of each type of opener, each of which has its own merits in different soil conditions. Disk-type openers are flat or dished circles of metal with smooth, scalloped, or serrated edges which are mounted either singly or in groups of two or three and rolled along to cut an opening for the row. Hoe-type openers include a wide range of shovels from a narrow spike to a 4- or 5-inch sweep which is pulled through the soil to open the row.

Some advantages of disk openers are that they are fairly easy to pull through the soil; they cause minimal surface soil disturbance; and they will roll up and over tree roots and clumps of heavy straw that are too tough to slice through. Hoe openers are superior to disk openers in their ability to penetrate hard soils, and they maintain a more uniform planting depth. However, they require more power to pull them, cause more soil disturbance, and are susceptible to plugging by tree roots and damp straw being raked along ahead of the openers (Schaaf et al., 1980). Since most farmers in interior Alaska are working with newly cleared lands and still have to contend with numerous tree roots and buried sticks, grain drills with disk openers have been the most popular.

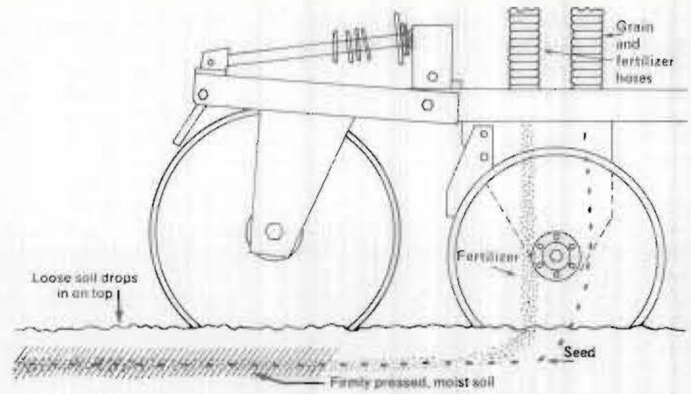
The next consideration for seeding equipment is some means of pressing the soil firmly around the seed. Good soil compaction aids in moisture transfer from the soil to the seed and encourages early seed germination. Most grain drills have only drag-chains which pull soil over the row, covering the seed but not packing it. Press wheels are usually preferred in interior Alaska because of their ability to roll over sticks and trash where drag chains are often pulled off by buried snags. In the absence of press wheels many farmers pull cultipackers behind their grain drills. The biggest disadvantage of a cultipacker is that it destroys a majority of the clods between the rows leaving the soil surface smooth and highly susceptible to wind erosion. This uniform compaction of the soil not only improves conditions for early barley germination within the rows, it also encourages early weed germination between the rows.

DECISIONS

Assuming that a farmer has access to a grain drill with furrow openers and press wheels suited for his field conditions, and meeting with all the desirable criteria listed above, he still must contend with a major obstacle. Most grain drills have a fertilizer box with a holding capacity of not more than 175 pounds for each foot of width. If a farmer is pulling 30 feet of grain drill and applying fertilizer in a band separate from the seed row at a rate of 400 pounds per acre, this means he must stop and refill his fertilizer box at least every 13 acres or a minimum of 153 times for 2000 acres. Given this choice, a farmer may wish to return to the broadcast method of fertilizer application. One logical compromise is to band a small amount of "starter" fertilizer in the row with the seed and broadcast the remainder either before or immediately after planting. When exercising this option, it is best to band the relatively insoluble phosphorus into the soil and broadcast the water-soluble nitrogen and potassium salts on the surface where the rains will leach them into the root zone. A fertilizer that contains a little nitrogen and a lot of phosphorus is usually considered a good choice for banding to get seedlings off to a good start.

ONGOING RESEARCH

The Agricultural Experiment Station initiated a tillage study in the Delta-Clearwater area of interior Alaska in the spring of 1980. Funding for this project has been provided by grants from the United States Department of Agriculture (USDA) and the USDA Soil Conservation Service. The major emphasis of the study is to compare the performance of barley and rapeseed grown on soils receiving varying amounts of tillage prior to planting. The main goal is to find a quick and effective method of conducting spring planting operations with minimum soil disturbance and maximum soil and water conservation.



Small amounts of starter fertilizer banded in the row with the seed get the plants off to a healthy start. The Haybuster MicroSeeder uses narrow angle double disk furrow openers followed by narrow steel press wheels to achieve this task.

A Haybuster MicroSeeder with narrow-angle double disk furrow openers and steel press wheels was purchased for the initial studies. This planter has the capability of planting in soil without prior tillage and banding fertilizer in the row with the seed, but cannot band fertilizer either beneath or beside the seed row. In this tillage study, 100 pounds per acre of starter fertilizer (11-51-0) has been banded in the row with the seed on all plots. Additional nitrogen and potassium fertilizers have been broadcast on the soil surface prior to any tillage or planting operations. During the first two years of the study, there have been no significant differences in barley yield between those plots receiving tillage before planting and those plots which were planted without prior tillage. On the rapeseed plots, however, differences have occurred with rapeseed plants in the no-till plots showing severe phosphorus deficiency symptoms. These differences are apparently due to planting depth, because barley is planted about 1½ inches deep and rapeseed is planted only ½-inch deep. Since all of the phosphorus is being banded with the seed, it is being placed only ½-inch deep in the rapeseed plots. The soil is apparently too dry at the ½-inch depth for the roots to absorb much of the added phosphorus.

In 1982, a Noble grain drill with hoe-type furrow openers and separate openers for banding fertilizers outside of the seed row was purchased to permit further research in these areas. The tillage study is being moved to another location in 1983 and changes are being made in the study design. More emphasis is being placed on barley being grown in a continuous cropping system. Again, major emphasis will be placed on reduced tillage, reduced soil and water losses, and maximum returns in barley production. □

REFERENCES CITED

Loynachan, T. E., W. M. Laughlin, and F. J. Wooding. 1978. *Field Crop Fertilizer Recommendations for Alaska.* Cooperative Extension Service, University of Alaska. Publication No. P-142.

Schaaf, D. E., S. A. Hann, and C. W. Lindwall. 1980. Performance evaluation on furrow openers, cutting coulters, and press wheels for seed drills. IN: *Crop Production with Conservation in the '80s, Proceedings.* American Society of Agricultural Engineers. St. Joseph, Michigan.

United Stated Department of Agriculture. 1973. Soil Survey, Salcha-Big Delta Area, Alaska. U. S. Government Printing Office, Washington, D. C.

White Mountain Trail: Wickersham Dome Area.

Recreation Planning in the White Mountains National Recreation Area

The Recreation-Opportunity-Spectrum System

By

Richard B. Tobin*

The passage of the landmark Alaska National Interest Lands Conservation Act of 1980 (ANILCA) ended a decade of debate over the future management of public lands and resources in Alaska. A major provision of ANILCA was the creation of Alaska's only National Recreation Area: the White Mountains NRA. Although overshadowed by the attention given the National Park and National Wildlife Refuge Systems, the million-acre White Mountains NRA rivals recreational opportunities found anywhere in Alaska. Coupled with the close proximity to Fairbanks via two major highways, the White Mountains NRA is clearly unique from the majority of remote national conservation system units.

At the heart of the National Recreation Area lie the jagged limestone peaks of the White Mountains, which rise sharply from the surrounding, rolling hills to over 4,000 feet in elevation. The clear, cold water of Beaver Creek National Wild River threads its way through the range, offering float-boaters an opportunity to view the impressive White Mountains from three

*Graduate Student, School of Agriculture and Land Resources Management, Fairbanks, and Outdoor Recreation Planner, Bureau of Land Management

sides. Perhaps the most spectacular view of the mountains is obtained by hiking into Fossil Creek Canyon where fossils and unexplored caves may be found. Opportunities for viewing wildlife also attract visitors to the White Mountains NRA, with a long list of sightings including moose, caribou, black and grizzly bear, wolf, Dall sheep, and numerous waterfowl species.

Congress had more in mind than providing for recreation opportunities when the White Mountains NRA was established. The legislative mandate to "provide for public outdoor recreation use and enjoyment" while still allowing for the management of other resource values and existing uses has provided the Bureau of Land Management (BLM) with one of the agency's most difficult (and potentially rewarding) planning assignments. Because recreation is normally considered as only one of many multiple-use values in a land-use plan, concern was raised that the standard planning methods would not be able to address recreation adequately as the predominant resource value at the complexity and scale required in the White Mountains NRA.The BLM would need to use a recreation planning approach which was compatible with the existing planning system for other resource values, realistically tied to choice, and capable of providing a full range of recreational opportunities. Based upon successful planning efforts outside of Alaska which met these standards, the BLM has adopted the Recreation Opportunity Spectrum (ROS) system for use nationwide. The land-use plan for the White Mountains NRA will be the first application of the ROS system in Alaska. The land-use plan is scheduled for completion in the fall of 1984.

The Recreation Opportunity Spectrum System (ROS)

As its name implies, the ROS defines a range or spectrum of recreational opportunities which the public and private sectors can provide to meet a diversity of visitor preferences. This range of recreational opportunities spans a continuum from primitive, back-country areas to modern urban parks.

The White Mountains National Recreation Area is located north of Fairbanks in interior Alaska.

ROS is based on the logic that people prefer to participate in specific types of recreation activities within certain preferred environmental settings in order to attain those kinds of experiences that yield personal satisfaction to them (Hoots and Buist, 1980). The role of the recreation manager is to provide a range of stable recreation opportunities in which a recreationist may shape his own experiences.

In the ROS system, evaluation criteria have been established which help to locate an existing or proposed recreation opportunity within the continuum (Brown et al., 1978; Clark and Stankey, 1979; Hoots and Buist, 1980; USDA, 1982). These evaluation criteria or factors can be clustered into three categories:

- *Physical factors* relate to the amount of environmental modification from human activities allowable at a given location. Physical factors include the degree of remoteness, the evidence of human activity, and the overall size of the area.
- *Social factors* relate to the amount of use and social interaction — the amount of contact between individuals or groups.
- *Managerial factors* relate to the amount and type of administrative action taken to manage current recreation use. This is reflected by the number of user controls and their visibility (Figure 1).

The ROS system is designed to help the manager select combinations of social, physical, and managerial factors which are compatible in a single location. These combinations are arranged along the ROS, as described in Figure 2.

The grouping of compatible factors along the spectrum also assists the manager in avoiding inconsistent or incompatible factor combinations. For example, managing an area for its "essentially unmodified natural environment" (physical factor found in primitive opportunity setting) would not be compatible with an objective to provide "facilities for highly intensified motor use" (physical factor found in urban opportunity setting). Because administering a site with incompatible combinations of physical, social, and managerial factors is the prime cause of conflict between recreationists, other resource users, and the managing agency itself, the recreation planner must be able to clearly identify and implement the combination of compatible factors which best describes the specific management objectives.

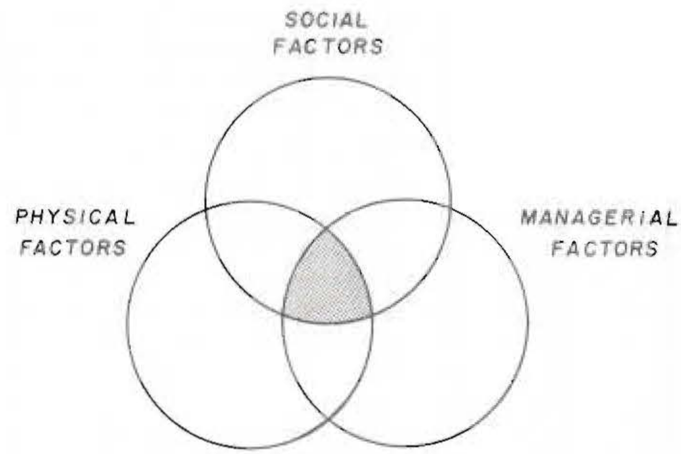
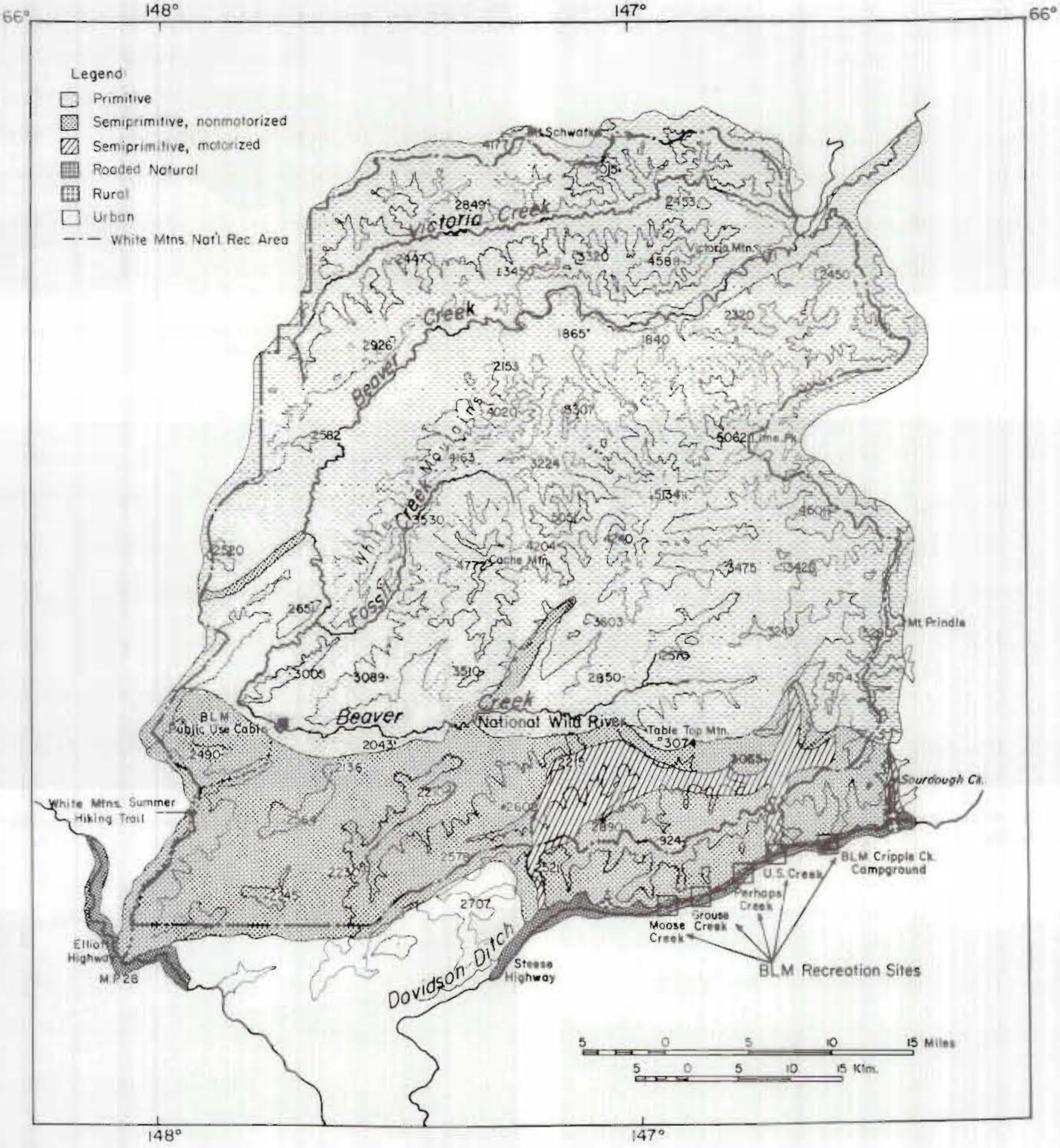


Figure 1. A recreation opportunity is created by a combination of physical, social, and managerial factors. (Note: The shaded area represents harmony between categories.)

Primitive	Semi-Primitive Non-Motorized	Semi-Primitive Motorized	Roaded Natural	Rural	Urban
Area is characterized by essentially unmodified natural environment of fairly large size. Interaction between users is very low and evidence of other users is minimal. The area is managed to be essentially free from evidence of human-induced restrictions and controls. Motorized use within the area is not permitted.	Area is characterized by a predominantly natural or natural-appearing environment of moderate-to-large size interaction between users is low but there is often evidence of other users. The area is managed in such a way that minimum on-site controls and restrictions may be present, but are subtle. Motorized use is not permitted.	Area is characterized by a predominantly natural or natural-appearing environment of moderate-to-large size. Concentration of users is low, but there is often evidence of other users. The area is managed is such a way that minimum on-site controls and restrictions may be present, but are subtle. Motorized use is permitted.	Area is characterized by a predominantly natural-appearing environment with moderate evidences of the sights and sounds of man. Such evidences usually harmonize with the natural environment. Interaction between users may be low to moderate, but with evidence of other users prevalent. Resource modification and utilization practices are evident, but harmonize with the natural environment. Conventional motorized use is provided for in construction standards and design of facilities.	Area is characterized by a substantially modified natural environment. Resource modification and utilization practices are to enhance specific recreation activities and to maintain vegetative cover and soil. Sights and sounds of humans are readily evident, and the interaction between users is often moderate to high. A considerable number of facilities are designed for use by a large number of people. Facilities are often provided for special activities. Moderate densities are provided far away from developed sites. Facilities for intensified motorized use and parking are available.	Area is characterized by a substantially urbanized environment, although the background may have natural-appearing elements. Renewable resource modification and utilization practices are to enhance specific recreation activities. Vegetative cover is often exotic and manicured. Sights and sounds of humans, on-site, are predominant. Large numbers of users can be expected, both on-site and in nearby areas. Facilities for highly intensified motor use and parking are available with forms of mass transit often available to carry people throughout the site.

Figure 2. The Recreation Opportunity Spectrum is created by arranging distinctive recreational settings along a continuum. Listed below each recreation opportunity setting is a descriptive summary of compatible physical, social and managerial factors.



Existing summer recreational inventory by ROS classification for the White Mountains NRA is shown above. The ROS classifications are derived by indentifying the existing physical, social and managerial factors which together comprise the present recreational opportunity setting.

A trail guides visitors through the White Mountains National Recreation Area.

Campers will find clean and attractive facilities near the NRA, such as the one at BLM's Cripple Creek campground.

Wildlife can be seen throughout the N.R.A.; this caribou represents one of many species.

Many spectacular vistas occur in the area, such as this one of the "Big Bend" of Beaver Creek.

Beaver Creek offers water-related recreational opportunities such as rafting.

This beaver pond adjacent to Beaver Creek offers an opportunity for wildlife study.

APPLYING THE ROS SYSTEM TO THE WHITE MOUNTAINS NRA

Step 1 – Identify Planning Goals and Contraints:

The manager must first be able to identify the goals and constraints within which the planning effort will take place. In the White Mountains NRA, these parameters were established by:

- legislation (ANILCA)
- agency policy (Department of the Interior and BLM directives), and
- the existing situation in the region (roads; patterns of recreation use; present management controls; and other physical, social, and managerial factors).

Step 2 – Identify Issues and Concerns:

The identification of key planning issues and concerns is accomplished through extensive public involvement, discussions with public and private organizations, and internal agency review. Without this step, the recreation planner may expend time and resources on issues of limited importance or public concern, or may inadvertently omit an issue or concern which may in fact be far-reaching in both scope and effect.

Step 3 – Inventory Existing Conditions:

During the recreation inventory process, the White Mountains NRA will be carefully examined to identify the existing physical, social, and managerial factors which together comprise the present recreation opportunity settings. Because of the significant difference between summer and winter recreational use in the White Mountains NRA, a separate summer and winter inventory assessment will be prepared.

Step 4 – Identify the Proposed ROS Classes:

One of the unique attributes of the ROS system is that, when the manager identifies the combination of compatible physical, social, and managerial factors which will create the proposed recreational opportunity setting, the planner has effectively established clearly defined management objectives for the planning area. Once the management objectives have been established, the planner can identify the types of activities which are likely to occur and propose developments (if any) which are required. In the White Mountains NRA, these recreation management objectives will then be incorporated into the overall land-use plan.

Step 5 – Action:

The final step in the planning process will be to:

- implement the land-use plan to accomplish the identified objectives;
- monitor the resources, the resource users, and the effectiveness of the plan over time;
- revise the plan as necessary to ensure that a stable recreation opportunity is provided, resource values are protected, and the BLM remains responsive to the future needs of the public.

THE ROS SYSTEM IN ALASKA'S FUTURE

Although the final outcome of the White Mountains NRA land-use plan remains some time away, the ROS system has already begun to prove its usefulness as an efficient and effective recreation planning tool. To date, the ROS system has been compatible with existing planning systems for other resource values, offered realistic choices, and provided a range of recreation opportunities within identified goals and constraints. Most importantly, the ROS system has helped to establish clearly defined management objectives and identify the consequences of alternative management actions.

In several respects, the White Mountains NRA is representative of many other areas in Alaska: untapped recreational opportunities, large acreages, and potential conflicts in resource allocation. The future of the White Mountains NRA, then, may lie not only in the area's ability to provide a diverse and stable range of recreational opportunities within its own boundaries, but in its ability to provide an example of how the ROS system can potentially enhance recreational opportunities on a statewide basis as well. □

REFERENCES

Brown, P.J., Driver, B.L., and McConnell, C. 1978. The Opportunity Spectrum Concept and Behavioral Information in Outdoor Recreation Resource Supply Inventories: Background and Application. Paper presented at the National Workshop on Integrated Inventories of Renewable Natural Resources, Tucson, Arizona, January 8-12.

Clark, R.N., and Stankey, G.H. 1979. The Recreation Opportunity Spectrum: A Framework for Planning, Management, and Research. U.S.D.A. Forest Service Gerneral Technical Report PNW-98.

Hoots, T.A., and Buist, L.J. 1980. Recreation Opportunity Spectrum: A New Management Concept. *Trends 17*:4.

USDA. 1982. ROS Users Guide, Forest Service Handbook, April.

Figure 1. Here white spruce forest covers all but the upper cliffs of this peak in the southern White Mountains.

Limestone Landscapes of the White Mountains

By

Glenn Patrick Juday*

INTRODUCTION

The helicopter had disappeared behind the sharp ridge crest of the White Mountains where we had landed. We began to make our way down the steep, south-facing, talus slope. Everywhere we put our boots, gravel and rock fragments shifted or began to tumble down with that clinking sound characteristic of limestone. Occasionally we found ourselves rim-rocked as we tried to work around huge slabs of the mountain, only to confront cliffs and overhangs. Across the valley, some of these overhangs were deep enough to form caves. In the bottom of this V-shaped valley, we saw stretches of a sizable stream, yet nothing but a dry gravel wash left the valley at its mouth. The play of sunlight on the mountain produced faint, subtle pastels of brown, yellow, and purple which nestled in the gray faces of cliffs and boulders. The gleaming white of sunlit, partially weathered limestone talus set off the crisp blue sky.

As I took in these features, some of them classic indicators of limestone country, I felt transported from interior Alaska. Larry Knapman, Dale Taylor, both of BLM, and I were evaluating one of five potential Research Natural Areas (RNAs) in the 2.2 million acres of the White Mountains National Recreation Area and the Steese National Conservation Area. (Research Natural Areas are officially designated parcels of Federal land, usually one to several thousand acres in size, managed for non-

*Visiting Associate Professor and Alaska Ecological Reserves Coordinator, Agricultural Experiment Station, University of Alaska, Fairbanks.

destructive scientific and educational uses.) We had agreed in advance on the kinds of geologic features and the species of plants and animals needed in the five "representative" RNA's. We expected the area on limestone in the White Mountains to be diverse. But it was especially pleasing to see how many of our research features we found and how clearly expressed some were.

How did the White Mountains come about? How do some of the classic features of limestone country show up there? How well developed are they? These questions motivated our search for an RNA; the answers, as well as we could determine them, give an understanding of a scientifically important and fascinating little piece of Alaska.

ORIGINS OF LIMESTONE FEATURES IN THE WHITE MOUNTAINS

In this article, the term White Mountains refers to the major limestone outcropping in the broader White Mountains area, sometimes referred to as Fossil Creek Ridge. The Tolovana limestone here is Silurian to mid-Devonian in age, probably deposited in a shallow, stable, marine environment. It is mostly made up of chemical or biochemical precipitates, forming a relatively homogenous microcrystaline calcium carbonate. The lack of terrestrial material mixed in is notable (Church and Durfee, 1961).

How did the White Mountains form? One new geologic theory holds that much of Alaska is made up of microplates of the earth's surface. This theory says that these microplates originated as islands and ocean bottom in the Pacific to the south and were swept up by plate motion and smashed into a growing edge of the North American continent. That theory accounts for many of the features of the White Mountains. For example, the White Mountains are limestone, a warm-ocean or saline-water rock. There are nearby exposures of basalt and serpentine, often ocean-bottom rock. Some of the basalt makes up portions of the White Mountains. Most of these and other rocks in the area are somewhat metamorphosed (altered by the pressure and heat of being squeezed in the earth's crust). The limestone portions of the White Mountains have no "roots;" they are a pod on top of other rocks and are so oriented that the layers tilt straight upward.

Limestone is, of course, calcium carbonate, except for whatever impurities are present in the rock. This is the key to the characteristics of limestone landscapes. They literally dissolve away. Acid water reacts with the carbonate, releasing carbon dioxide, and flows away calcium rich. Most water in the upper layers of soils is made acid from the compounds in humus and the respiration of plant roots. Acid groundwater works through joints and fractures in limestone bedrock and produces caves such as Mammoth Cave in Kentucky. Streams will disappear into limestone bedrock joints or gravel, and emerge as cold springs when they encounter an impervious layer of rock.

Depressions in the ground surface that represent the collapse of underground drainage-collection areas are called sinks or sinkholes. When the drainage of an entire region is primarily underground through sinks and bedrock joints, the area is called "karst" topography, from the Kars region of Yugoslavia.

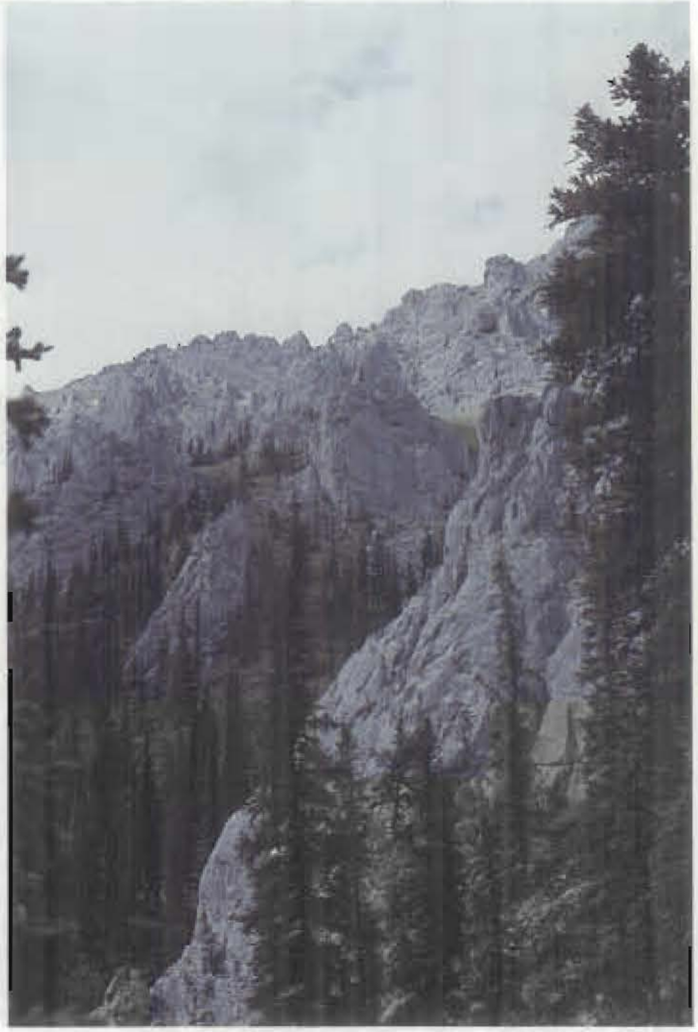


Figure 2. Peaks here in the northern White Mountains are well above treeline.

The weathering of calcium carbonate ultimately may leave soils that are rich in iron oxide and usually distinctively rusty red in color. Very rarely, a natural bridge or arch will form. This happens when a river undercuts bedrock at the point of a bend, and then drops to a relatively lower level (the land surface may rise); if subsequent erosion isolates that block of undercut rock, it will then stand as a natural arch or bridge.

These processes and features are very dependent upon the climate. The warmer and wetter the climate, the longer the active warm season, the more dissolution water available, and the faster the reactions. If a landscape is glaciated, then most features are, in effect, bulldozed over and must be reformed with time. The White Mountains have not been glaciated, but the subarctic climate has certainly slowed down the rate of weathering. On shaded, north-facing slopes underlain with permafrost, one might say that the dissolution process is "on ice." This, then, is one of the most interesting aspects of the White Mountains — the interplay of limestone versus subarctic, landscape-forming processes. The following is a discussion of some of these scientifically interesting features as they are found in the White Mountains.

Figure 3. Upper end of a gulch in the central White Mountains.

Figure 4. North-facing limestone cliffs in the White Mountains.

Cliffs

Figure 4 shows some typical cliffs in the central portion of the White Mountains. These are made up of the irregular edges of layers of limestone standing vertically. Shattered rock and talus collect on the uphill side, making a relatively gentle approach from that direction. But the downhill side drops away into sheer falls. In areas of complex shelves, ledges, cliffs, and pinnacles, Dall sheep find excellent escape terrain. Although they mostly abandon the White Mountains in the summer due to lack of forage, they use cliffs and the alpine zone (above timber line) heavily at other times of the year. Many of the higher limestone crags and pinnacles in certain parts of the White Mountains are colored bright orange from the growth of a lichen which is fertilized by the droppings of the peregrine falcon. The peregrines scout the landscape for prey, find easy soaring in updrafts, and choose their nesting sites in these cliffs.

Caves

The mouth of a cave in the central White Mountains is shown in Figure 5. This cave extends back nearly 66 ft (20 m), then opens on a chamber 13 ft (4 m) high with at least two chimneys. The rock here is cold, as the ice dam at the mouth of the cave in late June shows. Ribbon ice and icicles hang down from the ceiling of the cave for much of the summer. Porcupines currently use the cave; and predators in the distant past might have used it too. The cone of rock and soil at the mouth (which impedes drainage of the floor of the cave, also contributing to the ice dam) may contain bones and other remains of prey consumed by these predators during the ice age. Such sites have been excavated to give a picture of life in the Alaskan interior in the past. Another nearby cave along a major stream could have been occupied by early humans.

Disappearing Streams and Emergent Cold Springs

There are several good examples of streams disappearing into the ground in the White Mountains. Along the base of the mountain, many rather large springs pop out of the ground, as can be seen in Figure 6. At these springs, the mineral-rich waters and the microenvironment of high humidity encourages the growth of a luxuriantly green mat of mosses, leafy liverworts, and, in the emergent stream, green algae.

The White Mountains receive a higher precipitation than do the surrounding lowland portions of the Interior. On most summer afternoons, a bank of cumulus clouds builds over the uplands, quite often producing a brief shower. In spite of this, much of the time the major stream draining the White Mountains, Fossil Creek, disappears into the ground; so no surface water drains the entire area.

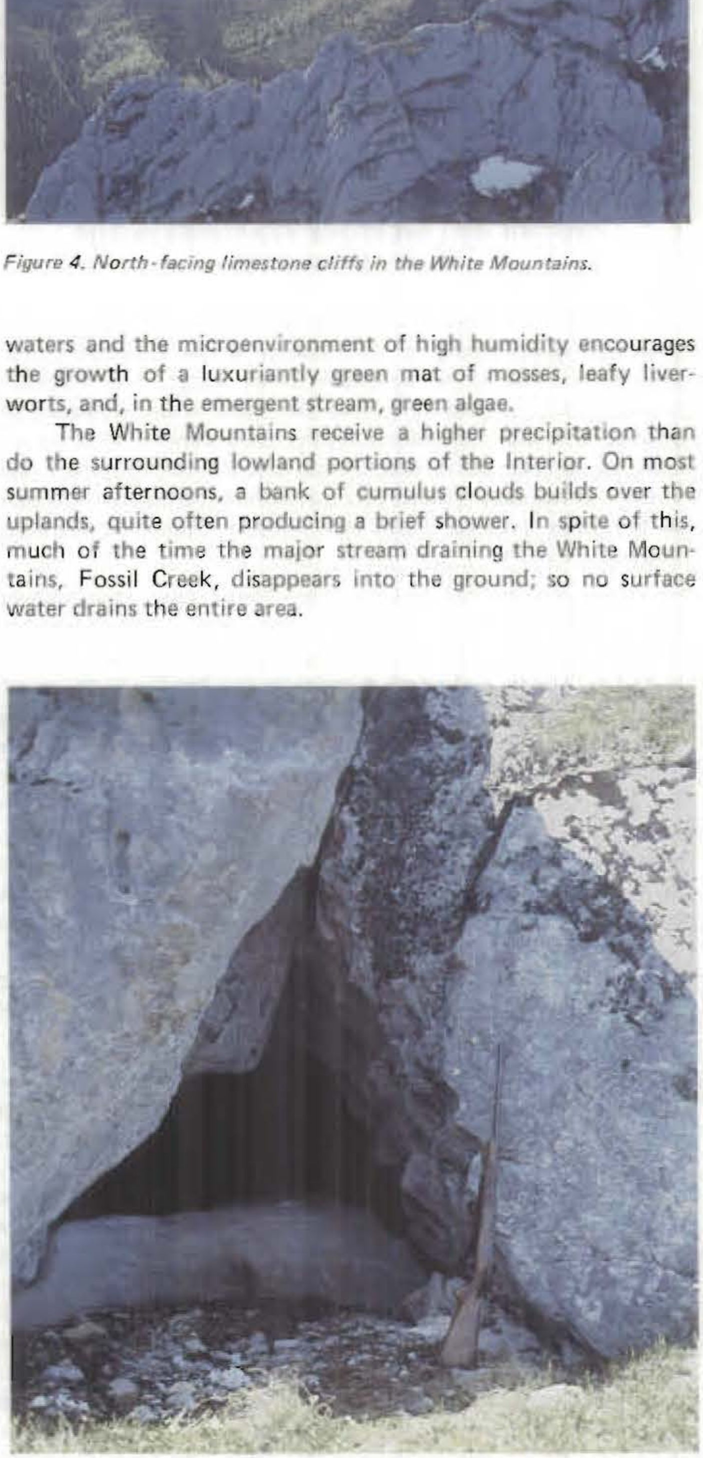


Figure 5. Cave mouth in the central White Mountains with ice dam in late June.

Figure 6. Large emergent cold spring lined with mosses and liverworts and green algae in stream in the northern White Mountains.

Figure 7. Red clay soil stripe on steep talus slope.

Figure 8. A natural arch or bridge in the White Mountains.

Figure 9. Sharp transition between limestone (left) and basalt (right) bedrock.

Figure 10. At the summit of a limestone ridge, a 20-m vegetation transect.

Figure 11. Stone sorting by frost action in limestone at high elevations in the White Mountains.

Red Soil

One of the most puzzling features to be found in the White Mountains are the stripes of red soil that cross the surface of some of its slopes. Figure 7 shows one of these. The conventional explanation for the origin of red soil in a limestone region does not seem to apply here. Aside from the fact that the weathering rate is and has been very low for some time in the area, the slopes have apparently been too unstable to permit the long periods of weathering necessary to produce large amounts of iron oxide. The exposure is not positioned as a residual soil would be. The stripes are somewhat discrete and linear. Perhaps they are the result of thermal alteration when veins of molten magma were injected into the rock. Veins of quartz do intrude into the Tolovana limestone.The magma itself may have been the source of the iron-rich clay. The solution of this mystery awaits further research.

Natural Arches

There are several partly developed natural arches or bridges in the White Mountains. A few are quite well developed, as can be seen in Figure 8. It would be interesting to determine whether the life of a limestone arch is longer or shorter in interior Alaska than elsewhere. Frost action fractures rocks on the surface of an arch, weakening it. Water and, especially, patches of soil on an arch contribute to its dissolution. But, other things being equal, arches in the cool, relatively dry environment of interior Alaska may last for a long time.

Contrasting Plant Communities

Figure 9 shows the abrupt transition of vegetation at the contact zone between basalt and limestone in the area. Such sharp breaks in bedrock type allow a look at how rock type controls plant-community development in situations where other factors of the environment are the same. Here it can be seen that the contrast is quite startling. There is a dense forest grading into alpine parkland and tundra on the basalt, but on the limestone there are only patches of alpine plants. Part of the difference is the stability of the land surfaces. The limestone here is fracturing and tumbling down the hill in contrast to the basalt, which is much more stable. Table 1 compares two vegetation transects taken on stable summits at a similar elevations on these two rock surfaces. The transects were made up of 20 plots of .7 x 1.6 ft (.2 x .5 m) taken each 3.3 ft (1 m) on alternate sides of a 65.6-ft (20-m) line running parallel to the ridge summit. The limestone summit transect can be seen in Figure 10.

As can be seen in Figure 10 and Table 1, there was a considerable amount of bare rock surface in the limestone transect.

Table 1. Characteristics of White Mountain Vegetation Transects on Limestone and Basalt Ridge Summits.

	Limestone	Basalt
Average amount of bare rock surface	27.1%	2.8%
Total number of species (excluding moss)	28	39
Number of lichen species in plots	9	16
Average total moss cover	3.6%	8.5%
Average cover of *Dryas octopetala*	30.8%	57.3%

The basalt transect, by contrast, had less than 3% bare rock surface. It also had more species, especially lichens, and more moss cover. The major dominant plant on both summits was *Dryas octopetala* L., but its average cover was nearly twice as great on the basalt transect.

Despite a very great similarity in flora, there were plants that occurred in one transect but not in the other. The grasses *Festuca brachyphylla* Schult. and the sweet-tasting *Heirochloe alpina* (SW.) Roem. and Schult., and two lichens, *Allectoria ochroleuca* (Hoffm.) Mass. and *Sphaerophorous globosus* (Huds.) Vain., occurred on the basalt but not on the limestone. While a few individuals of these species might be found on limestone, they would be much lower in prominence than on basalt.

Gjaerevoll (1958, 1963, 1967) and Persson and Gjaerevoll (1957) reported on the flora of the White Mountains paying particular attention to limestone. Many species they encountered were favored by, more prominent on, or nearly restricted to limestone habitats. These included mosses and flowering plants of all kinds. The flora is particularly rich because plants with different patterns of overall distribution mingle here. These include: (1) circumpolar species; (2) North American boreal, montane, and alpine species; (3) western-American species reaching north from the Rocky Mountains; (4) species restricted to northwest North America; (5) species across the former Bering land bridge; and (6) Asiatic species reaching Alaska. In the 1982 summer RNA expedition reported here, the moss *Andreaeobryum macrosporum* was collected. This moss was thought to be restricted to the Arctic in northwest North America and is nearly always found on wet limestone. This is the first collection outside the Brooks Range in Alaska.

THE SUBARCTIC ENVIRONMENT

Despite the presence of all the limestone landscape features discussed here, the White Mountains are in a subarctic setting. Permafrost effects on vegetation patterns are easily seen. Figure 11 shows the effect of frost sorting on limestone rubble. This sorting by size is a classic cold-landscape feature.

The cold and relative dryness of the climate have produced limestone features that are not well developed. The caves are relatively small, for example. There are only a few small and cryptic sinkhole-like depressions in the entire area.

Still, strolling and climbing around the dry gulches and gleaming white rocks, it's easy for the mind to wander and forget the miles and miles and miles of soggy black-spruce woodland and tundra one crossed to get there. □

REFERENCES

Church, R. E., and M. C. Durfee. 1961. Geology of the Fossil Creek Area — White Mountains, Alaska. University of Alaska. M. S. Thesis.

Gjaerevoll, O. 1958. Botanical Investigatons in Central Alaska, Especially in the White Mountains. Part I, Pteridophytes and Monocotyledones. Det KGL Norske Videnskabers Selskabs Skrifter. NR 5. 74 pp.

————. 1963. Botanical Investigations in Central Alaska, Especially in White Mountains. Part II, Dicotyledones. Salicaceae — Umbelliferae. Det KGL Norske Videnskabers Selskabs Skrifter. NR 4. 115 pp.

————. 1967. Botanical Investigations in Central Alaska, Especially in White Mountains. Part III, Sympetalae. Det KGL Norske Videnskabers Selskabs Skrifter NR 10. 63 pp.

Persson, H., and O. Gjaerevoll. 1957. Bryophytes from the Interior of Alaska. Det KGL Norske Videnskabers Selskabs Skrifter. NR 5. 74 pp.

Valuing Outdoor Recreational Opportunities

By

William G. Workman*

INTRODUCTION

A fundamental policy issue in Alaska, as in other western states where a significant proportion of natural resource wealth is held in the public sector, concerns the designation of publicly owned resources for various uses. To the extent that well-functioning markets exist for commodities and services that may be produced from this resource base, the resolution of use conflicts may be aided by an appeal to the information that such markets provide regarding relative prices and costs. Examples of industries or commodity groups that fall in this category are agriculture, forest products, and mineral resources including gas and oil.

In other cases, however, the evaluation of trade-offs among resource uses is complicated by the absence of useful market signals to guide these efforts. Outdoor recreation as a general category of resource use in western states is an important case for which economic values based on market transactions are largely lacking.

To many Alaskans, one of the greatest advantages of residing in the state is the opportunity to engage in outdoor recreational pursuits that our environmental setting affords. For this set of residents, public-policy decisions impacting the allocation of land and water resources and the associated wildlife and fisheries stocks among competing uses are of obvious interest and concern. To others in the state who may be indifferent regarding the environmental amenities present, these same policy issues remain important since the public support of recreational activities competes with alternative uses of resources in which these individuals may have an interest. Thus, the problem of valuing public recreational opportunities deserves careful consideration as the state proceeds with its efforts to designate uses of its resources and with the allocation of its revenues to various purposes.

The intent of this article is to provide an overview of some of the conceptual issues and procedures involved in the valuation of nonmarket recreational services. We begin with a presentation of the concept of benefits associated with the existence of outdoor recreational opportunities. Next is a brief review of the state-of-the-art methods of placing a value on these benefits. Finally, the role of the Agricultural Experiment Station in undertaking research in this important area is summarized.

*Associate Professor, Economics, Agricultural Experiment Station, Fairbanks.

BENEFITS OF OUTDOOR RECREATION OPPORTUNITIES

One role of the economist in resolving conflicts in using natural resources is to apply the techniques of benefit-cost analysis to provide estimates of the magnitude and distribution of gains and/or losses that can be associated with proposed changes in patterns of resource use. A standard evaluative procedure for allocative efficiency in public expenditure/policy analysis involves a "with-versus-without" project or program test. (See, for example, Haveman and Weisbrod, 1975.) This simply means that attempts are made to assess the public's net benefits from the use of its resources both with and without the change(s) under consideration. The conceptual framework that underlies the definition and measurement of net benefits in this assessment is the economic theory of consumer choice.

To illustrate this framework, consider the situation in which both recreationists and mining entities have an interest in the use of a clearwater stream. For simplicity, we will assume that the mining and recreational uses of the stream are mutually exclusive so that even the smallest amount of mining activity eliminates the attractiveness of the stream as a recreational setting. Suppose the goal of public officials is to dedicate the stream to its "highest use," that is, the use that results in the greatest amount of net benefits. As far as the private mining enterprises are concerned, the relevant measure of net benefits is revenues less costs or economic profits. These net returns are a *private* gain and reflect the maximum amount that the mining entities would be willing to pay for the right to operate on the stream.[1]

To assess the net *social* benefits from mining activities, however, we should include in the costs of mining the resulting reduction in net benefits to recreationists. This brings us to the issue of how to define and value these recreational benefits. Unlike the commercial mining enterprise, the fishing, boating, or other recreational users of the stream are not involved in the production of marketable services that are sold to someone else. Rather, these recreationists are, themselves, the final consumers of the recreation opportunities available at the stream. Thus, the appropriate concept of net benefits to this user group is the loss it would suffer if the opportunity for recreating on the stream were removed. Alternatively, we might say that the net recreation benefits are reflected by how much better off this user group is with this opportunity than without. In either case, the maximum willingness to pay on the part of the recreationists to retain these opportunities may be viewed as the conceptually correct measure of the net *private* recreation benefits.[2] Again, to capture the net *social* benefits from dedicating the stream to recreation, one should deduct from the recreationist's private benefits the foregone net revenues from mining.

[1] In the private sector of the economy, where private property rights are established for resources, the user group with the potential for earning the greatest net returns, and, thus, having the greatest willingness to pay for use of the resource, will acquire the property rights through voluntary exchange.

[2] An alternative concept of net benefits might be the recreationists' minimum willingness to accept compensation to relinquish the right to enjoy these opportunities. Under specific circumstances the two measures, i.e. willingness to pay and willingness to accept compensation, are expected to be equal. This is currently an area of controversy in the public-choice literature, particularly in the valuation of natural resources (see Gordon and Knetsch, 1979).

It is important here to note that the recreationists' net benefits from using the stream are not the same as their actual expenditures made to avail themselves of the opportunities present. A great deal of public confusion seems to exist on this point. Quite commonly, total expenditures by recreationists on equipment, transportation, food, etc. are viewed as the minimum value that they place on a recreation opportunity or site. These gross expenditures[3], however, while perhaps reflecting an impact on local business sales, are largely irrelevant in assessing how much worse off the recreationists would be if the opportunity were to be withdrawn. The measurement of the net benefit captures the difference between the maximum amount recreationist would pay to participate in these recreational activities and their actual expenditures. Defined in this manner, we see that net benefits and expenditures may be inversely related.

METHODS FOR VALUATION OF RECREATION RESOURCES

In the absence of market transactions on which to base the value of recreational resources, how does one estimate these net benefits discussed above? Presently, there are two general categories of methods of valuation of recreational resources being investigated and perfected by economists working in this area. The first is known as the Travel Cost Method (TCM) and is associated with the names of Hotelling (1949) and Clawson and Knetsch (1966). The second is known as the Contingent Valuation Method (CVM) and derives from the seminal work of Davis (1963).

Use of the TCM or "indirect" method begins by observing the rate of participation of certain population groups in outdoor recreational activities at a given site and relating these participation rates to the costs of transporting the recreationists from their places of residence to the site. The demand curve so estimated is then used as the empirical basis for computing the net willingness to pay or "consumers' surplus" associated with the site. Refinements of the TCM have included the more complete specification of the demand function to include other causal factors such as income and the examination of the role that travel and participation time plays in the recreationist's decisions and, hence, their net benefits. Ward (1980) has provided an excellent review of the TCM literature.

The CVM is a "direct" technique for resource valuation in that its approach is to ask recreationists specific questions regarding their willingness to pay and/or willingness to accept compensation if opportunities for participation in outdoor recreation activities are altered. The CVM has been the object of much criticism due to the hypothetical nature of the changes to which recreationists are asked to respond. Little work has been done until quite recently to test for the presence of biases that may result from this method of inquiry. Schulze et al. (1981), however, have recently summarized the results of several experiments involving such tests and have reported that "biases do not appear to be an overriding problem" with CVM. One of the sig-

[3] Brown, Singh, and Castle (1964) provide an excellent discussion and critique of the so-called "Gross Expenditure Method" of recreation resource valuation.

nificant advantages of CVM over TCM is that the former lends itself to the valuation not of only recreational benefits associated with natural resources but of environmental amenities in general. Bishop and Heberlein (1979) illustrate the use of CVM in the valuation of goose-hunting opportunities and also offer empirical comparisons of values estimated using the two methods.

RESEARCH IN OUTDOOR RECREATION ECONOMICS AT UNIVERSITY OF ALASKA-FAIRBANKS

The Agricultural Experiment Station at UAF currently participates in a Western Regional Hatch Project (W-133) designed to advance the techniques of recreational resource valuation (Cooperative Regional Project Outline, 1980). The focus of the project is on the procedures adopted by the Federal Water Resources Council in 1980 which include the use of both the TCM and CVM approaches discussed earlier (WRC, 1980). Through a cooperative effort with the Alaska Sea Grant Program and the Alaska Department of Fish and Game, researchers at the Agricultural Experiment Station in Fairbanks are conducting a study of the net economic value of salmon sport-fishing opportunities on the Russian and Kenai Rivers. Results of this effort will contribute to the evaluation of trade offs among sports, commercial, and subsistence uses of the salmon resource and will assist the Department of Fish and Game in its allocative decisions. In addition, results of this study will aid in the assessment of the economic implications of efforts to enhance salmon stocks.

Many other opportunties for research of this type exist in Alaska and future activities at the experiment station will include efforts to value hunting and other recreational pursuits. Both basic and applied research activities are needed to assist the state and Federal resource agencies in their assessment of trade offs in the uses of land and water resources. The experiment station will continue its committment to develop analytical methods and supply the data base required for making decisions for efficient allocations. □

LITERATURE CITED

Bishop, R. C., and T. A. Heberlein. 1979. Measuring values of extra market goods: Are indirect measures biased? *Amer. Journal of Agricultural Economics 61*(5):926-930.

Brown, W. G., A. Singh, and E. N. Castle. 1964. *An Economic Evaluation of the Oregon Salmon and Steelhead Sport Fishery*. Oregon Agricultural Experiment Station, Technical Bulletin No. 78.

Clawson, M., and J. L. Knetsch. 1966. *Economics of Outdoor Recreation*. Baltimore: John Hopkins University Press for Resources for the Future.

Cooperative Regional Project Outline (W-133). 1980. *Outdoor Recreation and the Public Interest: Evaluation of Benefits and Costs in Federal and State Resource Planning.*

Davis, R. K. 1963. *Value of Outdoor Recreation: An Economic Study of the Maine Woods.* Unpublished Ph.D. thesis, Harvard University.

Gordon, I. M., and J. L. Knetsch. 1979. Consumer's surplus measures and the evaluation of resources. *Land Economics 55*(1)1-10.

Haveman, R. H., and B. A. Weisbrod. 1975. The concept of benefits in cost-benefit analysis: With emphasis on water pollution control activities. IN: *Cost Benefit Analysis and Water Pollution Policy*, edited by Henry M. Perkin and Eugene P. Seskin. The Urban Institute, Washington, D. C.

Hotelling, H. 1949. Letter to director Newton B. Drury, June 18, 1947. IN: *The Economics of Public Recreation, An Economic Study of the Monetary Evalution of Recreation in the National Parks.* Washington: National Park Service.

Schulze, W. D., R. C. d'Arge, and D. S. Brookshire. 1981. Valuing environmental commodities: Some recent experiments. *Land Economics 57*(2):151-172.

Ward, F. A. 1980. *Review of Problems and Solutions in the Use of the Travel Cost Method for Valuing Recreational Resources.* Department Staff Report No. 14. Department of Agricultural Economics and Agricultural Business, New Mexico State University.

Water Resources Council. 1980. Proposed rules: Principles, standards, and procedures for planning water and related land resources. *Federal Register*, pp. 25302-25348.

Influence of a Complete Fertilizer on Soil pH and Available NO_3-N, P, and K in Kachemak Silt Loam

By

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

INTRODUCTION

Soil analyses are used to determine the nutrient-supplying power of a soil. When supplied with adequate nutrients, many field crops grow well over a fairly wide range of soil pH. Optimum pH varies among crops and even varieties of crops and is influenced by soil conditions. A low value for a particular nutrient means plants will probably produce less than maximum yield for the given soil and climatic conditions. Interpretation of available research data enables one to correct nutrient deficiencies by adding more of a particular nutrient. Soil analyses also enable one to estimate the amounts of various nutrients removed from a soil by growing crops.

The Kachemak soil series on the lower Kenai Peninsula consists of dark-colored, well-drained soil occurring on uplands where the topography varies from nearly level to steep. These are the most extensive soils in the Caribou Hills north of Homer.

Kachemak silt loam is classified as thixotropic (becomes fluid when agitated) over loamy, mixed Typic Cryandepts. These soils were formed in volcanic ash mixed with wind-blown silt from recently exposed glacial drift. They have an appreciable amount of allophane (associated with volcanic ash parent material) which has a pH-dependent action exchange capacity as low as 10 meq per 100 grams of soil with a low pH, and as high as 150 meq per 100 grams of soil at a pH of 8.2. Additionally, high phosphorus fixation capacity has been associated with allophanic soils in other areas.

Kachemak soils in undisturbed areas are covered by a mat of partly decomposed organic matter, mostly grass straw, as much as 8 inches thick. As is the case with most soils of the Andept subgroup, they have an extremely high concentration of organic carbon in the surface layer. Many of the characteristics described in the preceding paragraph are unique to the Andept subgroup and would probably result in soil-nutrient reactions which would be significantly different from other Alaskan soils.

MATERIALS AND METHODS

The effect of fertilizer application and cropping on soil reaction and on available NO_3-N, P, and K in the plow layer was evaluated from a 7-year 4×2^2 factorial experiment established on a native bluejoint reedgrass (*Calamagrostis canadensis* [Michx.] Beauv.) stand on Kachemak silt loam in 1972. Individual plots were 6 x 15 feet. The six replications of this experiment had four N rates (60, 120, 180, and 240 lb N/A) as ammonium nitrate, and two P and K rates (76 and 152 lb P/A, 83 and 166 lb K/A) as triple superphosphate and sulfate of potash, respectively. In addition were three nonreplicated plots with the following treatments: 0-152-166 lb/A, 240-0-166 lb/A, and 240-152-0 lb/A. Each June the various fertilizers were topdressed on plots.

Half of the N was applied in June and the remainder in July immediately after the first forage harvest. All P and K was applied in June. A second harvest was made each year in September.

The natural bluejoint stand was originally very hummocky because of large individual grass clumps. The area was leveled several years previously with a flail-type forage chopper that was run repeatedly and as low as possible over the area. Forage in succeeding years was removed about every other year, usually in late July or early August. We know of no fertilizer added before our experiment began.

Before fertilizer was applied each June, soil samples were removed from each plot by 2-inch increments to a 6-inch depth. In 1973 and 1974, only the soil pH was determined.

From 1975 to 1979, available NO_3-N, P, and K were also determined using a modified Morgan's procedure with sodium acetate buffered at pH 4.8 (Martin, 1970). The soil reaction was determined with a commercial pH meter from suspensions prepared from the air-dried samples of 1:2 soil to water.

RESULTS AND DISCUSSION

Soil pH

Figure 1 shows an increase in soil pH in 1973 with the first increment of N; rates exceeding 60 lb N/A had little effect. First fertilizer applications were made in 1972, which probably stimulated soil microorganism numbers and activity. The rise in pH may have resulted from the decomposition of organic acids in the soil. Such decomposition is also the logical explanation for the higher pH in 1979 when no N was applied. In the absence of applied N, decomposition of these organic acids probably required more time. Figure 1, which combines all three sampling depths, also shows that pH decreased with increased N application rates in 1975 and 1979 except little change was apparent when N rate exceeded 180 lb/A.

*Research Soil Scientist, ARS, USDA, Palmer.
**Laboratory Technician, Alaska Agricultural Experiment Station, Palmer.
***Biological Technician, ARS, USDA, Palmer.

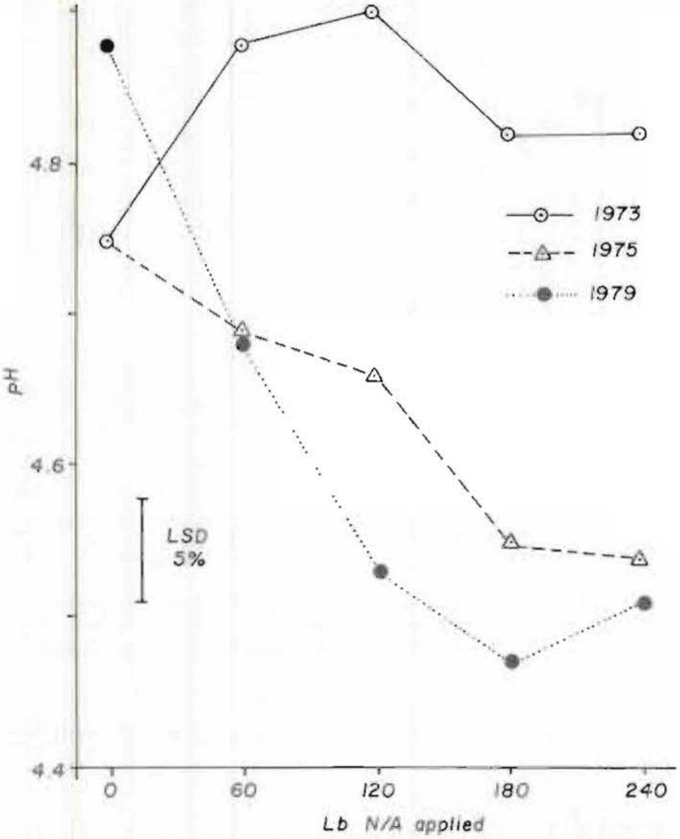


Figure 1. Effect of nitrogen rate on soil pH in 1973, 1975 and 1979.

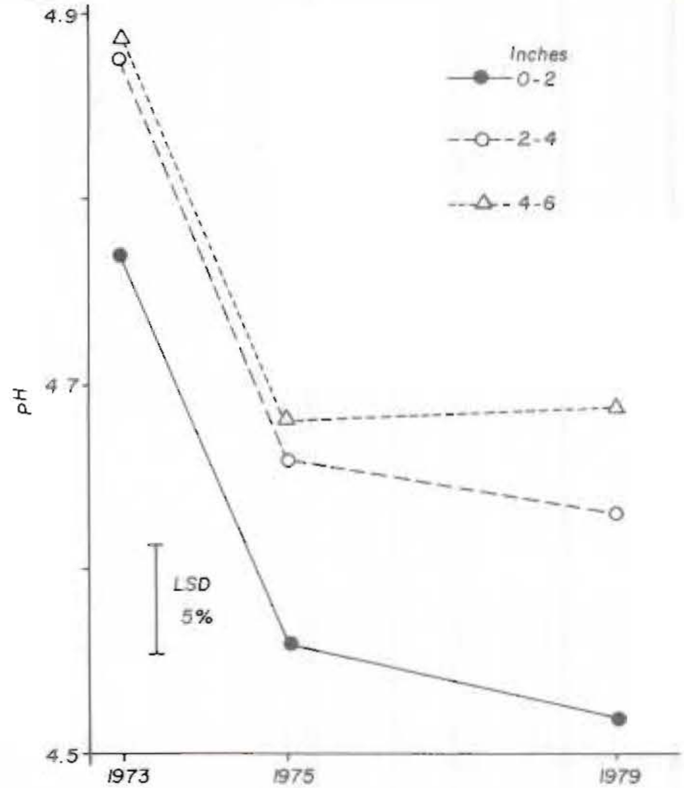


Figure 2. Effect of sampling depth on soil pH in 1973, 1975, and 1979 combining all N, P, and K rates.

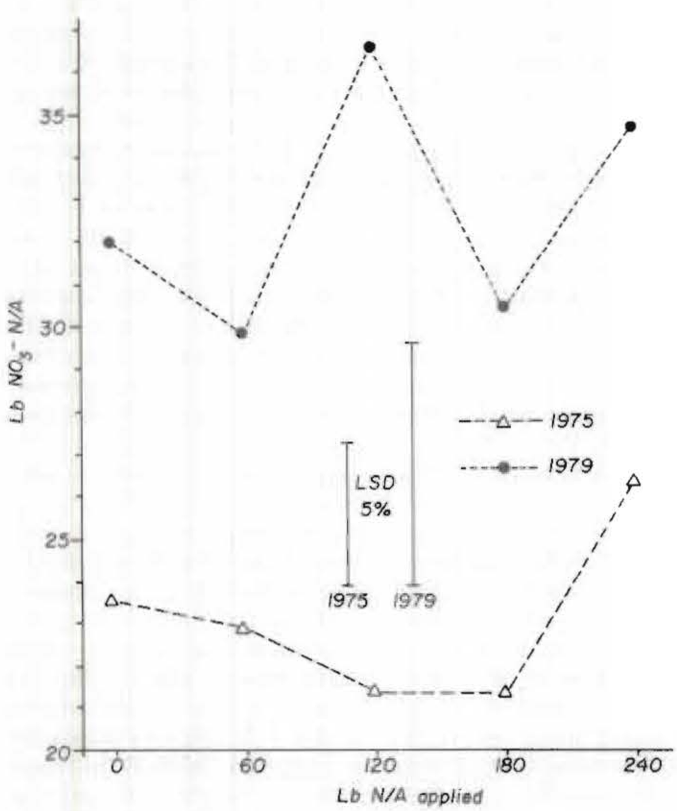


Figure 3. Effect of nitrogen application in combination with P and K on soils NO_3-N in 1975 and 1979.

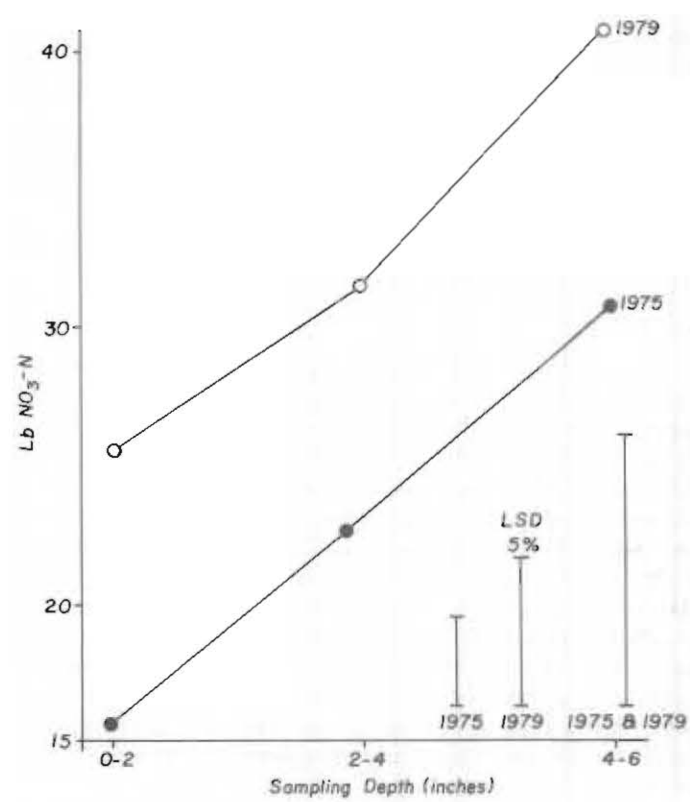


Figure 4. Effect of sampling depth on the NO_3-N in 1975 and 1979.

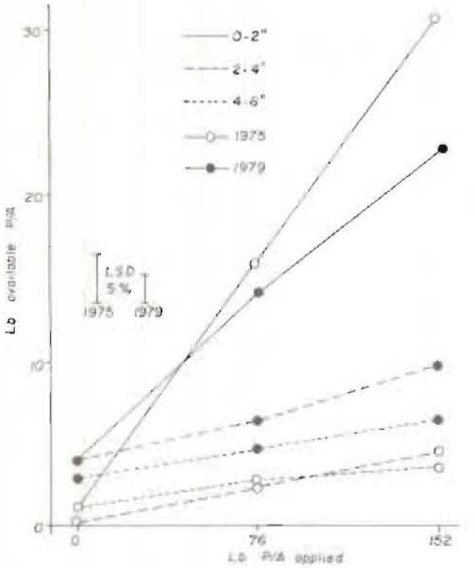


Figure 5. Effect of phosphorus application in combination with N and K on available P in soil in 1975 and 1979.

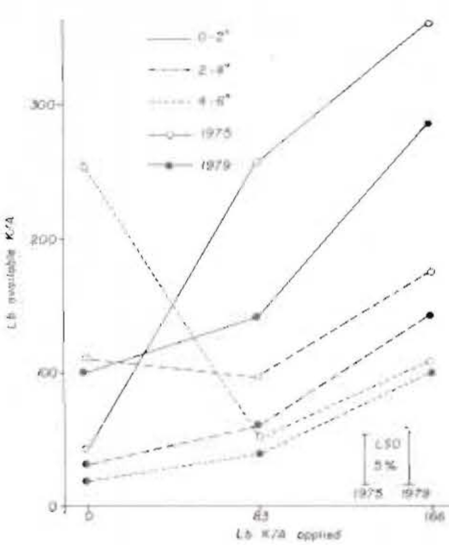


Figure 6. Effect of potassium application in combination with N and P on available K at three soil-sampling depths in 1975 and 1979.

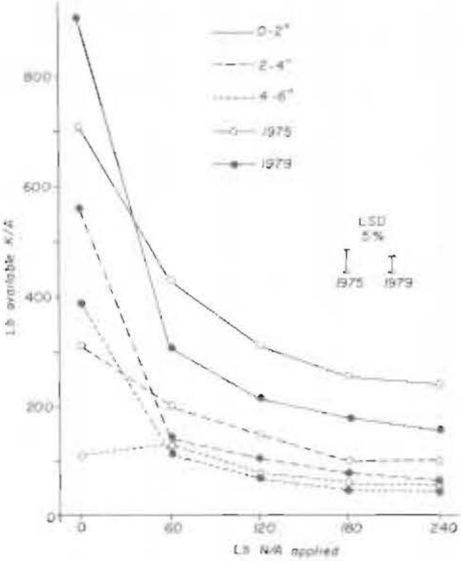


Figure 7. Effect of nitrogen application in combination with P and K on available K at three soil-sampling depths in 1975 and 1979.

Soil pH increased with each increase in sampling depth, particularly in 1979 (Figure 2).

NO_3-N

The NO_3-N in the soil tended to be greater in 1979 than in 1975 (Figures 3 and 4). Values were erratic as related to N application rates. Only with the highest N rate (240 lb/A) did the NO_3-N differ significantly from that where no N was applied in 1975; that difference was an increase in NO_3-N. Probably the amounts of N applied were being overshadowed by the amounts being released from the vast store of organic material by increased stimulation of soil-microorganism numbers and activities with fertilizer application.

With each increase in sampling depth, there was an increase in the NO_3-N (Figure 4).

Available P

Each increment of P increased available P in both 1975 and 1979, though not always by a statistically significant value (Figure 5). This increase was markedly greater in the top 2 inches of soil which shows P is a relatively immobile nutrient which does not move far from where it is applied. When 152 lb P/A was applied, available P was greater in 1975 than in 1979. This indicated that all the applied P was either removed by the two annual harvests each season, incorporated into the bluejoint roots, or converted into relatively insoluble forms. Much less P is available at the two lower sampling depths, and the values were higher in 1979 than in 1975. This, together with the increase in P at these sampling depths with increasing P applications, shows a slight downward movement of applied P, probably through root absorption, translocation to greater depths, and subseqent decomposition.

Available P was concentrated in the top 2 inches of soil in both years for which data are presented. Only with the highest P rate (152 lb P/A) in 1979 was there significantly more available P at the 2- to 4-inch depth than at the 4- to 6-inch sampling depth.

Available K

The available K in the soil reflected plant growth and resultant K depletion more than did the other nutrients. Figure 6 shows that each higher K rate increased the available K in the top 2 inches of soil in both 1975 and 1979. When no K was applied, the available K in the top 2 inches was greater in 1979 than in 1975 but, at 83 and 166 lb K/A, available K tended to be higher in 1975. This higher K value in the 0- to 2-inch soil layer in 1979 may have resulted from the release of K from organic matter (as promoted by the N and P applied) and movement from the nonexchangeable to exchangeable forms of K after the previous September harvest. In 1975, most available K at the 4- to 6-inch depth was in the plot receiving no K. This may reflect the very poor grass growth without K application the previous year and then the release of K since that September harvest. However, by 1979, available K at this depth had been depleted.

Each increase in sampling depth showed a decrease in available K except at the zero K rate in 1975 (Figure 6). This decrease was more pronounced between the 0- to 2- and 2- to 4-inch depths than between the 2- to 4- and 4- to 6-inch depths.

Available K both years was generally reduced by increasing N rates (Figure 7). Available K in the top 2 inches of soil decreased significantly with each increasing N rate through 180 lb N/A and, in the 2- to 4-inch depth, through 120 lb N/A. This decrease in available K with increasing N rates corresponded to increased forage yields (1.7 to 3.5 T/A oven-dry forage per year) as N application increased from 0 to 240 lb/A. Increased yields removed more K from the soil. Where N was applied, available K values in 1979 were lower than those in 1975. This may indicate that more K was being used by the crop than was applied. This theory is substantiated by a recovery in harvested forage of 130 and 105 per cent of applied K on the 83 and 166 lb K/A treatments, respectively. When no N was applied, available K in 1979 was greater than in 1975, reflecting the very poor bluejoint growth and lower K removal without N, and indicating that release of K from the soil was more rapid than grass uptake.

Although most of our soils contain relatively large amounts of available K as compared to available NO_3-N and P, the supply is not unlimited. When high grass yields are obtained with high N rates, increasing rates of K must be used to prevent depletion of K from the soil.

SUMMARY AND CONCLUSIONS

Increasing rates on N applications depressed the soil pH after 1973. The NO_3-N values were erratic as related to N application. Available K in the soil was reduced at the higher N rates, probably through depletion by increased forage production.

Each P increment increased available P in the soil, particularly in the top 2 inches.

Each K increment increased available K in the soil, particularly in the top 2 inches.

Soil pH and NO_3-N increased with each 2-inch increment in sampling depth.

Applied P and K were concentrated in the top 2 inches of soil. At the highest P rate, available P decreased with each 2-inch increase in sampling depth.

These results suggest continual use of high N rates using such fertilizers as ammonium nitrate or urea may eventually require lime application to reverse increasing soil acidity for most crops. Native bluejoint probably would never require lime as it grows well at an extremely low pH. ☐

Cooperative investigation of ARS, USDA, and the Agricultural Experiment Station.

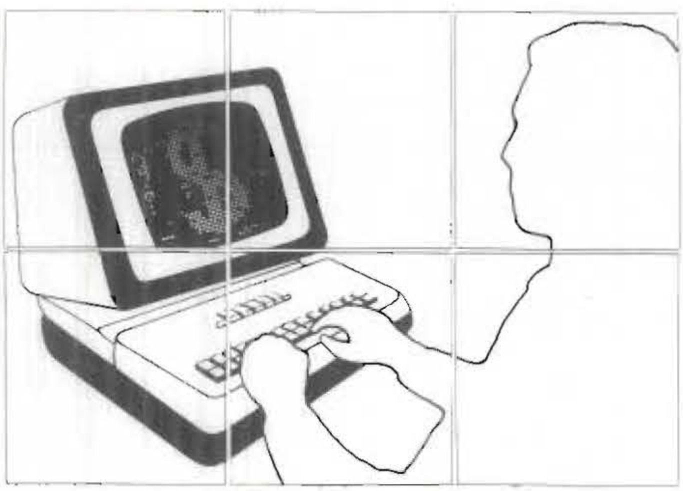
LITERATURE CITED

Martin, P. F. 1970. Alaska Agricultural Experiment Station "quick" soil tests. Laboratory methods and procedures. Alaska Agricultural Experiment Station. Mimeo. 11 pp.

The Computer Comes to Alaska Farming

By

Charles E. Logsdon*



INTRODUCTION

The personal computer is making an impact on Alaska's farmers just as on his counterpart in the "Lower 48;" and well it might. Alaska's farmers have always stayed at the forefront of developing agricultural technology as a means of survival in a rapidly changing world, and consequently Alaska's farmers take a back seat to no one when it comes to production techniques and capabilities.

Computers are nothing new. They are well ingrained in our late 20th-century lifestyle and influence many phases of our lives. They read the prices on our groceries at the store; they send us a bank statement at the end of each month; they inundate us with endless quantities of junk mail; and they help the IRS track all those little bits of income that we had forgotten about at reporting time. These are the BIG computers, the so-called "Main Frame" computers that dominate our lives and over which we have no real control.

The computers which are beginning to do so much for today's farmers are small, *personal* computers that are *user friendly* and do *handshaking* with printers and other computers. These are computerese terms which are used to describe a new relationship between man and his electronic environment. These terms indicate that man no longer needs to be held captive by the computer, but can now meet it face to face on a one-to-one basis. When he does, he sees that this is not some dreaded and insidious enemy, but a friend that can be a great help and that will work tirelessly in his behalf.

Just confronting it, of course, is not really quite enough, but it is a major step. The computer is no longer the frightening, blinking monster it used to be. The invention of the "chip" has allowed miniaturization of systems to the point that one can now have, in a small typewriter-size unit, computing power that used to require a very large, air-conditioned room. Size has been reduced from the very large to produce what are still known as minicomputers. These are still larger than the microcomputers now being referred to more and more as personal computers.

The transition in size has been accompanied by a transition in use. The large, mainframe computers and, even most of the minicomputers, are in that sacred domain of the data-processing departments of large banks, corporations, and government agencies. These tend to get larger and larger, and fewer and fewer people understand what they are all about. They lend themselves only to centralized data processing or to use as *data banks*. The microcomputers, which now have the processing power of former minicomputers, are now often called personal computers, because they are available for use by almost anyone with stored or *canned* programs even if he doesn't know one computer language from another. *User friendly* programs are those that will take you through a computer program step by step and gently remind you when you make an error.

At least two farms in the Matanuska Valley in Alaska have acquired and are using microcomputers. These are Mulligan Farms and Palmer Produce. Palmer Produce not only produces vegetables for the Alaska market, but also provides brokerage service to other farmers. Mulligan Farms produces a variety of vegetables and certified grain and grass seeds. It is the complexity of their farm operations that makes microcomputers attractive to them. Palmer Produce has chosen the Commodore because it is a good business computer with at least twice the on-line storage that the Apple has which is the computer chosen by Mulligan Farms. On the other hand, the Apple corporation has encouraged independent programmers to develop programs for their machines, so many more agriculturally oriented programs have been written for the Apple than for the Commodore. Both the Apple and the Commodore, as well as Atari and Ohio Scientific, use the 6502 central processing unit (CPU), but their programs are not interchangeable.

The largest group of microcomputers are those using the "80" chips such as Z-80, 8080, 8088, 8086, etc. This includes Radio Shack's TRS-80 series which are the largest-selling micro-

*Associate Director, Retired; Professor Emeritus, Agricultural Experiment Station.

computers in the United States. All of these machines can run under the computer program monitor (CP/M) operating system which has become a standard of the industry. TRS-80 may run under the TRS disk operating system (TRSDOS). The largest body of agricultural software, as well as other microcomputer software, has been written to run under CP/M. The Apple and some of the other 6502 computers can be run under CP/M. For instance, this article is being written on an Apple II + with a Microsoft card from Microsoft Consumer products which contains a Z-80 (trademark of Zilog, Inc.) CPU and operates under the CP/M (trademark of Digital Research, Inc.) system.

The Cooperative Extension Service has acquired Apple computers for its district offices, offering the possibility that sometime in the future, farmers will be able to access the extension service directly for some kinds of information rather than having to make a trip to town or call the agent. This is not possible yet, although the same the same kind of system is in use in other farming areas.

The Division of Agriculture has installed computer terminals, but is apparently using them to access the University of Alaska's large computer on a time-sharing basis. The division has installed a microcomputer at the Plant Materials Center which runs under CP/M. It is not accessible from outside the center, but will have its impact on agriculture through more-efficient operations of that institution. The same can be said of the computer terminals installed at the Palmer Experiment Station and of the computer system at the Mat-Su Community College.

Farmers in Delta Junction are looking into the use of micros on the farm, but they may wait to invest until better communications allow them to expand their use to access data bases.

WHAT CAN A PERSONAL COMPUTER DO FOR ME?

This is a very serious question that every farmer should ask himself before he invests in a computer, because computers are expensive. There are some things he needs to understand about the computer to start with. First of all, it is not just an elaborate calculator, although it will do even very complex calculations more rapidly than seems possible. Second, it will not do everything you would like it to do. And third, it will do things for you that you did not anticipate, so you will find more and more places where it can be of *assistance*. Assistance is emphasized because the computer is not a thinking machine and can do nothing unless you tell it what to do.

With that as a brief introduction to this fascinating world of computers, let's look at some of the things a personal computer will do for a farmer:

1. It will keep books and do accounting. You have to keep detailed records of your operation anyway, and most accounting programs for the computer provide bookkeeping systems and a certain discipline in maintaining those books. Although you may still want to use an accountant to be sure of new changes in tax laws or in advising you on depreciation, etc., many *software* accounting programs are quite good, and allow you to print out your own balance sheets, income and expense reports, and other records at any time you want them. These reports can be of help in making decisions about plantings, purchases, timing of sales, and can be valuable to take to the bank when you want to borrow money.

2. It will assist with planning and budgeting in ways that will almost make the process a pleasure. There are now programs for most, if not all, personal computers called electronic spreadsheets. One of the most popular of these is Visicalc, a product of Visicorp. These programs allow you to list your information in either words or numbers in columns and rows. Any column or row can be related to any other columns or rows by whatever appropriate formula you desire. A major advantage of this system is that it allows you to ask "what if" questions after you have filled in the blanks. If you change any number on the sheet, the program will automatically recalculate every other number on the sheet that was altered by the change you introduced. For instance, you might want to change your projected budget to see what the effect might be of an additional half a per cent in interest on an operating loan. That effect would be automatically calculated throughout to show what changes would occur anywhere else in your budget. Or, you might ask what the effect would be on your projected income if you got 10 bushels per acre more than you had originally expected.

3. There are any number of "data-base management" plans that will allow you to keep a variety of records and recall and organize those records almost instantaneously. Records on equipment, including repair and maintenance can provide a means of scheduling routine maintenance. Records of crop varieties, yields, prices, sales, etc. can be retrieved to provide your own records of best performance in terms of dollars, bushels, sales schedules, or any other way in which you wish to organize the information you need to make your decisions. You will probably use the same program to maintain recipes and Christmas mailing lists as well as records of birthdays, anniversaries, etc. There are programs which will organize stored data and present it in graph form for better understanding.

4. More than likely, you may wish to add a telephone modem to your system which will allow you to connect your computer to other computers by telephone. The term "modem" stands for modulate-demodulate which describes the process by which the instrument converts digital computer output to telephone analog transmission and then back to digital language at the other end. Telecommunication such as this has many advantages to the farmer, especially in acquiring up-to-the-minute information. For instance, a phone call to Tymnet or Telenet in Anchorage can connect you to a large data bank in McLean, Virginia, known as the *Source*, which has the latest commodity-market prices. Those prices are updated on a 15-minute basis during the trading day on the Chicago market. *Compuserve* is another data base in Columbus, Ohio, also with commodity-market news. Both have a great deal of other kinds of information as well. Probably the largest collection of data, although not necessarily as useful to farmers as market information, can be found by calling Dialog, a very large data-base system maintained by Lockheed Corporation at Palo Alto, California. Each of the data bases mentioned are accessible through a phone call to Anchorage. Another use would be to connect to *Agnet*, a farm computer network based in Nebraska, but connecting at least thirty states (not presently connecting Alaska, but by the time this article is published, the Division of Agriculture will have access to Agnet. Call them for more information or watch their weekly *Market News*). *Agnet* has over 200 programs specifically designed for farm use.

Programs are available for use with the modem to convert your personal computer to a teletype system if you intend to expand your business to national or international size. On a smaller level, the computer can be used for electronic mail through Source or Compuserve, and a system could be developed using the University of Alaska computer, the Department of Natural Resources computer, or possibly some other local system. With the aforementioned acquisition of computers by the Cooperative Extension Service, better and more rapid access to information may be provided when its system is complete and installed.

5. Personal computers can also be used to monitor and control temperatures, humidity, security systems, etc. Although not every farmer would have a need for this use, it should be considered in a farm operation. It could be just what you have been looking for.

There are many special farm programs available, but the ones listed would appear basic to any farming operation. The University of Florida's Extension Service Circular 531 of March 1982 lists about 1500 farm and home computer programs available for extension use. Some are also available to the public for prices ranging from supplying a disc for copying free of charge to $100. Of these 1500 programs, 71 are written for the Apple II +, 34 for the Commodore Pet, and 152 for the TRS 80 II, the most popular personal computers in use by farmers.

Almost anyone will want a word-processing program if his business includes a lot of correspondence, but it is not necessarily vital to farming as such. Printers are becoming available which have their own keyboard and can act as electronic typewriters as well as computer printers. It might be well to look into this sort of thing, because letter-quality printers can be as expensive as the rest of the system.

WHAT TO BUY?

Acquiring a computer system for personal and farm business use is a several-step process, no one of which should be neglected, and which should be performed in the following sequence:

1. Determine what you want a computer to do for you. If you don't know what a computer will do, there are a number of popular magazines that will give you ideas, or the Cooperative Extension Service might be willing to help you with information. Maybe you do not yet need one.

2. Look for software programs that will do the jobs you have decided are important to you. The Cooperative Extension Service or the Agricultural Experiment Station may be able to apprise you of available agricultural software. There are also a number of commercial sources such as Successful Farming Magazine's "Computer News" at 1716 Locust, Des Moines, IA 50336 and "Agpro Source Books" available from Agpro Micro Systems, Box 64539, Lubbock, TX 79464. Two other commercial sources of information on farm computer programs would be *AgriComp* magazine, 1001 East Walnut, Columbia, MO 65201 and *Agricultural Computing*, a newsletter published by Doane-Western, 8900 Manchester Road, St. Louis, MO 63144. You may find some at local computer dealers. Have dealers demonstrate their software before you buy. There are more and more dealers and more and more programs to do the things you want done, and a wide price range.

3. After you find the software that will do the things you want done in a way you feel comfortable doing them, then find a computer system that will use that software. A system consists of much more than the computer. In addition to the central processing unit, there is usually a keyboard for data input, a monitor or television screen, one or more disc drives for storage of information, and various printers that can be selected including thermal printer, dot-matrix printers, and impact printers, and discs containing various programs.

In spite of the fantastic strides that have been made so far, the computer is still in its infancy. Improvements are being made every day. Anything you buy today will probably be obsolete tomorrow, but don't worry about that; just look for a system that can be upgraded and expanded easily because you will find uses for it that you have not anticipated. □

Changes in Weed-Species Assemblage with Increasing Field Age

By

Jeffery S. Conn* and John A. DeLapp**

Dr. Curtis Dearborn (1959) published the first account of the Alaskan agricultural weed flora. Mentioned were some thirty-seven weeds affecting Alaskan agriculture. Most of the species listed are not indigenous to Alaska (Hultén, 1968) and must have been imported accidently.

In the summer of 1981, we surveyed the weed vegetation in agricultural fields of southcentral and interior Alaska in order to determine the current agricultural weed flora and to discern possible relationships between environmental variables and weed-species assemblage. Such data might also be used to determine whether new, economically important weed species had become established in Alaska since Dearborn's study was published.

METHODS

Weeds were quantitatively sampled during the summer of 1981 in 84 agricultural fields selected to be representative of typical crops and growing conditions to be found in Alaska. In southcentral Alaska, thirty-four fields were sampled in the Matanuska Valley. In the interior, forty-one fields in the Delta-Clearwater area and nine fields in the Fairbanks-Salcha area were sampled.

The crops sampled included potatoes, barley, wheat, oats, broccoli, strawberries, rapeseed, and Kentucky bluegrass. At each field, for each weed species, the percentage of cover was recorded in each of ten 1-m^2 quadrats located randomly along a transect. Synthetic importance values (the average of relative cover and relative frequency) were computed for each species in each field. Detrended Correspondence Analysis (DECORANA) (Hill, 1979), a multivariate statistical procedure, was used to reduce data dimensionality.

In the resulting ordinations (Whittaker, 1973), each field is represented by a single point, which indicates its vegetational similarity to other fields. Soil samples were obtained from twenty-seven of the fields and their chemical attributes (pH, % organic matter, Ca, Mg, total N, available P, and K) were analyzed at the Alaska Agricultural Experiment Station. All of the fields were classified as to age and a one-way analysis of variance was used to determine whether field age was related to the location of fields on the ordination axes.

*Research Agronomist, Agricultural Research Service, USDA, Fairbanks.
**Agricultural Assistant, Agricultural Experiment Station, University of Alaska, Fairbanks.

RESULTS AND DISCUSSION

A one-way analysis of variance showed that the location of fields on the DECORANA x axis is related to the number of years the field was in cultivation ($p < .0001$, $r^2 = 0.83$). In contrast, multiple regression analysis did not identify any soil-chemical properties significantly related to the ordination x or y axis. Thus, weed-species assemblage in the fields sampled seems to be related more to field age than to any other environmental factor studied.

Shown in Figure 1 is a shift in assemblage of weed species from mostly native species in fields that have just been cleared to mostly introduced species by the time the fields have been in cultivation for only three to five years. We also demonstrate that total weed cover (contributed by both native and introduced species) is initially low on newly cleared lands but increases dramatically with increasing time in cultivation.

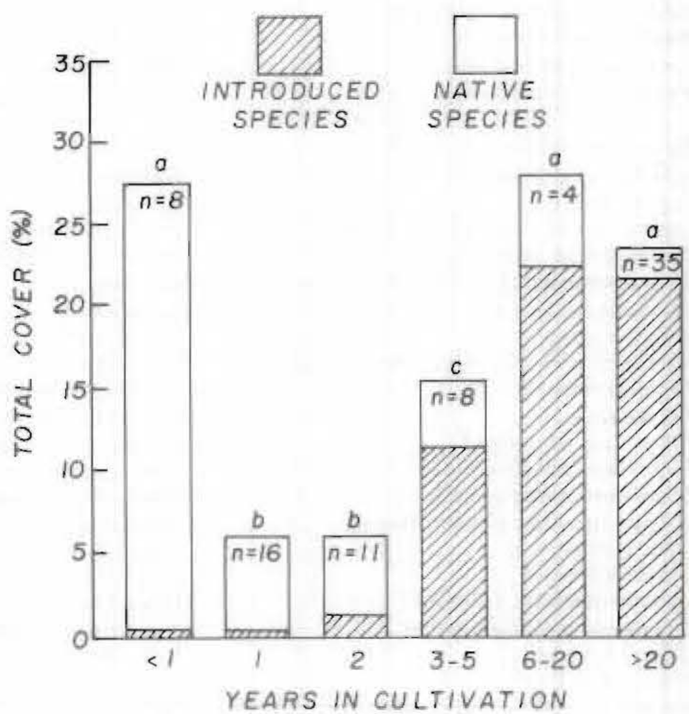


Figure 1. The relationship between number of years in cultivation and total weed cover and total cover of native and introduced weeds. Bars with different letters are significantly different at the .05 level.

Table 1. Mean Importance Values[1] of Native and Introduced Weeds in Agricultural Fields of Various Ages and Crops.

Name		Interior				Matanuska Valley	
		— Grains —				Grains	Potato
Scientific	Common[2]	1 yr	1-2 yr	3-5 yr	>5 yr	— >20 yr —	
NATIVE SPECIES							
Achillea borealis Bong.		0.4	0.4	0.5	1.0	0.9	0.0
Agropyron pauciflorum (Schwein.) Hitchc.		0.0	0.0	0.3	0.0	0.0	0.0
Agrostis sp.		0.4	4.1	0.3	0.0	0.0	0.0
Astragalus sp.		0.0	1.3	0.0	0.0	0.0	0.0
Alnus crispa (Ait.) Pursh	American green alder	0.3	0.3	0.0	0.0	0.0	0.0
Betula nana L.	dwarf birch[3]	0.9	0.0	0.0	0.0	0.0	0.0
Calamagrostis canadensis (Michx.) Nutt.	bluejoint reedgrass	16.9	8.0	0.0	0.0	1.3	0.0
Carex sp.		0.0	0.4	0.3	0.0	0.0	0.0
Chenopodium capitatum (L.) Aschers.	blite goosefoot	1.6	0.3	0.0	0.0	0.0	0.0
Cornus canadensis L.	bunchberry[3]	0.4	0.3	0.0	0.0	0.0	0.0
Corydalis aurea Willd.	golden corydalis	0.3	0.0	0.0	0.0	0.0	0.0
Corydalis sempervirons (L.) Pers.	pale corydalis[3]	0.3	5.9	0.3	0.0	0.0	0.0
Drachocephalum parviflorum Nutt.	American dragonhead	12.2	13.6	14.1	0.3	0.0	0.0
Epilobium angustifolium L.	fireweed	19.8	13.6	5.5	4.4	0.5	0.0
Equisetum arvense L.	field horsetail	11.5	7.3	18.7	20.2	2.9	3.3
Galium boreale L.	northern bedstraw	0.0	0.1	0.0	1.0	0.0	0.0
Ledum groenlandicum Oeder	Labrador tea	0.6	0.1	0.0	0.0	0.0	0.0
Linnaea borealis L.	American twinflower[3]	0.2	0.0	0.0	0.0	0.0	0.0
Lupinus arcticus S. Wats.	arctic lupine[4]	0.6	1.6	0.0	0.0	0.0	0.0
Luzula sp.		1.2	0.8	0.0	0.0	0.0	0.0
Mertensia paniculata (Ait.) G. Don	bluebell[3]	2.0	0.7	0.7	0.0	0.0	0.0
Moehringia lateriflora (L.) Fenzl	grove sandwort[3]	0.3	0.5	0.0	0.2	0.0	0.0
Oxtropis sp.		2.1	0.0	0.0	0.0	0.0	0.0
Petasites frigidus (L.) Franch.	arctic sweet coltsfoot[4]	0.6	0.0	0.0	0.0	0.0	0.0
Polemonium acutiflorum Willd.		2.2	4.1	0.0	0.0	0.0	0.0
Populus spp.		6.9	13.8	4.1	0.0	0.0	0.0
Potentilla norvegica L.	rough cinquefoil	1.3	3.4	0.9	0.0	0.5	0.0
Rosa acicularis Lindl.	prickly rose[4]	5.8	2.6	3.2	0.3	0.0	0.0
Salix spp.		4.8	3.8	0.0	0.0	0.0	0.0
Senecio congestus (R. Br.) DC.	marsh fleabane	0.9	0.0	0.0	0.0	0.0	0.0
Stellaria laeta Richards		0.3	0.0	0.0	0.0	0.0	0.0
Vaccinium uliginosum L.	alpine blueberry[3]	3.0	0.0	0.0	0.0	0.0	0.0
Vaccinium vitis-idaea L.	mountain cranberry	1.0	0.1	0.0	0.0	0.0	0.0
INTRODUCED SPECIES							
Agropyron repens (L.) Beauv.	quackgrass	0.0	0.0	0.9	4.2	2.7	17.3
Alopecurus pratensis L.	meadow foxtail	0.0	0.0	0.0	0.0	1.2	0.0
Avena fatua L.	wildoat	0.0	0.0	0.0	3.8	0.0	0.0
Capsella bursa-pastoris (L.) Medic.	shepherd's purse	0.0	0.0	1.1	7.7	6.7	1.4
Chenopodium album L.	common lambsquarters	0.0	7.9	33.3	33.1	8.9	14.8
Descurainia sophia (L.) Webb.	flixweed	0.0	1.2	0.0	2.5	0.0	0.0
Galeopsis tetrahit L.	hempnettle	0.0	0.0	0.0	0.0	3.8	0.0
Hordeum jubatum L.	foxtail barley	0.0	0.5	4.0	6.0	5.1	1.1
Matricaria matricarioides (Less.) Porter	pineappleweed	0.0	0.0	0.6	0.3	15.1	4.1
Plantago major L.	broadleaf plantain	0.0	0.0	0.0	0.0	0.1	0.0
Poa annua L.	annual bluegrass	0.7	0.0	0.2	1.3	8.7	4.8
Polygonum aviculare L.	prostrate knotweed	0.0	0.0	0.0	0.0	5.7	1.1
Polygonum convolvulus L.	wild buckwheat	0.0	0.9	9.6	3.2	2.7	10.9
Polygonum pensylvanicum L.	Pennsylvania smartweed	0.0	0.0	0.0	0.0	0.9	2.6
Rorippa islandica (Oeder) Borbas	marshcress	0.5	1.8	1.0	0.0	1.2	0.0
Senecio vulgaris L.	common groundsel	0.0	0.0	0.0	0.0	0.0	2.5
Spergula arvensis L.	corn spurry	0.0	0.5	0.0	2.0	2.7	1.2
Stellaria media (L.) Cyrillo	chickweed	0.0	0.1	0.4	6.0	25.7	26.0
Taraxacum officinale Weber	common dandelion	0.0	0.0	0.0	0.0	1.1	0.0
Thlaspi arvense L.	field pennycress	0.0	0.0	0.0	1.5	0.0	1.1
Vicia cracca L.	bird vetch	0.0	0.0	0.0	0.0	0.9	2.7

[1] Importance values are the average of relative cover and relative frequency. Species with high importance values occur in many of the sample plots, contribute a great amount of ground cover, or both. Importance values range from 0 to 100.
[2] Common name from WSSA (1971) unless otherwise noted.
[3] Common name from Hultén (1968).
[4] Common name from Welsh (1974).

Figure 2. Berms serve as reservoirs for native weed species.

As noted by Dearborn (1959), most of the native species present on newly cleared fields disappear with cultivation. Several exceptions to this trend were noted when winter wheat or grass for seed production was planted during the fall of the first year of cultivation. Under these conditions, the total cover of native species increased. Thus, growers clearing land for the first time can minimize their problems with native weeds by sowing spring-planted crops during the first few years of cultivation.

Almost all of the introduced weeds encountered in the study (Table 1) were present in 1959. Hempnettle (*Galeopsis tetrahit* L.) and common groundsel (*Senecio vulgaris* L.) are notable exceptions. Why have so few new weed species become established? Some possible reasons are: 1) a lack of dispersal opportunities; or 2) a limited number of species preadapted to the cropping systems, climate, and photoperiods characteristic of Alaska.

Though many of the weeds may already be here, plant-quarantine measures should remain strict to further restrict the entry of new weeds into the state. Equally important, however, is to control the spread of weeds that have already arrived in Alaska. Growers should take care to plant only weed-free crop seed, buy feeds that are not weed-contaminated, and clean farm equipment of weed seed before moving it to a clean field from one contaminated by weeds. These relatively inexpensive precautions could result in considerable savings in weed-control measures over the long run. □

REFERENCES

Dearborn, C. H. 1959. Weeds in Alaska and some aspects of their control. *Weeds 7*:265-270.

Hill, M. O. 1979. DECORANA. A FORTRAN program for detrended correspondence analysis and reciprocal averaging. *Section of Ecology and Systematics,* Cornell University, Ithaca.

Hultén, E. 1968. *Flora of Alaska and Neighboring Territories.* Stanford University Press.

Weed Science Society of America. 1971. Composite list of weeds. *Weed Science 20*:435-476.

Welsh, S. L. 1974. *Anderson's Flora of Alaska and Adjacent Parts of Canada.* Brigham Young University Press, Provo.

Whittaker, R. H., ed. 1973. Ordination and classification of communities. *Handbook of Vegetation Science 5*:1-737. W. Junk, The Hague.

Increased or Decreased Energy for Moose?

The Susitna Hydroelectric Project

By

William B. Collins*

A moose walks out onto a Susitna River gravel bar a few miles downstream from Talkeetna and begins to browse some low-growing willow and balsam poplar shrubs. The animal has spent approximately one-half of its day feeding on similar vegetation. Approximately one-fourth of its day will be spent rechewing its harvest, further converting the woody plants into a form it can use as energy. Energy cannot be created or destroyed, but only changed in form.

Forty-eight miles upstream, an engineer contemplates another form of energy conversion. His plan will alter the flow of the river to harness its energy. The man has selected the location for a dam because it represents a very efficient site for conversion of water power to electricity. The moose has selected its feeding site because, there too, energy conversion is most efficient.

During this study the Agricultural Experiment Station (AES) at Palmer was under contract to Terrestrial Environmental Specialists (TES) of Phoenix, New York, to investigate the possible impacts on vegetation and related habitat values for moose of hydroelectric development on the Susitna River. This effort was part of an overall feasibility study conducted by Acres American Incorporated for the Alaska Power Authority; TES was subcontracted to Acres. A primary concern has been to determine what effect regulated river flow may have on moose habitat within the floodplain downstream of the proposed Devil Canyon damsite. This land is frequently flooded in summer, a phenomenon which some believe may be responsible for maintenance of the vegetation in early successional stages which are highly productive of moose forage. With hydroelectric development, the annual fluctuation in downstream water levels and flooding would be reduced, thereby possibly allowing prime moose habitat to advance to later, less productive successional stages.

In May 1981, AES personnel began a study of vegetation succession on the Susitna floodplain from the Devil Canyon site downstream approximately 92 miles to the Deshka River. Through reconnaissance of the area and comparison of historical (1951) photographs with 1980 photographs, seven vegetation types were identified which were thought to represent stages of succession from bare ground to climax forest.

Vegetation soils data from each type were collected and analyzed to determine vegetation history as it may relate to flooding. Per cent cover of plant species and density, dimensions, and ages of trees and shrubs were estimated or measured to form the basis for characterizing each vegetation type. Particular effort was made to determine the point in time when each stand began developing. Soils from several pits within each type were analyzed to determine what relationships may exist between vegetation type and soil substrate. Elevations of each stand above the level of the river were measured at various times during the summer to be related to rates of flow (simultaneously being measured by R and M Consultants, another member of the feasibility study team). Eventually this information can be used to predict the extent of flooding under different hydroelectric development options.

Vegetation succession on the floodplain generally occurs in the following sequence (Figure 1). Commonly, horsetail (*Equisetum* spp.) is the first vegetation to become established on bare ground. However, its occurrence is dependent on the presence of fine sands and silts in the surface horizons of the soil. This vegetation is readily invaded by willow (*Salix* spp.) and balsam poplar (*Populus balsamifera*) seedlings. Similar topographic sites which have coarser substrate may never develop horsetail as the dominant species but may be occupied by willow-balsam poplar

*Assistant Professor, Range Management, Agricultural Experiment Station, Fairbanks.

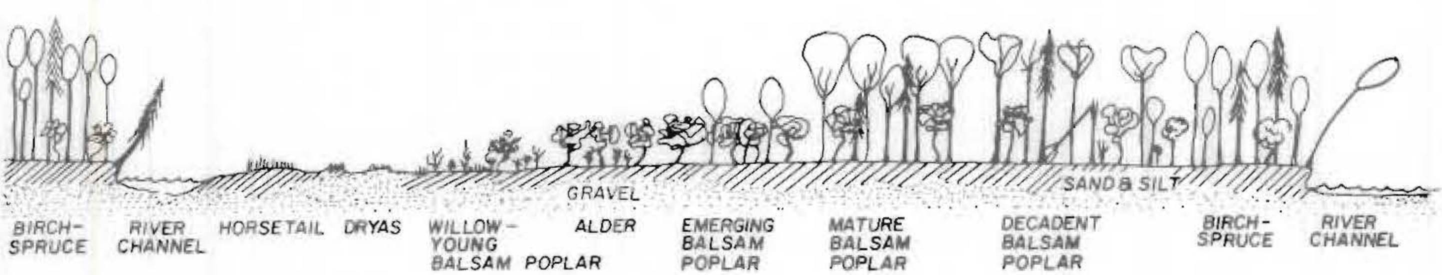


Figure 1. Possible sequence of vegetation succession (left to right) on Lower Susitna River. Horsetail, dryas, or willow-young balsam poplar may occur as the pioneering vegetation type, depending on the substrate, plant propagules present, and other environmental conditions.

Figure 2. Early successional vegetation. Horsetail stand (on left) is the initial pioneering vegetation. At a slightly higher elevation (on right) is a heavily browsed stand of feltleaf willow which is 8 to 10 years old.

Figure 3. Feltleaf willow, balsam poplar, and alder seedlings gain dominance over initial horsetail stand. Alder (the large shrubs) are 3 years old and already overtopping the willow and balsam poplar which are 7 to 10 years old.

directly, or in the case of gravelly or cobbley sites, be pioneered by dryas (*Dryas drummondii*), a nitrogen-fixing plant. In any case, the initial vegetation is important in holding the soil and in reducing the velocity of water and wind for further deposition of substrate.

In time, depending on a number of factors such as siltation and elevation of the surface above the level of frequent flooding, density of alder (*Alnus tenuifolia* and *A. sinuata*), another nitrogen fixer, apparently increases and gains dominance over the balsam poplar and willows. This may be in response to an inherently faster growth rate of alder, or preferential browsing of the other species by moose, or a combination of both. However, some time after the alder achieves maximum height, the balsam poplar emerges through the alder canopy, once again receiving full sunlight and begins fast growth into large trees. Addition of nitrogen to the soil by alder may contribute to the balsam poplar's increased rate of growth. Balsam poplar is shade-intolerant and does not reproduce in its own shade; consequently, most stands are even-aged.

As the balsam poplar forest matures, spruce (*Picea glauca*) may appear in the canopy (a few may become evident as early as the alder stage). Eventually, the balsam poplar becomes decadent and falls, leaving space for development of more balsam poplar or spruce and birch (*Betula papyrifera*). The factors responsible for development of the birch-spruce stands versus continuation of balsam poplar are still unclear but may be better understood after further analyses of soils. Balsam poplar does have a better chance of continuing if the disturbance exposes mineral soil. Elevation surveys of the different types did not indicate that the birch-spruce stands were any less likely to be inundated by high water than were mature balsam poplar stands. Much work still needs to be done to understand more fully the mechanisms underlying each of the apparent successional sequences.

Initial observations by both AES and Alaska Department of Fish and Game (ADF and G) personnel indicate that the willow-balsam poplar sapling type may be the most valuable feeding habitat for moose living on the floodplain. This is being

Figure 4. Substrate determines the type of pioneering vegetation which becomes established. Horsetail and willow readily establish on silty sites (top), while only sparse patches of dryas and balsam poplar are found on gravelly sites (bottom).

Figure 5. Alder thicket with balsam poplar emerging through the top.

Figure 6. After 25 years, a dryas stand (see Figure 4) may accumulate enough alluvial and windblown silt to support a more productive and diverse community of plants. However, the vegetation on siltier soils (background) has advanced to an immature balsam poplar forest in the same amount of time.

Figure 7. Balsam poplar browse is elevated far above the heads of moose as saplings grown into trees as seen in this immature forest.

Figure 8. Birch-spruce may be the climax vegetation Susitna River floodplain.

studied by the ADF and G which is responsible for the evaluation of the big game populations and distribution as part of the feasibility study. Since the willow-balsam poplar sapling type occurs early in vegetation succession, it is probably dependent on some form of disturbance to create conditions favorable for its establishment. Such disturbance could result from flooding and subsequent siltation, erosion of banks by ice and redeposition, wind throw, or fire. The relative influence of each of these factors thus is also an important consideration in defining the impact of flooding.

Mature and decadent balsam poplar and birch-spruce stands also produce abundant moose browse and provide security cover. Highbush cranberry (*Viburnum edule*) and prickly rose (*Rosa acicularis*) are important browse species in these forested types, whereas willow species have become much less abundant than in the open types. Paper birch saplings provide additional browse for moose in birch-spruce stands, and alder species may be browsed occasionally in all stands. Devilsclub (*Oplopanax horridus*), which often leaves numerous painful spines imbedded in the legs and hands of hikers, and ostrich-fern (*Matteuccia struthiopteris*) are highly preferred as forage by lactating cows and calves using mature and decadent balsam poplar stands in spring and early summer.

Birch-spruce stands appear to be in dynamic equilibrium or climax for vegetation occurring on the lower Susitna River floodplain. These stands characteristically have four phases which repeat themselves in the following cyclic sequence. The tallest, oldest part of the forest, having a well-developed understory of grasses and forbs but relatively few shrubs, begins to lose paper birch from the canopy as heart rot takes its toll. As the canopy opens up, the spruce apparently becomes more susceptible to windthrow, and large patches of overstory are completely lost. This then leads to the decrease of some shade-tolerant species and the increase of paper birch saplings, highbush cranberry, prickly rose, willow, and thinleaf alder (*Alnus tenuifolia*). As brush fields age, spruce begins to appear and eventually this phase advances to birch-spruce forest. The early

Figure 9. After roughly 150 years, balsam poplar can become decadent, creating space for emerging spruce and/or birch. Newly deposited bar in the foreground shows the successional sequence starting over.

birch-spruce stands characteristically retain more browse in the understory than do more mature stands. As birch-spruce stands age, the cycle apparently is repeated. The close association of brush fields with mature forest in the birch-spruce type appears to provide good overall moose habitat.

AES personnel will begin estimating the forage productivity of each vegetation type. This information, coupled with habitat-preference data collected by ADF and G and vegetation succession information, will be used to assess the effects of changes in vegetation which may occur if hydroelectric development takes place. Then it may be known how development of Susitna hydroelectric energy will affect the availability of an efficient source of energy for moose.

ACKNOWLEDGMENTS

Funding for this project was provided by Terrestrial Environmental Systems. TES was subcontracted to Acres American Incorporated who was the prime contractor to the Alaska Power Authority. ☐

THE DYNAMIC FORCES OF THE SUSITNA RIVER AT WORK

Figure 10. Siltation during summer flood occurring on dryas, horsetail, and balsam poplar sapling communities. AES personnel discuss the impacts with a wetlands specialist and forester from Sweden.

Figure 11. A black spruce peat bog (not considered part of the floodplain) is being undercut and pulled into the river.

Figure 12. Young alder and balsam poplar which were "bulldozed" by ice during spring breakup. Rocks were deposited as the ice block melted from beneath them.

Figure 13. Young balsam poplar trees (center) exhibit "flood-trained" shape as a result of past ice jamming.

Undergraduate Degree Encompasses New Options in Forestry and Agriculture

By

Carla A. Kirts*

As a land-grant university, the University of Alaska at Fairbanks must be responsive to the needs of the public it serves. The School of Agriculture and Land Resouces Management recently initiated several changes in the undergraduate degree program as a result of public requests and new trends emerging in various disciplines encompassed within the realm of natural resources management in Alaska, particularly forestry and agricultural production.

The School of Agriculture and Land Resouces Management is composed of the Instruction and Public Service Program and the Agricultural Experiment Station. The courses and degree program guidelines within the Natural Resources Management curriculum are developed not only through a concerted effort on the part of the divisions within the school, but also in cooperation with other units within the university concerned with natural resources management. These include the Institute of Social and Economic Research, the Institute of Water Resources, the Environmental Quality Engineering program, the Cooperative Extension Service, and the Rural Education program. Thus, individual faculty throughout the university make significant contributions to the program.

In an effort to ensure that the degree program prepares students for the real world of work available in Alaska, cooperation is obtained also from related agencies and organizations. These include: the Alaska Department of Fish and Game, Alaska Rural Development Council, Alaska Department of Natural Resources, Alaska Conservation Society, Alaska Association of Soil Conservation Subdistricts, Soil Conservation Service, Agricultural Research Service, Bureau of Land Management, U. S. Forest Service, and the U. S. Fish and Wildlife Service.

A B. S. in Natural Resources Management is offered as the undergraduate degree. Flexibility in the degree requirements affords students an opportunity to correlate course work with specific resource interest. All degree candidates are required to complete all core major requirements involving 30 credit hours of specified courses, and an additional 12 credits are also required. These must be selected from a list of 21 restricted electives (including approved special topics) and a list of 16 related disciplines such as geosciences, biological sciences, economics, education, and engineering (See Table 1).

Thus, judicious utilization of courses in restricted electives and related disciplines allows a study emphasis on a particular resource field while simultaneously providing cohesive instruction in the various land resources in general.

A program can vary from providing a very broad degree to one allowing some depth. Upon graduation, career opportuni-

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

Students in natural resources management classes participate in field experiences. This site is one of many used to illustrate principles of natural resource management.

Students are felling trees for an experimental thinning study. Hands-on experiences such as this are provided throughout the degree progams.

Table 1. Requirements for the Natural Resources Management Degree.

		Credits
1. Complete the general university and B.S. degree requirements listed in the University of Alaska catalog. These include required minimum courses in English, math science, social science and humanities.		
2. Complete the following program (major) requirements:		
ALR 101	Conservation of Natural Resources	3
ALR 310	Agricultural Concepts and Techniques	3
ALR 340	Natural Resources Measurements	3
ALR 350	Introduction to the Forest System	3
ALR 370	Introduction to Watershed Science	3
ALR 380	Soils	3
ALR 400	Natural Resources Policies	3
or 401	Natural Resources Legislation	3
ALR 430	Land Use Planning	3
ALR 460	Principles of Outdoor Recreation Mgt.	3
Biol. 105 -106	Fundamentals of Biology	8
Biol. 271	Principles of Ecology	4
Chem. 105 -106	General Chemistry	8
Econ. 235, 435	Resources Economics	6
GeoS. 101	General Geology	4
W.F. 301	Principles of Animal Population Dynamics and Management	3
3. Plus at least 12 credits from the following courses in man's environment and/or resources. Approved special topics courses may at times be applied toward this requirement.		
ALR 311	Introduction to Agronomy & Horticulture	3
ALR 320	Principles of Animal Science	3
ALR 400	Natural Resources Policies	3
ALR 401	Natural Resources Legislation	3
ALR 411	Plant Propagation	3
ALR 450	Forest Management	3
ALR 461	Interpretive Services	3
Biol. 474	Plant Ecology	3
Biol. 476	Animal Ecology	4
Econ. 437	Regional Economic Development	3
E.Q.S. 403	Solid Waste and Air Pollution	3
Geog. 327	Cold Lands	3
Geog. 402	Man and Nature	3
GeoS. 304	Geomorphology	3
Min. 101	Minerals and Man	3
Min. 407	Mineral Industry and Environment	3
Ocn. 411	General Oceanography	3
W.F. 402	Wildlife Biology and Man	2
W.F. 417	Forest and Tundra	2
W.F. 419	Wetlands	2
W.F. 430	Fisheries and Their Management	3
W.F. 435	Water Pollution Biology	2

4. Plus a minimum of 12 credits in one of the following fields or combined fields beyond those taken to fulfill numbers 2 and 3 above. These courses are to be selected for their clear pertinence to a cohesive program in resource study and must be approved by the Director of the Instructional Program in the School of Agriculture and Land Resource Management.

   Anthropology (cultural)
   Biological Sciences
   Broadcasting, Journalism
   Business Administration
   Civil Engineering, Engineering Sciences, Environmental-Quality Engineering
   Economics
   Education
   Geography
   Geology
   Land Resources, Agricultural Sciences
   Mining Engineering and Petroleum
   Police Administration
   Political Science
   Psychology
   Sociology
   Wildlife and Fisheries

5. The total program must include a minimum of 12 credits in the following social sciences:

   Anthropology
   Economics
   Political Science
   Psychology amd/or Sociology

   Courses must include one relating man's culture to his environment, and one dealing with human population characteristics and dynamics.

ties are available in general fields such as conservation education, resource communications, resource engineering, general resource management, and in many specific fields related to resource management.

The development of the curriculum is based on the major objectives of the undergraduate degree program in natural resources management. Thus, to the greatest extent possible, the degree program is designed to 1) provide a basic science foundation for natural resources management; 2) provide core courses in management of each of the major natural resource disciplines; 3) prepare students to meet the present and immediate future job market needs in natural resources management, particularly in Alaska; and 4) provide courses useful for majors in other disciplines, personnel in natural resource agencies, persons in continuing education, and agents in extension education. It is primarily with the third objective in mind that the new options in agriculture and forestry were added. As the enrollment in Natural Resources Management increases as shown in Figure 1, it becomes more feasible to respond to students' and potential employers' requests for increased depth in particular disciplines. Furthermore, state government entities are encouraging educational institutions in Alaska to prepare Alaskans for Alaskan jobs.

If forestry and agriculture in Alaska are to expand the degree that they become viable, stabilizing industries, education must play a significant role in such development. In essence,

Table 2. Examples of Duties of Forest Technicians, Grades I-V, and State Forester I[1].

Job Series	Examples of Duties
Forest Technician I	Entry level skills: perform data collection; forest flagging, cruising, and inventory; timber scaling; fire fighting, prevention, detection, and evidence preservation; safety practices
Forest Technician II	In addition to lower level duties: perform more advanced forest management; planting; thinning; general aerial photo interpretation; weather checks; assist in drawing maps; allocation of burning permits; landowner instruction in forest-measurement techniques; public presentations of fire prevention
Forest Technician III	In addition to leading small crews in performing duties of Technician I and II: provide general assistance to landowners; prepare project reports
Forest Technician IV	In addition to directing several crews in performing duties of Technician I, II, and III: prepare routine timber sales projects; consolidate small project reports into area project reports; supervise prescribed burns; offer training to other technicians on fire evidence preservation, and collect evidence; manage burning-permit programs; provide timber sales assistance to landowners
Forest Technician V	In addition to supervising lower-level technicians: perform cost estimates for projects; interpretation of complex bridge designs for sale layouts; quality checks of scaling; interpret aerial photos; instruction for other instructors; development of fire-prevention program content; explanation of timber-sale procedures to landowners; investigation of fires and post-fire inventory
Forester I	Entry level of Forestry class series: make stereoscopic interpretation of ground cover; compile filed data into statistical charts; map forest types; participate in field surveys for land-use planning; maintain map and photo files; supervise work crews; inspect logging and earthwork projects for compliance with regulations and sound management principles

[1] Job descriptions are abbreviated. For more detailed information contact the Alaska Department of Administration, Division of Personnel.

educational programs at all levels, including elementary, secondary, postsecondary, and higher and adult education, are necessary to complement statewide efforts to develop these renewable-resource industries. At the present time, it appears that many students interested in studying forestry and agriculture at institutions of higher learning are leaving Alaska to further their education. It is imperative that instructional programs in forestry and agriculture be developed such in a manner that interested individuals can obtain an education without leaving the state. Most programs outside the state do not afford students an opportunity to gain fundamental and practical concepts and techniques related to subarctic and arctic situations. Thus, in light of the charge to a land-grant university to respond to public demands for programs, forestry and agriculture options have been added to the general natural resources degree.

FORESTRY OPTION

To better prepare graduates to obtain technical, professional, and managerial jobs within Federal, state, and private sectors, an option in forestry was added to the general natural resources degree program. With this option, students can select forestry as the natural resource area of emphasis which will appear in the degree title on the diploma (i.e. Natural Resources Management/Forestry).

Several factors have increased the demand for experienced forestry personnel needed by the Alaska Department of Natural Resources (DNR), which in the past has hired a substantial number of natural resources management graduates. First, the state has assumed greater responsibility for wildfire suppression in interior Alaska. Both agency staff and students have requested more in-depth instruction in wildfire behavior and utilization of fire as a management tool in the undergraduate degree program. These topics are components of a new course, Forest Protection.

Second, passage of the State Forests Practices Act established a detailed policy for maintaining forest productivity and protecting forest soils, water, and related resources by requiring harvest methods to conform to "best management practices." The act will be ineffective unless timber harvesting, marketing, management, and inspection are conducted properly and efficiently. As a result, DNR has established new technical and professional positions to address these needs and, again, both students and agency staff have requested the addition of related courses such as the new courses in the forestry option, Regeneration of Alaskan Woody Plants, and Harvesting and Utilization of Forest Products.

The third and most recent general change involves the establishment of the new Forestry Division within the Alaska Department of Natural Resources. With this higher-level interest in statewide forest management, additional personnel with forestry-related experiences will be required at all job levels throughout the state. The forestry option will enable graduates to qualify for the state Forest Technicians Series, particularly grades I and II. Furthermore, outstanding graduates can potentially qualify for a state Forester I position (Table 2).

To further justify the addition of the forestry option, increased interest of students within the school has been evident. Students have repeatedly requested that additional courses in forestry be taught which examine more in-depth concepts and techniques. Furthermore, both the Instruction and Public Service Program and the Forest Soils Laboratory, a component of the Agricultural Experiment Station, are involved in research which attracts student interest and inquiries. In fact, several students have been afforded summer employment through technical assistantships provided by forestry-research projects.

In addition to the new course offerings, the requirements for the forestry option (Table 3) include many of the previous-

Table 3. Requirements for the Forestry Option.

		Credits
1. Complete general university and B. S. degree requirements		
2. Complete all core (Major) requirements for the B. S. degree in Natural Resources Management		
3. Complete the following courses:		
CE 112	Elementary Surveying	3
Biol 331	Systematic Botony	4
ALR 450	Forest Management	3
ALR 451	Regeneration of Alaskan Woody Plants	3
ALR 452	Forest Protection	3
ALR 453	Harvesting & Utilization of Forest Products	3
4. Complete nine credits from the following restricted electives:		
Geos 422	Geoscience Applications of Remote Sensing	3
Geos 408	Map and Airphoto Interpretation	2
WF 430	Fisheries Management	3
WF 417	Wildlife Management – Forest and Tundra	2
WF 401	Wildlife Management Techniques	3
BA 350	Real Estate	3
ALR 312	Range Management	3
ALR 300	Internship in Natural Resources Management	1-6
5. Fulfill requirements of category 5 in the B. S. in Natural Resources Management		

ly offered natural resource management courses such as those involving conservation, introductory forestry, forest management, resource measurements, watershed management, outdoor recreation, soils, land-use planning, and resource policy and legislation. Courses in other units within the university provide foundation instruction in economics, basic natural sciences, and wildlife management.

AGRICULTURE OPTION

To provide majors with greater depth of understanding and competency needed for successful employment and/or entrepreneurship in agricultural enterprises, an agriculture option was added to the general natural resources management degree program. Increased enrollment in natural resources management (Figure 1), availability of the necessary funds, employment and/or entrepreneurial opportunities, trends in agricultural development in Alaska, and continued requests from various interest groups warranted the addition of an agriculture option.

During the past six years, interest has increased in developing agricultural enterprises in Alaska. In 1976, Governor Jay Hammond announced that a major goal of state government was to encourage the economic development of renewable resources, including agriculture. During the following legislative session, the Alaska State Legislature responded by approving the first funding program for agriculture, followed in 1979 by the creation of the Alaska Agricultural Action Council (AAAC, 1981). A soil survey completed in 1979 by the U. S. Soil Conservation Service classified approximately 20.5 million acres in Alaska as having tillable soils (Reiger et al., 1979). As a result of these legislative activities and studies of agricultural potential in Alaska, the AAAC has planned and/or developed several agricultural projects and has determined that having 500,000 acres

Table 4. Requirements for Agriculture Option.

		Credits
1. Complete general university and B. S. degree requirements		
2. Complete the following core (Major) requirements:		
ALR 101	Conservation of Natural Resources	3
ALR 311	Introduction to Agronomy & Horticulture	3
ALR 312	Range Management	3
ALR 313	Introduction to Plant Pathology	4
ALR 320	Introduction to Animal Science	3
ALR 321	Applied Animal Nutrition	3
ALR 340	Natural Resources Measurements	3
ALR 350	Introduction to Forest Systems	3
ALR 370	Introduction to Watershed Science	3
ALR 380	Soils	3
ALR 403	Farm Planning and Management	3
ALR 411	Plant Propagation	3
ALR 412	Field Crop Production	3
ALR 420	Animal Nutrition and Metabolism	3
ALR 450	Forest Management	3
ALR 480	Soil Management	2
3. Complete 12 credits from the following restricted electives:		
Biol 210	General Physiology	4
Biol 239	Plant Form and Function	4
Biol 242	Introductory Microbiology	3
Biol 252	Principles of Genetics	4
WF 301	Animal Population Dynamics & Management	4
Any ALR courses not used in above categories		
4. The total program must include a minimum of 12 credits in the following social sciences: anthropology, economics, sociology, and political science.		

in production by 1990 is a feasible, long-term goal. Of course, an expansion in agriculturally related employment accompanies increased development of the agricultural industry in Alaska. By 1990, the number of jobs directly resulting from agricultural development in Alaska is expected to double the 1975 figures (AAAC, 1981).

Over the past several years, both students and practicing agriculturalists have requested that additional courses in agricul-

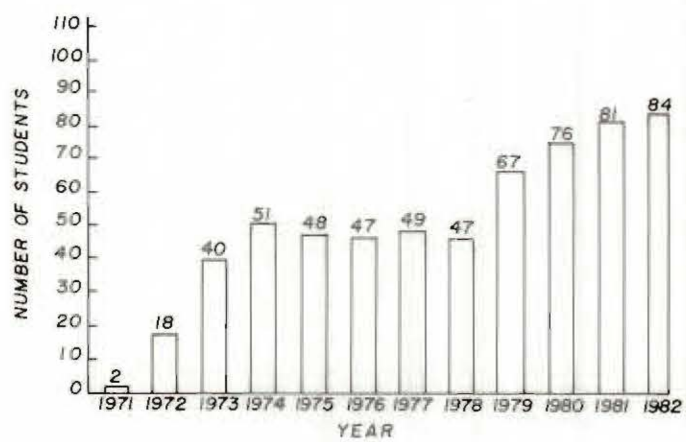


Figure 1. Undergraduate Enrollment Trend in Natural Resources Management, 1971-1982.

ture be included in the curriculum in natural resources management. A survey of natural resources management majors conducted two years ago revealed that majors were interested in agricultural courses above and beyond those presently offered. In addition, several organizations such as the Alaska Farmer and Stockman's Association and Two Rivers Grange adopted resolutions which were presented to appropriate legislators requesting that a complete four-year degree program in agriculture be initiated. The organizations expressed an interest in courses both for present and potential agriculturists, particularly for the younger generation growing up on farms in Alaska. The number of high-school vocational agriculture programs in Alaska has been increasing, and outstanding students have expressed an interest in attending the University of Alaska, Fairbanks, to pursue a degree in agriculture.

In the past, several courses in agriculture have been included in the general natural resources degree. Introductory courses previously offered are agronomy and horticulture, soils, animals science, and animal nutrition. More advanced, upper-division subjects included plant propagation, and animal metabolism and nutrition (Table 4). To accommodate the requirements for the agriculture option, five new courses have been added to the curriculum: Soil Management, Field Crop Production, Range Management, Introduction to Plant Pathology, and Farm Planning and Management. These courses will be of interest not only to natural resources management majors, but also to students in preveterinary medicine, biology, and wildlife.

SUMMARY

The new options in forestry and agriculture not only strengthen the general undergraduate and graduate programs, but also allow natural resource management majors at UAF to emphasize these disciplines within their degree program and have the option stated on the diploma. Both agriculture and forestry are viable industries in Alaska, and the employment outlook for each is promising. The School of Agriculture and Land Resources Management is modifying programs in light of anticipated future trends. However risky this may seem, it appears to be more feasible to develop educational programs in conjunction with industrial expansion rather than play "catch up" after the industries abound. □

LITERATURE CITED

Alaska Department of Administration. 1978 revised. Division of Personnel. Forestry Job Description.

Alaska Agricultural Action Council. 1981. *Alaska's Agriculture, A Positive Future: 1981 Annual Report to the Legislature.*

Reiger, S., D. B. Schoephorster, and C. E. Furbrush. 1979. *Exploratory Soil Survey of Alaska.* Soil Conservation Service, U. S. D. A.

University of Alaska. 1970-1980. Statistical Abstract. Instutional Studies and Testing.

Spinach Creek Watershed

A Resource for Education and Research

By

John D. Fox*

Near-complete peripheral road access outlines the heart-shaped Spinach Creek watershed on this infrared aerial photo.

The Spinach Creek watershed is operated under a Special Land Use Permit from the state of Alaska as a demonstration and instructional watershed for the Natural Resources Management Program of the School of Agriculture and Land Resources Management. The 10-mi^2 area is located approximately 15 miles north of Fairbanks, and includes state, borough, and private lands with little opportunity for experimental control on future land-use development. However, what may seem like an experimental disadvantage may, in fact, be a very useful feature. Although state land disposals are slated for part of this land, the watershed is currently undeveloped. Thus, the opportunity exists here to initiate a basic data-collection program which will yield fundamental hydrologic information while also serving as a predevelopment reference as land-use patterns change.

In addition, the Spinach Creek watershed offers some very desirable features. First, Spinach Creek is readily accessible by an all-weather, maintained road and is only a short drive from the University of Alaska. Thus, the area can be conveniently visited in an afternoon for student field exercises, assignments, and research. This logistic advantage also facilitates faculty and graduate-student research activities compatible with teaching responsibilities and course-work schedules.

Second, Spinach Creek affords a variety of landscape and topographic features including several north- and south-facing subwatersheds; perennial, intermittent, and ephemeral channels; permafrost and nonpermafrost areas; deep, loess-covered slopes; shallow, moss-covered talus; and steep faces of exposed schist bedrock. Vegetation includes typical mixed birch-aspen-spruce forests on southerly exposures and both dense and open black-spruce stands on north-facing slopes. Evidence of past logging, probably for fuelwood, and some mining exists within the area.

Although the area is used in a manner directly related to objectives of the University of Alaska's course in watershed management, it also provides a field setting appropriate for study of soils and vegetation, terrestrial and aquatic wildlife, outdoor recreation, and land-use planning. Currently, rain, temperature, humidity, solar radiation, and stream water-level sensors have been installed for collection of basic data and for demonstration of equipment. Students will use the area to learn

A student attends to the water-level recorder on Spinach Creek.

*Assistant Professor, Resource Management, Agricultural Experiment Station, Fairbanks.

A student observes an aufeis area in the Spinach Creek valley.

Groundwater bubbles to the surface during spring runoff.

techniques of measuring precipitation, streamflow, and water quality. They will also have the opportunity to learn other practical watershed-management skills.

In addition to being an educational resource, the Spinach Creek watershed provides an excellent opportunity for research in watershed management and basic hydrology. Why is such research needed? Let me explain. The state of Alaska has recently passed a Forest Practices Act (FPA) and is currently in the process of formulating "Best Management Practices" (BMP) to ensure minimum negative impact of forest land uses on streamwater quality, aquatic habitats, and land productivity.

Unfortunately, there is little research information or routinely collected data that is directly applicable to interior Alaska watersheds. This is particularly true of small, low-order streams that are likely to be most affected by timber harvest operations.

Dingman (1966, 1971) initiated early efforts in watershed research at Glenn Creek near Fox, Alaska. This area has received some renewed attention by two University of Alaska graduate students and by the U.S. Army Cold Regions Research and Engineering Laboratory. Various hydrologic studies have been carried out by the Institute of Water Resources, UAF, but no one watershed unit has been the focus of work.

Currently, the only active experimental watershed in interior Alaska is the Caribou-Poker Creeks Research Watershed which exists today primarily because of the dedication and persistence of Charles Slaughter of the Institute of Northern Forestry, U.S. Forest Service. Here precipitation and streamflow data have been collected for some 13 years and various research studies have been initiated (Slaughter and Lotspeich, 1977; Slaughter, 1982, personal communication).

The need expressed here for more information is not intented to deny the value of past or ongoing watershed research, but rather is a recognition of the many unanswered questions requiring diversified strategies and innovative approaches in addition to cooperative and complementary efforts by diverse research groups.

In lieu of abundant historical data, water-accounting schemes (i.e. models, computer programs, etc.) are sometimes used to estimate the quantity of runoff, the pathways of water transport to streams, and the hydrologic impact of changes in land use. These watershed models are often claimed to be "general purpose" and not restricted to a single watershed system or geographical region. However, one must be cautious, if not skeptical, of such claims when working in the climatic extremes so characteristic of interior Alaska. Alaskan resource managers must avoid the dangers of adopting the computerized "conventional wisdom" of the "lower 48." However, if these techniques could be evaluated, field tested, and adapted for Alaskan conditions, there is little question they would be useful in identifying problem situations and evaluating management alternatives in the context of FPA and BMP. Conceivably, the future of forestry in interior Alaska may rest upon the writing of workable and meaningful BMP or guidelines. Such guidelines will evolve much more rapidly if relevant watershed research is initiated at the present time.

The focus of current research has been the improvement of water-balance estimation procedures for forested watersheds. This is being done in conjunction with a computer model of watershed processes that estimates streamflow given inputs of precipitation, temperature, and certain watershed characteristics. We are attempting now to improve these calculations (simulations) by investigating (1) the variations in precipitation with elevation; (2) infiltration into frozen soils; and (3) the relationship of net radiation to cover type and standard climatological data.

Our preliminary results indicate that there maybe a doubling of rainfall over a 1300-ft. rise in elevation but that this increase may not exist for all storm types and meteorological conditions. The value in knowing this relationship is in estimating basin-wide precipitation from only one regional or local rain gauge. Also, if precipitation increases significantly and consistently over such a small elevation range, the importance of permafrost-free upland areas for groundwater recharge will be amplified.

Although the reduction of infiltration rates due to frozen soils has been documented elsewhere (Hale, 1950; Stoeckeler and Weitzman, 1960), results from studies in interior Alaska (Kane, 1980) indicate that autumn soil-moisture content is critical in determining the hydrologic significance of this effect. The task remains to incorporate these hydrologic effects of soil ice content into our hydrologic models.

Finally, in order to estimate adequately the impact of timber harvest on streamflow, the hydrologist needs some estimate of water lost by vegetation through transpiration and evaporative losses from the forest floor, bare soil, and other wetted surfaces. Since all evaporative processes require energy, we could estimate the potential evapotranspiration rate if we knew the net radiation. However, net radiation is not a standard, routine measurement, and where measurements do exist, they are only representative of the particular surface over which they are collected. In this project, we are developing a net-radiation model that requires standard climatological data (temperature and cloud cover) and surface characteristics (slope, aspect, latitude, surface albedo, and cover-type density). The actual evapotranspiration is then calculated as proportional to the available soil or wetted surface water content. Thus, the rate may be limited by either energy availability or water availability. Estimates of net radiation will also be used in the watershed model to calculate snowmelt rates and, if successful, soil freezing and thawing rates.

Efforts to date have focused on collecting basic descriptive information on the Spinach Creek geology, soils, vegetation, and topography. Future plans include an upgrading of data-collection facilities and more detailed studies of hydrologic processes. One immediate objective is to install a fiberglass Parshall flume which will yield better streamflow data and provide an excellent facility for the watershed class.

We feel that, due to Spinach Creek's accessibility, year-to-year continuity can be maintained with respect to data collection. Gradually, the area will become a highly productive resource for both education and research at the University of Alaska. □

REFERENCES

Dingman, S. L. 1966. Hydrologic studies of the Glenn Creek drainage basin near Fairbanks, Alaska Special Report 86, Army Cold Regions Research and Engineering Laboratory, Hanover, N.H., 30 pp.

Dingman, S. L. 1971. Hydrology of the Glenn Creek Watershed, Tanana River basin, cental Alaska. Research Report 297, Army Cold Regions Research and Engineering Laboratory, Hanover, N.H., 111 pp.

Hale, Charles E. 1950. Some observations on soil freezing in forest and range lands of the Pacific Northwest. *Pacific Northwest Forest and Experiment Station Research Note 66*:1-17.

Kane, D. L. 1980. Snowmelt infiltration into seasonally frozen soils. *Cold Region Science and Technology 3*:153-161.

Slaughter, C. W., and F. B. Lotspeich. 1977. Caribou-Poker Creeks Research Watershed. *Arctic Bulletin Vol. 2*(10):182-188.

Slaughter, C. W. 1982. Personal communication.

Stoeckeler, J. H., and S. Weitzman. 1960. Infiltration rates in frozen soils in Northern Minnesota. *Soil Science Soc. Am Proc. 24*(2): 137-139.

Tissue Culture

A Feasible Method of Plant Propagation

By

Heather McIntyre* and Donald H. Dinkel**

INTRODUCTION

Imagine—50,000 plants per year from a single mother plant – actually a very conservative estimate of the potential inherent in the tissue-culture method of propagation. Many plant cells contain all the genetic information about the plant, making possible the production of many clones (genetically identical plants) by removing a small section of plant tissue and placing it on a defined nutrient medium. Figure 1 shows a simplified schematic of the tissue-culture process.

Several aspects of tissue culture make it particularly compatible with the Alaskan greenhouse and nursery industry where short day lengths and immense heating requirements throughout the winter discourage operation from October until March. Conversely, heat and light requirements for tissue culture are minimal – a 2- by 8-foot shelf with an 8-foot fluorescent fixture is sufficient to accomodate 966 25-mm test tubes, each containing 5 to 10 plantlets. Thus a small portion of a well-insulated structure such as a shop or basement can be utilized to produce a significant portion of the following year's nursery stock.

Tissue culture, as a propagation method for the nursery industry, is most applicable for the rapid multiplication of rare or valuable plants. Plant species which particularly warrant experimentation are those which are available in only a limited supply. Hardy plant materials from Canadian and European northern latitudes are often well adapted to the Alaskan environment. Initial dormancy cues are normally related to specific photoperiods with northern latitude plants initiating dormancy when day lengths are still relatively long as compared to plants from more southern latitudes (i.e. latitude of origin is likely to be more indicative of cold hardiness than winter temperature at site of origin). Import restrictions limit introduction of potentially valuable plant materials from Canada and Europe. The distribution of these plants to the consumer is normally delayed for 5 to 10 years until sufficient stock has been built up by conventional propagation methods. For example, the Nor series of apples (Noret, Norhey, Norcue, Norson, and Norda) developed at the Canadian research station at Beaverlodge, Alberta, show promise as fruit-bearing trees in Alaska. A limited amount of virus-free bud wood has been introduced through the Plant Materials Center at Palmer and has been grafted onto hardy rootstock at Palmer and at the University of Alaska, Fairbanks. Buds have also been isolated from Noret, Norda, and Norcue and established on an agar-based nutrient media using tissue-culture methods.

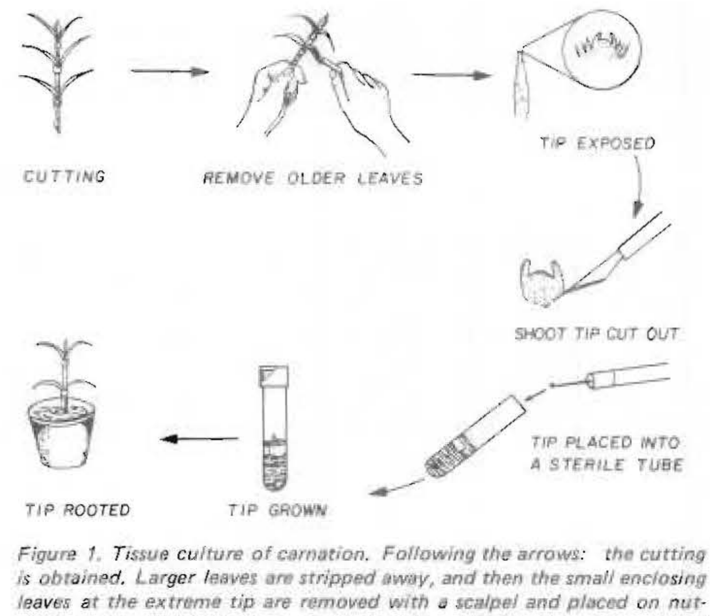


Figure 1. Tissue culture of carnation. Following the arrows: the cutting is obtained. Larger leaves are stripped away, and then the small enclosing leaves at the extreme tip are removed with a scalpel and placed on nutrient media. Multiplication of shoots takes place in the culture vessel and rooted plants are transferred to normal potting media (Hartmann and Kester, 1975).

It is not uncommon for a single plant of an otherwise marginally hardy species to show increased hardiness over plants of the same species when field tested in Alaska. These specimen plants are good candidates for tissue culture since build-up of stock by conventional cutting propagation is a slow process. At the present time, we have cultures established from two species of *Prunus* from hardy specimen plants selected from Northern Lights Nursery in Fairbanks.

Another reason for choosing tissue culture is for its role in virus eradication. Since the apical meristem (growing tip) of an otherwise virus-infected plant is often virus-free, the production of "clean" mother plants is frequently possible by culturing only the apical meristem (Langhans et al., 1977; Mellor and Stace-Smith, 1977). Elevated temperature of plants while still in the culture vessel can also be used for viral elimination (Monette, 1982; Walkey et al., 1974). Don Carling has initiated work at Palmer which will provide disease-free potato stock for growers by means of tissue culture.

Plant pathologists, plant physiologists, and plant geneticists also use tissue culture as a research tool. The controlled envi-

*Graduate Student, Horticulture, Agricultural Experiment Station, Fairbanks.

**Professor, Plant Physiology, Agricultural Experiment Station, Fairbanks.

ronment possible with this method makes it a valuable adjunct to basic research.

GENERAL TISSUE CULTURE METHODS

Selection of Plant Material

Actively growing, juvenile tissues usually provide the most successful material to start cultures. "Juvenile" is defined as the physiological state of a young plant characterized by rapid growth. Stem cuttings from juvenile tissue show increased rooting ability over cuttings from mature tissue.

Sections of sterile seedlings or swelling buds are the preferred explant material (Gamborg and Shyluk, 1981). Tissues taken from the spring and early summer flush of new growth are physiologically more responsive to tissue culture than those which are either approaching their dormant season or which have not had their dormancy requirements met.

Disinfection of Plant Material

Since the culture medium is designed to provide an optimum environment for plant-cell growth, it also supports the growth of bacterial, fungal, and algal microorganisms. If contamination by these microorganisms is not prevented, they may overgrow the plant cells and inhibit their development. It is essential to eliminate all microorganisms that contaminate the plant materials prior to culturing and to prevent recontamination during subsequent handling operations. Disinfection of plant materials is achieved by soaking in a solution of 10% household bleach (sodium hypochlorite) plus 0.1% Tween 20 (a surfactant which acts as a wetting agent) for 5 to 30 minutes.

Outer leaves of the bud or shoot tip are then removed with scalpel and forceps using a dissecting microscope. The excised meristematic tip (undifferentiated cells) and surrounding tissue are rinsed in sterile distilled water and transferred to sterile media in test tubes and the tubes are capped. All handling of open culture vessels and plants is done under a laminar air-flow cabinet to prevent contamination. Air is forced into the cabinet through a bacterial filter; it flows forward over the work bench at a uniform rate.

MEDIA PREPARATION AND FORMULATIONS

The culture media are composed of essential nutrients, vitamins, sucrose (as an energy and carbon source), and hormones. Major differences in formulations are related to hormone types and concentrations. The two classes of plant hormones important in tissue culture are the cytokinins and auxins. Cytokinins promote shoot multiplication, making them useful in the early stages of tissue culture (cultural stages are discussed in a later section). The cytokinins which are frequently used are benzyladenine (BA), N^6-(2-isopently)-adenine (2IP), and kinetin.

Auxins favor root formation and are therefore present in higher quantities in later cultural stages. Indole-3-acetic acid (IAA) and indole-3-butyric (IBA) are commonly used auxins.

Other plant hormones such as gibberellic acid (GA_3) and abscisic acid are useful in the culture of some species.

A wide variety of media have been reported (Recheigl, 1977). The choice depends on the plant species and, to a degree, upon the intended use of the culture.

Figure 2. Comparison of effect of different hormones and different hormone rates on the shoot multiplication of Amelanchier alnifolia. *The combination of BA and IBA at two different rates causes higher proliferation than a medium containing Kinetin and IAA.*

CULTURAL STAGES

As many as three or four stages are necessary between the time a shoot tip is excised and a new plant is growing independently in soil. Establishment of the culture is followed by a shoot-multiplication phase with rooting being the final step prior to planting in a soil media.

Establishment of the initial culture is often the most crucial stage. Secondary, chemical compounds, associated with the shoot tip of some species, appear to inhibit growth in some instances. When this occurs, a daily reculturing on fresh medium is required for several weeks. Other species seem to require a period of time to revert to a juvenile state which is physiologically more conducive to shoot multiplication than is more-mature tissue.

The first two cultural stages, namely establishment and multiplication, are designed to promote shoot proliferation and inhibit callus and root formation. The relative concentrations of the plant hormones, cytokinin and auxin, in the medium influence these plant responses. A high ratio of cytokinin to auxin favors shoot proliferation. Shoot meristems are an important site for natural auxin production and some species respond well to multiplication medium which provides only cytokinin, additional auxin being inhibitory. Other species with low endogenous auxin levels may require a medium which provides relatively low levels of auxins as well as higher levels of cytokinins for optimum multiplication rates. Figure 2 shows the different rates of multiplication at three different hormone ratios for *Amelanchier alnifolia* (service berry).

The third stage, *in vitro* rooting, is stimulated by a high auxin-to-cytokinin ratio. Some species root readily on a media containing only auxin, while other species benefit from the addition of a small quantity of cytokinin (e.g. *Dianthus*, Figure 3). The *in vitro* (in glass) rooting stage can sometimes be eliminated, as many species are easily rooted in mist chambers or humidity beds.

Since the *in vitro* microclimate has near 100% relative humidity, hardening off and gradual acclimatization to green-

Figure 3. In Vitro rooting. Rooted dianthus (carnation) shoot ready for transfer to soil.

house or field conditions is required. Plants are removed from culture vessels and any nutrient media thoroughly washed off (media clinging to roots would provide optimum growth conditions for air- or soil-borne pathogens). Plants are first established in a well-drained potting mix in humidity chambers and slowly exposed to the less-humid greenhouse environment over a period of 1 to 2 weeks.

Table 1. Species in Culture at University of Alaska, Fairbanks.

Limited Availability	Difficult to Propagate Conventionally	Genetic Mutant
Malus sylvestris (apple) cv. Norda, cv. Noret, cv. Norcue, cv. Trailman	*Amelanchier alnifolia* (service berry); *Amelanchier north-line*	*Dodecatheon pulchellum* (white variety of shooting star)
**Prunus maackii* (chokecherry)	*Rhododendron lapponicum*	*Mertinsia paniculata*
**Prunus besseyi* (sour pie cherry)	*Rosa rugosa* (rose) cv. F. J. Grootendorst, cv. Magnifica	(white variety of bluebell)
**Ribes fruticosa*		
**Lonicera carlton* (honey suckle)		

*specimens chosen from Northern Lights Nursery in Fairbanks which have shown exceptional hardiness.

PLANT SPECIES IN CULTURE AT THE UNIVERSITY OF ALASKA, FAIRBANKS

A variety of plant species are now being cultured at the University of Alaska, Fairbanks (Table 1). Most were selected on the basis of one of three criteria:

1. plants which have limited availability.
2. plants which are difficult to propagate by conventional methods.
3. genetic mutants selected from the wild.

Readily available species, easily propagated from seeds of cuttings, are more economically propagated by conventional methods rather than using tissue culture.

Preliminary work at the University of Alaska has been directed at establishment and proliferation of a variety of species. This will be followed by a systematic comparison of different ratios and rates of hormones to determine maximum multiplication rates and rooting requirements for each of the desired species.

Large, specialized nurseries in the U.S. and Canada have already incorporated tissue culture into their propagation schedules (Matsuyama, 1980; Rees, 1982). The small space and low light requirements needed for tissue culture make it a natural winter complement to the existing greenhouse industry in the state of Alaska. Our research at the University of Alaska is designed to develop techniques which can be used by commercial nurserymen for the propagation of desirable plant species. ☐

REFERENCES CITED

Gamborg, O. L., and J. P. Shyluk. 1981. *Plant Tissue Culture Methods and Applications in Agriculture.* Academic Press, New York.

Hartmann, H. T., and D. E., Kester. 1975. *Plant Propagation Principles and Practices*, 3rd edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Langhans, R. W., K. R. Horst, and E. D. Earle.1977. Disease-free Plants via Tissue Culture Propagation. Hort Science, 12(2) pp. 149-150

Matsuyama, J. 1980. Overview of Tissue Culture at K. M. Nursery. Proc. International Plant Propagators Society, 30, pp. 40-47.

Mellor, F. C. and R. Stace-Smith. 1977. *Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture.* Springer-Verlag, New York.

Monette, P. 1982. *In vitro* virus eradication techniques. C. S. H. S. Conference

Recheigl, M. 1977. C. R. C. *Handbook Series on Nutrition and Food.* C. R. C. Press Inc., Boca Raton, Florida.

Rees, J. 1982. Trees by tissue culture. *Nursery Business*, pp. 52-53.

Walkey, D. G. A., V. Cooper, P. Crisp. 1974. The production of virus-free cauliflower by tissue culture. *Journal of Hort Science 49*: 273-275.

The Effects of Feeding Whole-Grain Barley to Free-Ranging and Penned Reindeer

By

J. M. Blanchard*, W. E. Hauer**, and J. R. Luick***

INTRODUCTION

In 1979, the Reindeer Herders Association of Alaska stated that the overall, twofold goal of the reindeer industry was to provide a stable meat supply and an enhanced economic base for the people of northwest Alaska. In establishing this goal, the association called for the application of modern livestock-production techniques, including those that would be effective in reducing infectious diseases and would increase the production of high-quality meat.

Death losses, at least in some herds, have been extraordinarily high on the Seward Peninsula (Luick, 1980). Until this problem is solved, the herders' goal of achieving a stable meat and economic base cannot be met. Improvement of husbandry practices in Alaskan herds is an important place to begin to reduce high death losses.

Several areas of the Seward Peninsula currently used for reindeer herding have limited quantities of good winter range (Cooperative Extension Service, 1980). This is a result of a combination of factors such as heavy snow cover and the destruction of ranges by fire and overgrazing. Reindeer that overwinter on such marginal rangelands become undernourished and lose both body weight and condition. They also seem to be more susceptible to disease and predation.

In Scandinavia, these environmental conditions are often encountered during winter. In order to improve nutritional status, the reindeer are fed supplemental rations consisting of various feed products which usually contain a high proportion of cereal grains (Skjenneberg and Slagsvold, 1968). In Australia, all-grain diets have been fed successfully to cattle and sheep when ranges become depleted by drought (Watson, 1975; Watson et al., 1975; Franklin and Sutton, 1952).

In a previous study (Blanchard and Luick, 1980), we fed a mixed-grain diet (50% oats, 25% corn, 25% barley) for 60 days to penned reindeer during late winter. The grain-fed reindeer maintained body weights better than did reindeer grazing on alpine taiga pastures during the same period. Therefore, we proposed to investigate the performance of reindeer when fed an all-barley diet over an extended period of time and when fed as a grain supplement to reindeer grazing on tundra range in northwest Alaska.

*Graduate Research Assistant, Institute of Arctic Biology, Fairbanks.
**Animal Technician, Institute of Arctic Biology, Fairbanks.
***Professor of Nutrition, Institute of Arctic Biology, Fairbanks.

The development of a cereal-grain industry in interior Alaska has provided a source of relatively low-cost livestock feed. Utilization of barley from the Delta Agricultural Project could make supplemental feeding of Alaskan reindeer economically feasible where the high cost of feed shipped from out-of-state sources has historically been prohibitive.

METHODS

Long-Term Feeding of All-Barley Diets

The first phase of our study tested the performance of penned reindeer fed an all-barley (whole grain) diet over a period of several months. We were particularly interested in di-

Improving the diets of Alaska's reindeer is one way in which research supports this important industry.

gestive disturbances which might be encountered when reindeer were fed all-barley diets for extended periods. Eight adult female reindeer were fed a pelleted livestock ration (Quality Texture, Fisher Mills) *ad libidum* for 90 days prior to adapting them to an all-barley diet. The adaptation period was 20 days in duration, beginning January 10, 1980. The reindeer were weighed at the beginning of barley feeding and at frequent intervals thereafter until October. Two reindeer, No. 7 and No. 68, were continued on the all-barley diet for an additional 142 days, until March 22. During this period, weekly body weights were taken and daily feed intake measured. During August 1981, daily intake of whole-grain barley was again measured on two reindeer for a period of 14 days. One reindeer, No. 7, had been fed an all-barley diet for 20 months while the other, No. 58, had been fed barley for the previous 60 days.

Barley Supplementation of Grazing Reindeer

The second phase of our study consisted of feeding whole-grain barley as a supplement to free-foraging reindeer. The experiment was conducted on the Baldwin Peninsula near Kotzebue, Alaska, in cooperation with NANA Reindeer Enterprises. The study herd, which consisted of 77 reindeer, was divided into two groups of similar age, sex, and body weight. One group of 38 reindeer was herded daily into feeding pens and offered supplemental whole barley grain *ad libidum* for a period of 3 to 4 hours, then released back out onto the range. The second group, containing 39 reindeer, served as nonsupplemented controls. The two groups were kept apart but grazed on nearly

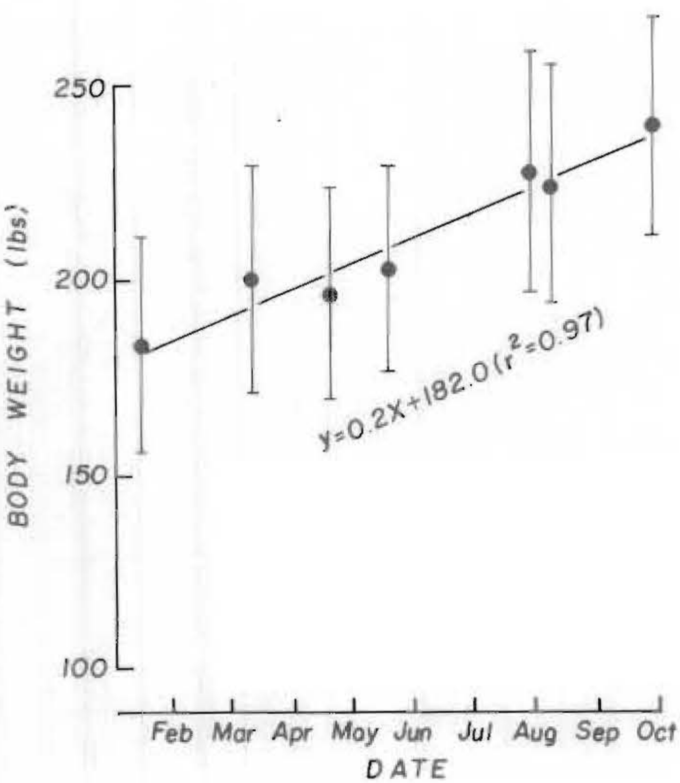


Figure 1. Body weight changes for eight adult female reindeer fed whole-grain barley for 9.5 months (value are means ± S.D.).

Table 1. Proximate Analysis of Whole-Grain Barley[1] and Quality Texture (QTX)[2] on a Dry-Matter Basis[3] (%).

Component	Diet	
	Barley	QTX
dry matter	91.5	93.3
crude protein	11.3	11.2
crude fat	1.7	2.7
neutral detergent fiber	42.1	68.0
cellulose	8.2	6.4
hemicellulose	29.8	58.0
lignin	3.3	3.4
ash	3.2	9.4

[1] Barley obtained from Alaska Farmers Coop., Delta Junction, Alaska.
[2] Fisher Mills, Seattle, Washington.
[3] Feed analysis completed by University of Alaska, Agricultural Experiment Station Plant and Soils Laboratory, Palmer, Alaska.

identical plant communities. All reindeer were weighed on March 3, 1981, prior to the initiation of supplemental feeding and were weighed again at the end of the experiment. During the 37-day period of supplemental feeding, the grain-fed reindeer consumed an average of 1 lb. barley/head/day.

Table 1 shows the nutrient composition of the whole-grain barley and pelleted livestock ration (QTX) fed in all experiments.

RESULTS

Long-Term Feeding of All-Barley Diets

During adaptation to the all-barley diets, no digestive problems or prolonged periods of feed refusal were noted. Figure 1 shows the mean body weight of eight reindeer over 257 days when fed *ad libidum* levels of whole-grain barley. Average daily gain for this period was 0.22 lbs/head (S.D. ± 0.02 lbs), which resulted in an average body weight of 241 lbs after 257 days, or a 31% increase in the initial weight of the reindeer in this group.

Figure 2 shows the body-weight changes for two reindeer fed an all-barley diet over a 440-day period, beginning January

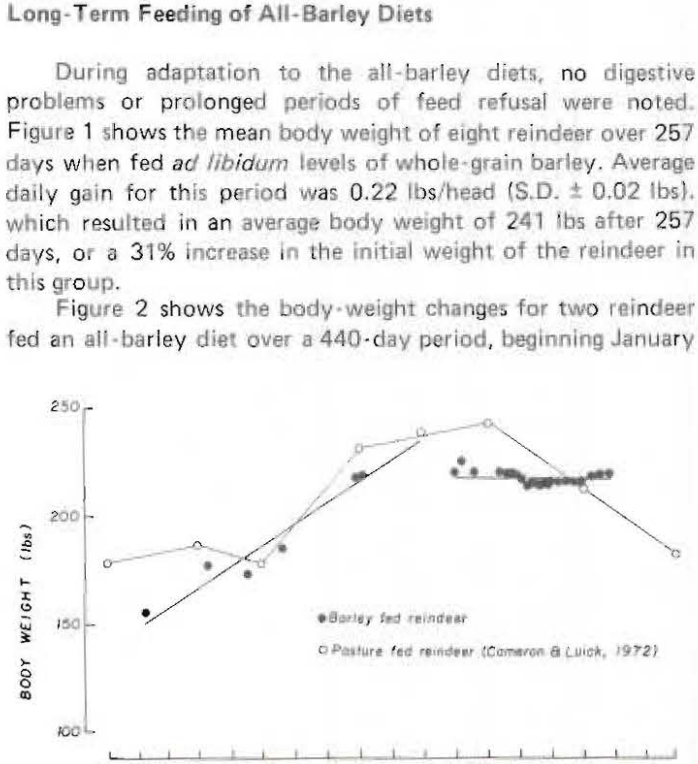


Figure 2. Changes in mean body weight for two adult female reindeer fed whole-grain barley for 14.5 months and for three adult female reindeer grazing on alpine taiga pastures for 18 months.

Table 2. Body Weight Changes of Control and Barley Supplemented Reindeer.

	Controls				Barley Supplemented			
	Number of Reindeer	Average Initial Body Weight (lbs)	Change in Body Weight (lbs)	Change as % of Initial Body Weight	Number of Reindeer	Average Initial Body Weight (lbs)	Change in Body Weight (lbs)	Change as % of Initial Body Weight
Adult Males	4	221	-0.8	-0.1	7	232	21.0	9.2
Adult Females	15	201	3.9	1.9	13	202	6.9	3.5
Long Yearlings	7	167	4.6	2.8	5	167	7.6	5.0
Calves	13	120	1.9	1.7	13	117	9.8	8.6
Overall	39	170	2.9	1.8	38	174	10.6	6.5

1980 and ending March 1981. Average daily gain was 0.30 lbs/head/day for the first 257 days of this trial. This resulted in an average weight of 235 lbs, or a 50% increase in the initial average body weight. During October 1980, these two reindeer lost an average of 18 lbs, which we attributed to rut activity during this time. From the end of October to the end of March (122 days), body weights remained constant, averaging 218 lbs. The changes in the mean body weight of three reindeer grazed on alpine taiga pastures over a 19-month period is also shown on Figure 2 (Cameron and Luick, 1972). These reindeer obtained similar peak body weights at essentially the same time of year as the barley-fed reindeer, however, an average weight loss of 23% occurred during the winter months between December and June.

Daily dry-matter consumption was measured on reindeer No. 7 and No. 58 between day 315 (November 20) and day 437 (March 22) of this trial. Average daily dry-matter consumption was 2.7 lbs (1.24 lbs/barley/day/100 lbs body wt) for this period. In the summer, daily intake of whole-grain barley increased to an average of 5.9 lbs/head/day (2.50 lbs barley/day/100 lbs body wt) measured on two reindeer for 14 days in August 1981.

Barley Supplementation of Grazing Reindeer

Table 2 shows the results of barley supplementation in free-foraging reindeer. The data are presented for four cohort groups: adult males, adult females, long yearlings, and calves. As there was no significant difference between male and female calves or yearlings, the data were combined. Change in body weight is listed as the difference between the initial and final body weight.

Overall, the barley-supplemented reindeer gained significantly more body weight (p less than 0.05) in both pounds per animal and as a percentage of the initial body weight gained when compared with the controls. The mean difference was 7.7 lbs/head (S.D. ± 1.5 lbs) more gain for the barley-supplemented reindeer, which resulted in a 4.7% (S.D. ± 0.9%) greater gain for the supplemented group. On a daily basis, the body-weight gain of the barley-supplemented reindeer over the controls was 0.2 lbs/head/day for the entire experimental period.

All barley-supplemented reindeer gained significantly more body weight (p less than 0.05) compared to the controls, with the exception of the long yearlings. The barley-supplemented adult males gained more than any other group with an average gain of 21.8 lbs/head, or a 9.3% increase in initial body weight.

DISCUSSION

Long-Term Feeding of All-Barley Diets

The results indicate that reindeer perform comparatively well when fed all-barley diets and that reindeer can be maintained on barley throughout the year. In winter, reindeer fed all-barley diets lost little or no body weight, as opposed to those fed the pelleted livestock feed (QTX), but consumed only 70% as much dry matter as reindeer maintained on QTX feed (Blanchard et al., 1982). This apparent higher efficiency in feed utilization by barley-fed reindeer may be an artifact resulting from the small number of reindeer (two) on each diet. However, body water and whole-body protein turnover results from the above study indicate that reindeer fed barley may have been in a different metabolic status than those fed pelleted livestock feed. Barley-fed reindeer had a body-water turnover rate of one half and a whole-body protein turnover rate one-fourth that of reindeer fed pelleted feed during the same time period. The cause of the apparent slower turnover of these constituents in barley-fed reindeer remains uncertain. By comparison, reindeer feeding on natural vegetation were unable to maintain body weights and condition throughout the winter months (Cameron and Luick, 1972). Reindeer fed all-barley diets for extended periods appeared to be in very good body condition and peak body weights obtained at the end of summer were equal to or higher than those obtained on any other feeding regime tested in our experimental herd (Luick et al., unpublished).

In Australia, cereal grains are considered a feasible replacement feed for sheep during drought (Watson et al., 1975). Although considerable metabolic difficulties may arise when converting sheep from natural forage to all-grain diets (Watson, 1975), we saw no indication of such problems in our studies with reindeer. This may, in part, be attributed to the fact that our reindeer had previously been fed a complete pelleted livestock ration (QTX), which contains a substantial amount of cereal grain. Luick (1977) encountered fatal digestive disorders when reindeer were captured and their diet immediately changed from tundra range to commercial livestock rations. However, it is not clear to what extent the stress of capture and transportation contributed to these deaths. Recent modifications and improvements in shipping techniques have substantially reduced mortality among translocated reindeer (personal observation). It remains apparent, though, that any change in diet, especially between feeds differing greatly in nutrient composition, should be gradual in order to allow for sufficient rumen adaptation.

Routine use of all-barley diets shows great potential in reindeer, but may cause certain reproductive problems, the extent and seriousness of which have yet to be determined. Preliminary results indicate that when barley is fed for an extended period (i.e. greater than 6 months prior to rut) there may be a decline in the pregnancy rate. In our small herd, the problem may have been due to an inferior herd sire. Those reindeer that become pregnant seem more susceptible to abortion or tend to produce weak calves. This may be due to vitamin and/or mineral deficiencies, and may indicate a need for a vitamin/mineral supplement to all-barley diets. Continued study on the reproductive performance of reindeer fed all-barley diets is indicated.

Barley Supplementation of Grazing Reindeer

Supplemental feeding of small amounts of barley to free-ranging reindeer in winter resulted in a substantial positive weight response over a short period of time. It appears that the barley supplement enables the reindeer to better cope with grazing on marginal rangelands by providing a higher plane of nutrition when natural feed supply is limited.

The economics of feeding supplemental barley to reindeer herds in western Alaska may seem prohibitive at first glance. The purchase price of barley grown in Delta Junction, Alaska, accounted for only 20% of the final cost of barley at Kotzebue, Alaska, while transportation made up the other 80%. Balancing our costs of purchase and air freight to the Baldwin Peninsula against the resulting body weight gains that resulted from feeding supplemental barley, the cost of live body weight gain could run as high as $1.15/lb. Thus the herder would have to receive about $2.50/lb of carcass meat to break even, which is about $.75/lb more than the wholesale price of carcass meat in Nome, Alaska (personal communication, C.E.S., Nome, Alaska). However, weight gain is not the only potential benefit of supplemental feeding. The supplementation of small amounts of barley under certain conditions could decrease death losses of reindeer during periods of undernutrition or severe climatic stress, a factor that has considerable economic significance (Luick, 1980).

SUMMARY

The results of our studies show that Alaska-grown barley can serve as a useful supplemental feed for Alaskan reindeer, especially during winter months when grazing conditions are marginal. Results also indicate that all-barley diets may be useful during summer and fall for fattening reindeer prior to slaughter. Increased use of barley grown in the state would seem beneficial to both the reindeer and cereal-grain industries in Alaska, especially if the costs of transportation can be reduced.

REFERENCES

Blanchard, J., W. Hauer, and J. Luick. 1982. Proc. 3rd Intl. Reindeer/Caribou Symp., Helsinki Finland, August 1982 (In press).

Blanchard, J. M., and J. R. Luick, 1980. The use of 75 Selenomethionine as a indicator of protein turnover in reindeer. Proc. 2nd International Reindeer/Caribou Symp. Roros, Norway 1979, Reimers, T., E. Gaare, and S. Skenneberg eds. Direktorestat for vilt of ferskvannsfisk, Trondheim, Norway. pp. 196-201.

Cameron, R. D., and J. R. Luick, 1972. Seasonal changes in total body water, extra cellular fluid, and blood volume in grazing reindeer. *Can. J. Zool. 50*:107-116.

Cooperative Extension Service. 1980. Land ownership charges: How will they affect reindeer grazing leases? IN: What's Developing in Alaska, June 1980, CES &USDA, Fairbanks, Alaska. pp. 6-7.

Franklin, M., and P. Sutton. 1952. *Aust. J. Agric. Res. 3*:168.

Luick, J. R. 1977. Diets for Captive Reindeer, CRC Handbook Series in Nutrition and Food, M. Rechcigl, Jr. ed. CRC Press, Cleveland. pp. 279-294.

———. 1979. *Reindeer Herders Newsletter 4*(2):2.

———. 1980. Calf mortality due to summer handling of reindeer. *Reindeer Herders Newsletter 5*(2):1-3.

Skjenneberg, S., and L. Slagsvold. 1968. Reindeer Husbandry and Its Ecological Principles. Anderson, C., and J. R. Luick, eds. USDI (BIA) Juneau, Alaska. pp. 155-170.

Watson, M. 1975. Metabolic studies on daily and weekly feeding of ruminants given all-wheat diets. (II) concentrations of metabolites in blood and ruminal fluid. *Aust. J. Agric. Res. 26*:885-99.

Watson, M., R. Leng, and G. McClymont. 1975. Metabolic studies on daily and weekly feeding of ruminants given all-wheat diets. (I) digestibility and nitrogen balance in sheep. *Aust. J. Agric. Res. 26*:329-36.

Winter grazing lands in the Buckland Valley, shown above, in summer is a potential area of reindeer-caribou range rivalry.

Public Policy and the Future of Alaska's Reindeer Industry

By

Wayne C. Thomas* and Edward L. Arobio**

INTRODUCTION

Public policy continues to be the major force which determines the direction taken by Alaska's reindeer industry. It is, therefore, important to relate herd management to those major public-policy decisions which affect the industry. Policy implementation sometimes results in conflicts for the various entities involved, and identification of those situations which result in conflict should aid understanding of this complex resource activity in Alaska.

*Professor, Economics, Agricultural Experiment Station, Fairbanks.
**Planning Coordinator, Alaska Agricultural Action Council, Office of the Governor, 1514 Cushman St., Fairbanks, AK 99701.

A CHRONOLOGY OF PUBLIC POLICY

Domestic reindeer *(Rangifer tarandus)* were first imported into Alaska's Seward Peninsula in 1892. The Eskimos of that

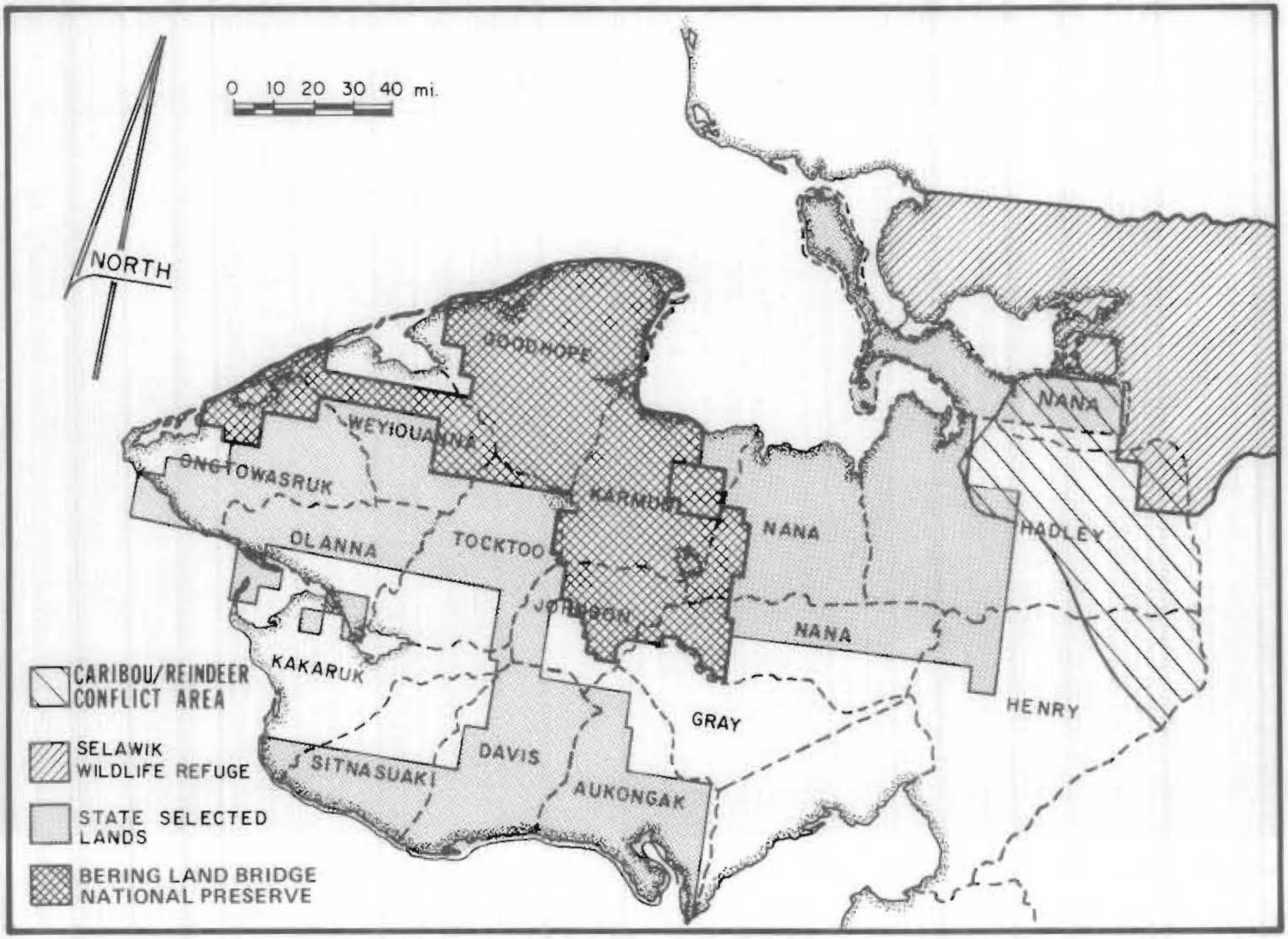


Figure 1. Overlapping land-management responsibilities have created areas of potential conflict and in the case of the NANA, Hudley and Henry permit areas, reindeer-caribou range rivalry as well.

region were perceived by outside observers to be in great need of additional food sources because of declines in both sea and land mammals (Lantis, 1950). In particular, the western Arctic caribou herd, the primary land-based game resource utilized by the Eskimos of northwest Alaska, suffered a serious decline between 1850 and the turn of the century (Skoog, 1968). Initially, church-related efforts rather than direct government policy, led to the importation of reindeer from Russia. Within two years of importation, however, the United States government took over sponsorship of the program. This action set in motion the continuing public-policy position of the United States toward reindeer, that is, to support routine participation in reindeer husbandry as a means to extend the food base and to create employment in some areas of rural Alaska.

By 1915, the total number of reindeer in Alaska was estimated to be at approximately 70,000 animals. Native people owned 46,000, and other groups owned 23,000 (Stern et al., 1980). These reindeer were largely the result of natural increase of 1280 animals imported from Russia in 1892. This growth can be attributed primarily to favorable natural conditions of range availability and relatively mild winters during this early period.

A second reason for this growth was related to the discovery of gold in Alaska. Thousands of people moved to Nome on the Seward Peninsula and other areas in search of gold. Concerns by the United States government over insufficient food supplies for these new immigrants led to expanded government involvement in agriculture, including reindeer (Thomas, 1981; Berton, 1958; Stern et al., 1980).

Lack of restrictions on reindeer ownerships permitted non-Natives to obtain an increasing share of the reindeer industry. Non-Native sales of reindeer meat were directed to the continental United States in an attempt to avoid conflicts with Native leaders for the local market (Olson, 1969). As the mining areas matured, machines were substituted for men; the population declined; and local markets for reindeer declined.

The uneasy relationship between Native and non-Native reindeer owners remained until the Great Depression of the 1930s, when export markets collapsed. During this same time, reindeer had been increasing throughout the territory of Alaska to, by some accounts, over 600,000 animals (Hanson, 1952). This crisis of lost markets and multiple ownership was resolved by a major public-policy decision to remove the right of non-

Natives to own reindeer in Alaska and to compensate the losers. This was accomplished in the Reindeer Act (Public Law 75-413) of 1937 and with some modification it remains the center piece of United States reindeer policy to this day.

The effect of this legislation was to reduce the United States government role in reindeer to range protection and acquainting herders with more efficient techniques of herd management (Stern et al., 1980). Until 1962, the responsibility for the range rested with the United States Department of Interior, Bureau of Indian Affairs. Beginning in 1962, this function was assumed by the United States Department of Interior, Bureau of Land Management (BLM). The major goal of the Reindeer Act — that of Native ownership — has been reached, but the complexities of the present-day situation were probaby not apparent in 1937.

The industry went into a major decline during the 1930s; and, by 1948, reindeer numbers in Alaska had fallen to less than 50,000 animals. Several reasons have been suggested, including overgrazing, predation, and especially large losses to migrating caribou herds. Many of the younger herders became disassociated with reindeer because of involvement in World War II. The industry retreated to the caribou-free Seward Peninsula and became a village-related activity.

More recent public-policy decisions and market forces have brought further change to the industry. In 1959, Alaska became a state of the United States and, as a part of the Statehood Act (Public Law 85-508), was given the right to select approximately 30 per cent of the land within state boundaries. Some 20 years later, as part of its overall land entitlement, the state has selected approximately 45 per cent of the Seward Peninsula. Reindeer herders now must face not only Federal but also state land managers.[1]

The third significant national legislation which affected Alaska reindeer herders was the 1971 Alaska Native Claims Settlement Act (Public Law 92-203). It allowed Alaska Natives to select lands from the public domain and created within the state of Alaska twelve, regional, for-profit corporations owned by the Native peoples associated with each region. The regional corporation whose area lay in the northern part of the Seward Peninsula was NANA. NANA acquired its first reindeer in 1975; however, because of the for-profit nature of the corporation, reindeer herding, like any other of its activities, was a business.

Nevertheless, a social factor, food security of regional Native people, was also an important consideration. The western Arctic caribou herd went through a serious decline during the period 1970-76 (Adams and Robus, 1981); and the regional corporation, NANA, by increasing control of the reindeer industry, was attempting to provide a more stable food supply. Within three years, NANA controlled the largest reindeer herd in the state and the only one in which close herding was attempted.

NANA was also involved with the major market-related event of the industry during the 1970s. In 1977, it carried out a sealed-bid auction for green antlers (in velvet) and received three times the price that most other Alaska reindeer herders were receiving at that time. This auction emphasized the economic potential of the industry and has led to many of the present-day industry conflicts.

The final, major, public-policy legislation to affect the Seward Peninsula was the Alaska National Interest Lands Conservation Act of 1980 (Public Law 96-487). This transfers approximately 30 per cent of the peninsula to a third Federal government agency, the National Park Service (NPS), part of the United States Department of Interior. Thus, public-policy decisions have taken land management out of a simpler, one-agency system and placed it in a multiagency framework, each with different goals for land use.

Table 1. Land Management of Grazing Permits, 1982

		Agencies Having Land-Management Responsibility		
Permit Holder	Head-quarters	State of[a] Alaska	BLM	NPS
Qungnig (NANA)	Kotzebue	X	X	X
Karmun	Deering	X	X	X
Goodhope	Shishmaref		X	X
Weyiouanna	Shishmaref		X	X
Ongtowasruk	Wales		X	X
Olanna	Brevig Mission		X	
Tocktoo	Brevig Mission		X	X
Kakaruk	Teller		X	
Sitnasuak	Nome		X	
Davis	Nome		X	
Aukongak	Golovin		X	
Gray	Nome		X	
Henry	Koyuk		X	
Sagoonick	Shaktoolik		X	

[a]Land for which the state has recieved tentative approval. The state has also selected a large block of the land on the western Seward Peninsula for which it has not yet received tentative approval.

CURRENT MANAGEMENT SITUATION

In 1982, there were 14 permit holders on or adjacent to the Seward Peninsula. Total reindeer in these herds were estimated to be 20,500 in the summer of 1981. With the exception of the NANA regional corporation herd and the Sitnusuak village corporation herd, herds are owned and managed by individuals.

Reindeer have traditionally grazed on public lands. From 1962 until just recently, all these ranges were managed by the BLM. Grazing permits could initially be obtained for up to ten years; in recent years they have been for one year. The only charge for the use of the grazing lands has been a $10 permit-filing fee. Now, herders need to apply to different Federal and/or state land managers annually, depending on location of their allotment, to obtain grazing permits. In some instances, permits may have to be obtained from several agencies (Table 1).

In order to expedite the permitting process, the state and Federal agencies have agreed to allow the BLM to receive all applications, distribute them to other agencies, receive them back, and then return them to the owners. Although these agencies have differing land-management regulations, an effort is being made to keep regulations as standard as possible. Whether or not this continues in the future is difficult to determine. The possibility exists that herd owners may be faced with a wide variety of regulations for such things as corral or cabin placement, snowmachine use, or stocking rates from different land managers.

[1]Native village and regional corporations are also receiving title to land in reindeer herding areas. The effect this will have on current herders is unclear at this time.

Table 2. Reindeer on the Seward Peninsula, 1960-1980.[a]

Year	Number	Year	Number
1960	18,529	1971	NA
1961	16,405	1972	19,828
1962	17,940	1973	17,387
1963	18,880	1974	NA
1964	20,449	1975	20,600
1965	18,944	1976	17,425
1966	22,168	1977	17,800
1967	18,795	1978	NA
1968	16,369	1979	19,900
1969	17,009	1980	NA
1970	20,292	1981	20,500

[a]For the year 1960-1977, estimates of reindeer numbers can be found in Stern et al., (1980). Estimates for 1979 and 1981 were based on summer handling tallies provided by the Alaska Reindeer Herders Association.

For the most part, herds are individually owned, loosely herded, and graze over wide areas. The herd owner may not see his herd for long periods of time, particularly in the summer months. NANA, however, is trying to implement year-long close herding and a system of rotational grazing, Some owners of the smaller herds are attempting rotational grazing, but have not tried close herding in the summer.

Most herds have fewer animals than the maximum number permitted by their grazing permits. Several herders are interested in expanding their herds, but this has been difficult to accomplish, as evidenced by the relatively stable number of reindeer on the Seward Peninsula since 1960 (Table 2). Some expansion can be expected in the next several years due to efforts now being made to graze rangelands more efficiently, improve animal health, and reduce handling stress. Substantial economic advantages of improved herd management have been reported (Luick, 1979; Arobio et al., 1980; Thomas et al., 1983).

CONFLICTS THROUGH IMPLEMENTATION

The basic policy instruments have been identified: Reindeer Act, Statehood Act, Land Claims Settlement Act, and National Interest Lands Act. These give powers to the implementing agencies to carry out the purpose of each act. Conflicts arise when public lands traditionally associated with reindeer activity undergo a change in land managers or land-management philosophy. There are two new government entities which, within the past three years, have taken over land-management responsibilities on the Seward Peninsula. These are the NPS and the State of Alaska, Department of Natural Resources.

The NPS is generally regarded as the chief conservation agency of the United States, and a major characteristic of its management is limiting the interference of human beings in designated natural or historical environments. Herd owners who have permits on lands now under the management of the NPS (the Bering Land Bridge National Reserve) are in conflict with traditional NPS management approaches (Figure 1). This is particularly evident when the herders use snowmachines to herd reindeer, or use low-flying aircraft to round up animals and maintain corrals for antler harvest. Restrictions by the Park Service on any of these activities will *de facto* remove reindeer from part of the peninsula (Stern et al., 1980). To date, the affected reindeer herders are conducting business as usual, and the National Park Service has been considerate of herders and their concerns; however, the legal base for change exists and is of potential concern in the reindeer-herding community.

The state of Alaska is the second new land manager. It has selected lands on the Seward Peninsula for their economic potential, e.g. mineral development and reindeer grazing. The state government appears interested in restricting human conduct only to prevent abuse of lands. Given that perspective, the state government has land-permit statutes which could, if implemented on the Seward Peninsula, mean substantially higher costs for use of the land to the affected herd manager than the previous BLM permit-application fee. Since the 1930s, while revenue per herd was low, the case for permit fees was rarely, if ever, considered. With increased revenue from antler sales, the ability of herd owners to pay land fees has increased and so, apparently, has the state's interest in applying grazing fees. The problem of course is that those herds not on state lands will benefit from lower fees should the state act unilaterally to raise its land charges. This will cause conflicts between the affected and nonaffected herders as well as between the affected herders and the state government. The potential exists for three sets of fees: one on BLM lands, another on NPS lands, and a third on state lands. The need for coordination here is readily apparent, but is not assured.

The second conflict has to do with land-management philosophy. The reindeer industry in Alaska was established as a food-producing activity for Eskimo people. It was seen as a means to improve their subsistence lifestyle by providing a more secure food source. Herds were established not only on the Seward Peninsula, but also on land areas to the east, north, and south. In 1948, only 10 per cent of the reindeer were located on the Seward Peninsula. Since then, failure of many herds due to poor management, losses to caribou by loose herding, and predation has resulted in the majority of reindeer being restricted to the Seward Peninsula with the remainder on offshore islands (Olson, 1969).[2] This reduction has led to rethinking of Federal policy implementation by prevailing government bureaucrats. A rise in national interest regarding protection of the natural environment apparently was a part of this "new" Federal policy of reindeer containment.

By the 1970s, Alaska reindeer had come to be regarded as a part of the Seward Peninsula and offshore islands. A recent attempt by NANA to expand its reindeer operations outside the eastern boundary of the peninsula has led to conflict with the BLM. As reported by Adams and Robus (1981), NANA took control of the Hadley permit in 1980. The corporation proposed to increase the number of reindeer on the permit area above BLM carrying-capacity rates and were planning significant use of the winter range in the Buckland Valley. The Hadley family had rarely used this part of its allotment. This valley is also range for the migrating western Arctic caribou herd and the rivalry for the same winter range caused concern at BLM.

As a result, that agency has temporarily excluded NANA from the Buckland Valley and is developing regulations specifically for public lands with potential reindeer-caribou grazing conflicts. The agency, although noting that compromise is

[2]A small herd is located at Stebbins Village on mainland Alaska just south of the Seward Peninsula.

possible, has indicated that, where conflicts over grazing exist, reindeer will be excluded from this range or other areas of conflict (BLM, 1981). This effectively prevents any new reindeer operations on any BLM land areas outside the Seward Peninsula.

Potential overgrazing was not the only factor. Klein (1980) reports that, even with close herding, some losses to caribou cannot be avoided. Thus valid concerns from BLM's perspective were evident. BLM's approach, apparently, is to deemphasize human commerical use where this may lead to wildlife conflicts on public lands, except for Seward Peninsula reindeer ranges.

CONCLUSIONS

The Alaska reindeer industry started as a means to provide better food security for Eskimo people of Northern Alaska. The industry was commercialized by non-Native people and that was deemed unlawful by a major public-policy decision. As long as it remained a semisubsistence activity of the Eskimo, it was left reasonably free of government restrictions. Into the 1970s, greater environmental awareness within the United States coincided with retrenchment of the industry ot the Seward Peninsula. Further public-policy decisions which created commercial Native corporations with the resources to undertake herd management, including closer herding, have led to proposals for expansion of the industry beyond its current borders. At least one Federal agency, the BLM, is actively trying to retard the industry, at least relative to new land areas.

In addition, lands on the Seward Peninsula have been separated into units under the aegis of different land-managing agencies, making reindeer management more difficult. Depending on the aggressiveness of NANA and other reindeer herd owners, the period of the 1980s could be one of substantial conflicts among land management agencies and between agencies and herd owners. □

Editor's Note: This is an expansion of a paper given by the authors at the Third International Reindeer/Caribou Symposium, Saariselka, Finland, August, 1982.

REFERENCES

Adams, L., and M. Robus. 1981. Caribou and domestic reindeer on public lands in Alaska: Introduction to a unique management problem. Paper presented at 46th North American Wildlife and Natural Resources Conference. Washington, D.C.

Arobio, E., W. Thomas, and W. Workman, 1980. Mathematical programming for considering management options in Alaska reindeer herding. *Proceedings, Second International Reindeer/Caribou Symposium*. eds. Reimers, E., E. Gaare, and S. Skjenneberg, pp. 659-80.

Berton, P. 1958. *The Klondike Fever: The Life and Death of the Last Great Goldrush*. Knopf, New York.

Bureau of Land Management. 1982. Northwest planning area: land-use proposals. U.S. Department of Interior, Bureau of Land Management, Fairbanks District Office.

Hanson, H. 1952. Importance and development of the reindeer industry in Alaska. *Journal of Range Management* 5(4):243-251. July.

Klein, D. 1980. Conflicts between domestic reindeer and their wild counterparts: A review of Eurasian and North American experience. *Arctic* 33:739-756.

Lantis, M. 1950. The reindeer industry in Alaska. *Arctic* 3(1):27-44. April.

Luick, J. 1978. Antlers, aphrodisiascs and the impotency of the reindeer industry. IN: Luick, J. R. (ed.), *Reindeer Herders Newsletter*. Inst. Arctic Biol., Univer. Alaska 3(4):1-54.

Olson, D. 1969. Alaska reindeer herdsmen. A study in Native management in transition. Institute of Social, Economic and Government Research, University of Alaska, Fairbanks. SEG Report No. 18.

Skoog, R. 1968. Ecology of the Caribou *(Rangifer Tarandus Granti)* in Alaska. Ph.D. Thesis. University of California, Berkeley.

Stern, R., E. Arobio, L. Naylor, and W. Thomas. 1980. Eskimos, reindeer and land. Fairbanks: University of Alaska Agricultural Experiment Station Bulletin 59.

Thomas, W. 1981. The Role of Agriculture in Alaska's Rural Development. Chapter 3 IN: *Alaska's Rural Development*. eds. Cornwall P., and G. McBeath, Boulder, Colorado: Westview Press.

Thomas, W., E. Arobio, L. Naylor, and R. Stern. 1983. An alternative management system for Alaska reindeer herds. *Agricultural Systems* (in press).

Does Feeding Crab Meal to Dairy Cows Adversely Affect Milk Taste?

By

A. L. Brundage*

INTRODUCTION

The third and most comprehensive feeding experiment on the use of crab meal in dairy feeds has been completed at the Matanuska Research Farm of the University of Alaska. The primary objective of this study was to obtain information for use in making practical recommendations for feeding crab meal to milking dairy cows.

One question frequently raised during investigations with crab meal, has been possible adverse consequences on milk taste. At the start of research with crab meal several years ago, a few samples of milk were tasted to rule out the possibility of major problems with milk quality. As I progressed toward formal recommendations on the use of crab meal in dairy feeds, I recognized that the question of milk quality had to be addressed in greater detail. It was not sufficient to demonstrate that dairy cows would eat feeds containing crab meal and maintain creditable levels of performance; reasonable confidence was required that milk of acceptable quality was produced with no objectionable taste.

EXPERIMENTAL PROCEDURE

Five pelleted concentrates (Table 1) were fed to thirty Holstein cows from the 6th through 17th week of lactation in six randomized blocks during 1980-82. Blended rations of barley/oat silage and concentrate were fed *ad libitum* in equal portions on a dry-matter basis. All cows were fed the same, positive-control ration for 3 weeks prior to assignment to one of the five concentrates in Table 1. Concentrates were formulated to contain 22 per cent crude protein, with crab protein replacing 0, 25, 50, 75, and 100 per cent soybean protein. Because crab meal is lower in crude protein than soybean meal, mixed feed oats were used as a filler to be deleted from the mixture as crab meal was added to replace soybean meal. Monocalcium and dicalcium phosphate were deleted from concentrates containing crab meal because the shell content of crab meal was considered an adequate source of calcium and phosphorus.

Milk quality was assessed by single-blind taste evaluation, wherein milk evaluators did not know sample identity. Samples of milk were taken during the 2nd week of each 3-week period and randomly sequenced for evaluation by dairy personnel. Each set of samples included one sample from the bulk tank at the research farm. Evaluators were asked to rank the milk from 1 to 20, with lower scores indicating greater acceptability. Because participants were not experienced or trained in milk taste evaluation, they were asked only to rate samples according to acceptability and not to define reasons for unacceptability. I assumed that if participants could not consistently distinguish milk samples according to acceptability, milk quality was not being affected by concentrates fed. Bulk tank samples gave a standard reference point for each set of samples evaluated.

Statistical analysis of the data was by least squares (Harvey, 1975; Harvey and Thomson, 1969), according to the mathematical model defined in the box (on the next page). Of primary interest in the analysis were the relative ratings for milk from cows receiving the five concentrates. Because replacement of soybean protein by crab protein was proportional from 0 to 100 per cent, the four degrees of freedom for diet were subset into orthogonal components: linear, quadratic, cubic, and quartic. This approach is predicated on the assumption that if milk acceptability were rated differently according to diet, consequences of diet on milk quality might be expressed by a more complex relationship than a simple linear one. A simple linear relationship between crab meal and milk taste implies that each additional unit of crab meal in the diet has an equal impact on

Table 1. Ingredient Composition of Concentrate Mixtures.

Ingredients	Mixtures[1]				
	1	2	3	4	5
Corn	4.9	4.9	4.9	4.9	4.7
Barley	45.0	45.0	45.0	45.0	45.0
Mixed feed oats	10.0	8.3	5.3	2.3	0.0
Alfalfa meal	10.0	10.0	10.0	10.0	10.0
Linseed meal	7.5	7.5	7.5	7.5	7.5
Soybean meal	19.0	14.0	9.5	5.0	0.0
Crab meal	0.0	7.5	15.0	22.5	30.0
Molasses	2.0	2.0	2.0	2.0	2.0
Monocalcium phosphate	0.4	0.0	0.0	0.0	0.0
Dicalcium phosphate	0.4	0.0	0.0	0.0	0.0
Trace Mineral Salt	0.8	0.8	0.8	0.8	0.8
Vitamin A	2,000 IU/lb.				
Vitamin D_2	6,000 IU/lb.				

[1] 1) 100/0, 2) 75/25, 3) 50/50, 4) 25/75, 5) 0/100 soybean meal/crab meal on an isonitrogenous basis, i.e. crab meal replaced soybean meal on the basis of nitrogen content. Crab meal being lower in nitrogen, more than one unit of crab meal was required to replace each unit of soybean meal. Our objective here was to have all rations fed on an equal protein basis.

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

STATISTICAL MODEL

$$y_{ijkl} = \mu + a_i + (b{:}a)_{ij} + d_k + \tau_l + (ad)_{ik} + (d\tau)_{kl} + (db{:}a)_{ijk} + \beta(s_{ijkl}) + \epsilon_{ijkl}$$

Where

y_{ijkl}	=	score by l^{th} taster on milk from cow receiving the k^{th} diet in the j^{th} block nested in the i^{th} year
μ	=	common mean
a_i	=	effect of the i^{th} year, i = 1 to 2
$(b{:}a)_{ij}$	=	effect of the j^{th} block nested in the i^{th} year, j = 1 to 3
d_k	=	effect of the k^{th} diet, k = 1 to 5
τ_l	=	effect of the l^{th} taster, l = 1 to 10
$(ad)_{ik}$	=	year by diet interaction
$(d\tau)_{kl}$	=	diet by taster interaction
$(db{:}a)_{ijk}$	=	diet by block within year interaction
s_{ijkl}	=	taste score on bulk tank sample, covariable to y_{ijkl}
ϵ_{ijkl}	=	random residual component

milk taste irrespective of the amount fed. One might find, however, that the addition of crab meal to the diet, to a given level, would not affect milk taste but that further additions would adversely affect milk taste in greater proportion with each unit added. The experimental design permitted us to evaluate this relationship between amounts of crab meal fed and milk taste in increasing levels of complexity, each independent or orthogonal to the others.

Variability is a fact of life in most experimentation and one purpose of statistical analysis is to account for effects of little or no interest in order to view more clearly those of primary importance. In this experiment, the effect of years (2), evaluators (10), and certain interactions of these in addition to the effect of diet were included in the analysis. Scores for samples from the bulk tank were used for covariance adjustment of diet scores. Covariance is a statistical procedure used to adjust observations according to well-defined relationships prior to statistical analysis. Subjects who gave high scores to samples from the bulk tank may be more discriminating than those giving lower scores, and their scores given to milk from cows on experimental diets may reflect this difference. Therefore, adjustment on the basis of scores given a standard may place scores given milk from cows on experimental diets on a more equal basis for comparison. The general linear model used in the analysis provided weighted means on the basis of available data, because although all ten evaluators tasted milk from all five diets, extenuating circumstances precluded having every evaluator taste every milk sample.

RESULTS AND DISCUSSION

Mean taste scores given to milk from each of the five diets by each evaluator are shown in Figure 1. It is obvious that when asked to rate samples on a scale of 1 to 20, different evaluators set different standards for themselves, ranging from 4.4 to 10.6 for the ten evaluators across all five diets. Differences between evaluators were highly significant ($p < .01$). However, when ratings were considered for individual evaluators, Figure 1 shows that individuals were consistent across milk from all diets. Thus, if they rated one sample low (very acceptable) they tended to do so for all samples, and vice versa. This suggests that there is a greater difference between taste discrimination by evaluators than there is in the perceived taste of milk from cows on different diets.

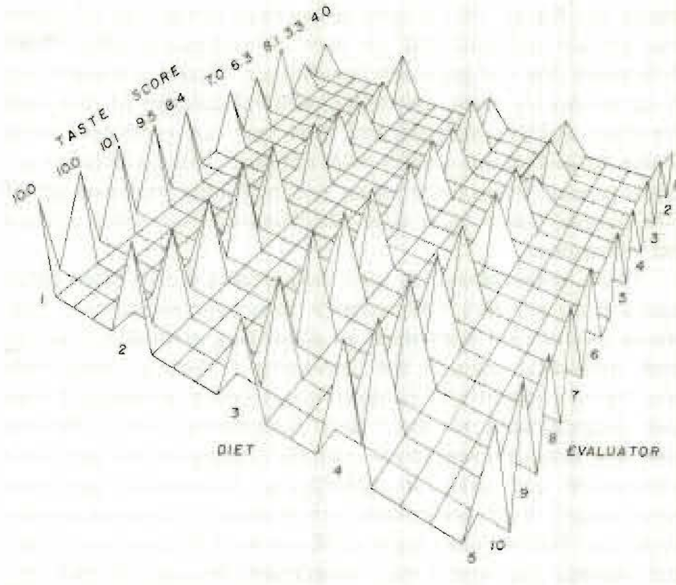


Figure 1. Average taste scores from (1) most acceptable to (20) least acceptable given by each of ten evaluators to milk produced on five diets. Diets were 1) 100/0, 2) 75/25, 3) 50/50, 4) 25/75, 5) 0/100 soybean meal/crab meal on an isonitrogenous basis. Each score is shown as a peak at the intersection of diet and evaluator on the three-dimensional graph. Actual values are given for diet (1) scores as reference to scores on the other four diets.

Mean taste scores given by all evaluators to milk from each of the five diets are shown in Figure 2. Scores ranged from 7.6 with no crab protein in the diet to 7.4 when crab protein re-

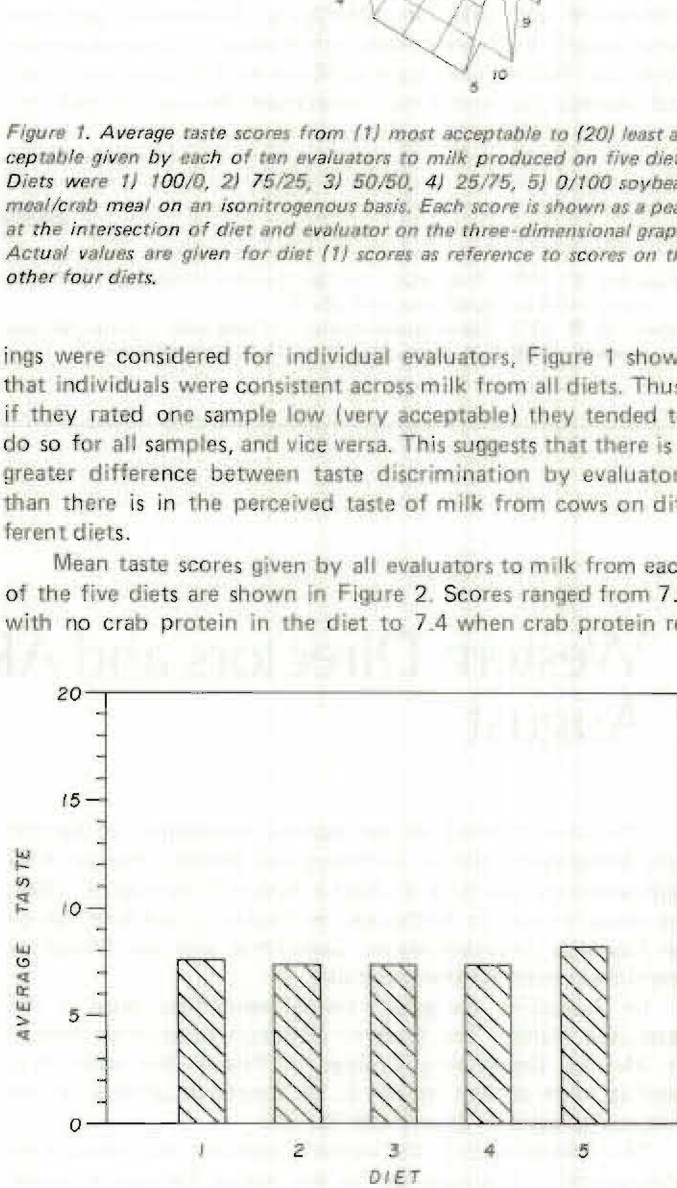


Figure 2. Average taste scores when milk produced on five diets was rated from (1) most acceptable to (20) least acceptable by ten evaluators. Diets were 1) 100/0, 2) 75/25, 3) 50/50, 4) 25/75 5) 0/100 soybean meal/crab meal on an isonitrogenous basis.

placed 25, 50, or 75 per cent of soybean protein to 8.2 when crab protein replaced 100 per cent of soybean protein. These differences did not approach significance. Figure 2 suggests little difference in taste scores for milk irrespective of diet, and statistical analysis substantiates that our ten evaluators were unable to distinguish among milk samples. This observation assumes greater importance when one considers that one set of milk samples came from cows receiving no crab meal in their diet whatsoever.

These observations on milk taste enable me to place other results from my nutrition research in proper perspective. Few people would find crab meal an appetizing substance, and, indeed, individual cows in the University of Alaska's dairy herd have found concentrates containing substantial amounts of crab meal unacceptable to their taste (Calcaterra, 1982). Results from the feeding experiment recently completed are yet to be summarized and analyzed statistically. However, I can state unequivocally from preliminary observations of cows on experiments that feeding crab meal as 30 per cent of the concentrate feed exceeds the level I will recommend for routine feed formulation. Consequently, we do not anticipate that feeding crab meal at reasonable levels to dairy cows will adversely affect milk quality. On the contrary, we will exceed the cow's tolerance for crab meal in her feed before we exceed her ability to digest and assimilate this material without adversely affecting milk taste.

ACKNOWLEDGMENTS

This work is a result of research sponsored by the Alaska Sea Grant Program, cooperatively supported by NOAA Office of Sea Grant, Department of Commerce, under Grant NA81AA-D-00009, and by the University of Alaska with funds appropriated by the State of Alaska; and from a project contributing to North Central Regional Project, NC-115, Nutrition of High Producing Dairy Cows. The support of Seward Fisheries, Inc. is gratefully acknowledged. I am especially indebted to the ten people who tasted and rated milk samples, and to Mary Lou Herlugson for the computer-generated graphics. □

REFERENCES

Calcaterra, K. 1982. Crab meal — a local protein source for the Alaska dairy industry. *Agroborealis 14*:86-89.

Harvey, W. R. 1975. Least-squares analysis of data with unequal subclass numbers. ARS-H-4, Agric. Res. Serv., U. S. Dept. of Agric.

Harvey, W. R. and G. Thomson. 1969. Instructions for use of LSMLGP (Least-squares and maximum likelihood general purpose program). Ohio State University.

Western Directors and ARS Review Team in Alaska in August

The joint meeting of the Western Association of Agricultural Experiment Station Directors and Western Region ARS Administrators was held in Alaska August 5 through 9, 1982. The group arrived in Anchorage on August 5, and meetings of the Research Implementation Committee and the Executive Committee were held there that day.

On August 6, the groups toured agricultural areas in the Matanuska Valley. The Western Directors Association met at the Mat-Su Community College in Palmer the same day; meetings were chaired by Dr. L. W. Dewhirst, director of the Arizona Agricultural Experiment Station.

The following day, the western directors continued their deliberations in a private car on the Alaska Railroad en route to McKinley National Park. On Sunday, August 8, the group took time out from its work schedule to take the Tundra Wildlife Tour at the park, and then continued by train north to Fairbanks.

The Western Director's Meetings concluded on August 9 on the University of Alaska-Fairbanks campus. Following adjournment, the groups toured the Delta Agricultural Project area and visited with local farmers.

During the visit to Alaska, a CSRS-ARS review team reviewed the Alaska Agricultural Experiment Station programs at the station's Fairbanks and Palmer Research Centers. Members of the review team were:

Dr. Chas. M. Smith, Soil Scientist, CSRS-USDA, Washington, D. C.

Dr. Dennis L. Oldenstadt, Associate Director, Washington State AES, Pullman

Dr. Wilson H. Footer, Associate Director, Oregon AES, Salem

Dr. John Vetterling, ARS-USDA Director, Rocky Mountain Area, Ft. Collins, Colorado

Notes

Dr. Robert F. Cullum has joined the Fairbanks staff of the Alaska Agricultural Experiment Station as an assistant professor of agricultural engineering. Dr. Cullum will be working to build a research program in his field with emphasis on plant and animal environments, energy resources for agriculture, and process engineering for agricultural products. His duties primarily will involve research in agricultural engineering directed toward the needs of agricultural development in the north. He will also be teaching courses in his field.

Dr. Cullum received his B.S. in Agricultural Engineering from the University of Tennessee at Knoxville in 1977, graduating with high honors. He received his Ph. D. in 1982, also in agricultural engineering. Dr. Cullum's hobby interests include archery, hiking, and biking.

Dr. William B. Collins, the first instructor of range management at the University of Alaska is now the first assistant professor of range management at the U of A. Dr. Collins moved from the Palmer Research Center to the Fairbanks campus to assume his new role. In doing so, he became responsible for teaching the first course in range management offered at U of A.

Dr. Collins's research duties are with reindeer range management on the Seward Peninsula. Except for some studies by the Alaska Dept. of Fish and Game, reindeer range research has not been conducted in that region for almost 50 years.

His research will address such problems as determining proper intensity and frequency of use on range sites in northwestern Alaska, as well as evaluating the availability and quality of forages used by reindeer on those sites.

Patrick V. Mayer became a range technician at the Palmer Research Center in April 1982. Pat has a B.S. in range management and soils from Washington State University. Before coming to Alaska, he was a range technician for the Bureau of Land Management in Rawlings, Wyoming. He was previously a forestry technician on the Siskyo National Forest in Oregon.

Pat is energetic and enthusiastic about his current assignment on the Susitna Hydroelectric Project. In addition to being a part of the summer field crew, he is also in charge of drying, weighing, grinding, and cataloging the thousands of soil and plant samples which were collected during the field season.

Dr. William D. Steigers, Jr., assumed a position as instructor in range management at the Palmer Research Center in June 1982. Dr. Steigers is only the second person to hold this position at the U of A. Dr. Steigers received his B.S. (1976) and M.S. (1978) degrees in wildlife at the University of Idaho. He completed a Ph. D. (1981) at Brigham Young University in range management and wildlife. During his Ph. D. program, Bill took courses at Utah State University and conducted habitat-use and mule deer fawn-mortality research in South Dakota. His research experience with wildlife habitat use are particularly valuable to the AES studies currently underway for the proposed Susitna Hydroelectric Project. Bill was raised on a farm in Nez Perce Country, Idaho, and brings practical as well as academic expertise to the experiment station staff. Dr. Steigers and his wife, Sharon, have two sons, Chadron and Mark.

James G. MacCracken became a range ecologist at the Palmer Research Center in June 1982. This is the first range ecologist position at the U of A. Jim is originally from California. He attended Pasadena City College, Calif.; Adams State College of Colo.; and Colorado State University. He received a B.B.S. in wildlife biology and a M.S. in range ecology from Colorado State University.

Jim specialized in dietary analyses of predator and relationships between wildlife and habitats. Prior to his coming to the University of Alaska, he worked for the U. S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Rapid City, South Dakota. He has worked extensively at the Idaho National Engineering Laboratory site between ARCO and Idaho Falls, Idaho. His experiences vary from basic wildlife ecological research to studies involving wildlife and domestic livestock. These types of research are of great importance to Alaska as various energy, mineral, and agricultural developments proceed.

Jim has proven to be a competent researcher with an impressive list of publications. He came to the Palmer Research Center with high recommendations.

Dr. Dot J. Helm has become a research associate at the AES. The position, titled plant synecologist, involves research on plant community ecology. Dr. Helm received her Ph.D. at Colorado State University in 1981. Her dissertation focused on comparisons of vegetation diversity indices, their relative values in describing vegetation communities, and their statistical characteristics in testing hypotheses. This type of research is especially useful for quantifying impacts and mitcyations of various developmental projects on wildland vegetation. Federal regulations require that reclamation efforts restore not only the vegetation cover, but also the vegetation diversity that existed prior to the developmental effort.

Dr. Helm is continuing work which she began on the Susitna Hydroelectric Project. She has also investigated plant communities at the Usibelli Coal Mine, the proposed Beluga Coal Mine, and on the bison range near Delta Junction. Prior to becoming a research associate, Dr. Helm was a range technician at the Palmer Research Center. She has a B.S. in mathematics (Universtiy of Delaware); M.S. in computer science (University of Michigan), and a M.S. in quantitative ecology (Colorado State University). Most recently, Dr. Helm has earned her private pilots license.

IN MEMORIUM

Dr. Curtis H. Dearborn, who retired from the Palmer Research Center of the Alaska Agricultural Experiment Station in 1981, died of cancer in Anchorage in May of 1982.

Dr. Dearborn was one of Alaska's foremost horticulturists. For more than thirty years, he conducted research on cultural practices for potatoes, garden peas, lettuce, and strawberries; the possbility of peas as an Alaskan frozen-food product for local distribution; and, especially significant to Alaskans, determination of light quality available for crops.

After his retirement, Dr. Dearborn continued writing the results of his many years of research and was continuing a number of projects at his home in Palmer. He was also continuing to pursue his work with Eskimo villages in the Kobuk River Valley in order to help the residents grow potatoes for local markets.

Dr. Dearborn will be missed by his colleagues and by the many Alaskan who knew his dedication to improving one aspect of life in this state.

He is survived by his wife, Doris, his five children, and several grandchildren.

Publications List for 1982

JOURNAL ARTICLES

Carling, D. E., and M. F. Brown.1982. Anatomy and physiology of vesticular-arbuscular and nonmycorrhizal roots. *Phytopathology 72*: 1108-1114.

Holloway, P. S. 1982. *Rubus arcticus,* the arctic raspberry. *Fruit Varieties Journal 36*:84-86.

Holloway, P. S., R. M. Van Veldhuizen, C. Stushnoff, and D. K. Wildung. 1982. Vegetative growth and nutrient levels of lingonberries grown in four Alaskan substrates. *Can. J. Plant Sci.*, October.

Holloway, P. S., R. M. Van Veldhuizen, C. Stushnoff, and D. K. Wildung. 1982. Effects of light intensity on vegetative growth of lingonberries. *Can. J. Plant Sci.*, October.

Laughlin, W. M., G. R. Smith, and M. A. Peters. 1982. A multipurpose wetting agent, WEX and a cultured biological product, AGRISPON, leave potato yields unchanged. *American Potato Journal 59*:87-91.

MacCracken, J. G. 1982. Coyote foods in a southern California suburb. *Wildlife Society Bulletin 10*(3):280-281.

MacCracken, J. G., and R. M. Hansen. 1982. Herbaceous vegetation of habitat used by blacktail jackrabbits and nuttull cottontails in southeastern Idaho. *American Midland Naturalist 107*(1):180-184.

MacCracken, L. G., and R. M. Hansen. 1982. Seasonal food of coyotes in southeastern Idaho: A multivariate analysis. *Great Basin Naturalist 42*(1).

Michaelson, G. J., T. E. Loynachan, F. J. Wooding, and G. A. Mitchell. 1982. Effects of N, P, and K fertilization on barley grown in a newly cleared subarctic soil. *Agronomy Journal 74*:694-699.

Mitchell, W. W. 1982. Forage yield and quality of indigenous and introduced grasses at Palmer, Alaska. *Agron. J. 74*:899-905.

Steigers, W. D., Jr., J. T. Flinders, and S. M. White. 1982. Rhythm of fecal pellet production and protein content for black-tailed jackrabbits. *Great Basin Naturalist 42*(4).

Thomas, W. C., and M. Thomas. 1982. Public ploicy and petroleum development: The Alaska case. *Arctic 35*(3):349-357.

Van Cleve, D., and L. K. Oliver. 1982. Growth response of post fire quaking aspen (*Populus tremuloides* Michx) to N, P and K fertilization. *Can. J. For. Res. 12*(2):160-165.

BOOKS AND CHAPTERS IN BOOKS

Becker, R.H., and A. Jubenville. 1982. Forest Recreation Management, IN: *Introduction to Forest Science* (R. A. Young, ed.). John Wiley and Sons. New York.

Jubenville, A., and R. H. Becker. 1982. Outdoor recreation management — Two competing schools of thought, IN: *Recreation Planning and Management* (S. R. Lieber and D. R. Fasenmaier, eds.). Venture Publishing, Inc. State College, Pa.

Thomas, W. 1982. The role of agriculture in Alaska's rural development, Chapter 3 in *Alaska's Rural Development* (P. Cornwall and G. McBeath, eds.). Westview Press. Boulder, Colorado.

AGROBOREALIS

Allen, L. D. 1982. Solar energy for grain drying in Alaska. *Agroborealis 14*:66-68.

Brundage, A. L. 1982. Beefalo in Alaska. *Agroborealis 14*:48-49.

Elliot, C. L., and J. D. McKendrick. 1982. Stripmine reclamation and wildlife in Alaska. *Agroborealis 14*:4-6.

Feyhl, J., and A. Jubenville. 1982. Using the recreation concept plan technique to assess public choice. *Agroborealis 14*:38-42.

Gasbarro, A. 1982. Forestry in Sweden and Finland: Its applicability to interior Alaska. *Agroborealis 14*:16-24.

Helm, D. 1982. Vegetation studies for the proposed Susitna hydroelectric project. *Agroborealis 14*:52-55.

Juday, G. 1982. Climatic trends in the interior of Alaska: Moving toward a high CO_2 world? *Agroborealis 14*:10-15.

Laughlin, W. M., G. R. Smith, and M. A. Peters 1982. A cultured biological product provides no beneficial effects on barley or bromegrass. *Agroborealis 14*:25-27.

Lewis, C. E., and C. W. Knight. 1982. Rapeseed response to seeding rate, row spacing and nitrogen application. *Agroborealis 14*:50-51.

McKendrick, J. D. 1982. Alaska's Bison — a game biologists' range-management problem. *Agroborealis 14*:73-79.

Michaelson, G. J., F. J. Wooding, and G. A. Mitchell. 1982. Fertilizer requirements for barley grown on newly cleared land in Alaska's interior. *Agroborealis 14*:44-47.

Mitchell, G. A. and J. R. Offner. 1982. Nitrogen: transformation and availability in Alaskan soils. *Agroborealis 14*:69-72.

Mitchell, W. W. 1982. Grasses and their uses in Alaska. *Agroborealis 14*: 34-37.

Richmond, A. P. 1982. Intensive forest management: The Bonanza Creek demonstration project. *Agroborealis 14*:90-94.

Slaby D., and C. E. Lewis. 1982. A village-based plan for the small-scale production of ducks, geese, and rabbits. *Agroborealis 14*:60-65.

Thomas, W. C. 1982. Project agriculture: An experience in the southern hemisphere. *Agroborealis 14*:7-9.

Warren, C. 1982. Potential markets for ducks, geese and rabbits in Alaska. *Agroborealis 14*:56-59.

Workman, W. B., and E. L. Arobio. 1982. Toward a system of grazing fees for state rangelands in Alaska. *Agroborealis 14*:80-85.

CONFERENCE AND SYMPOSIA PROCEEDINGS

Bleicher, D. P. 1981 (omitted from 1982 list). Thermal unit accumulations and spring emergence of *Hylemya* species (Diptera: Anthomyiidae). IN: Proceedings, First Alaska Integrated Pest Management Conference. Fairbanks.

Bleicher, D. P. 1982. *Capsus simulans* (Hemiptera: Miridae) in relation to grass seed production in Alaska. IN: Proceedings, 33rd Alaska Science Conference. American Association for the Advancement of Science, Arctic Division, University of Alaska.

Casavant, K., and W. Thomas. 1982. Designing a physical distribution system for developing resource sectors. IN: Proceedings, Northern Transportation Conference: The Challenge of the Eighties. Whitehorse, Yukon, Canada.

Conn, J. S. 1982. Integrated pest management and weed control in Alaska. IN: Proceedings, Second Annual Integrated Pest Management Conference. University of Alaska. Cooperative Extension Service, Fairbanks. pp 69-71.

Gipson, P. S., and J. D. McKendrick. 1981 (omitted from 1982 list). Bison depredation on grains fields in interior Alaska. IN: Fifth Great Plains Wildlife Damange Control Workshop, Proceedings. University of Nebraska, Lincoln. October 13-15, pp 116-121.

Gordon, A. M., and K. Van Cleve. 1982. Seasonal patterns of nitrogen mineralization following harvesting in the white spruce forests *(Picea glauca* [Moench] Voss) forests of interior Alaska. IN: Proceedings, 33rd International Symposium of Dynamics of Boreal Forest Ecosystems. Thunder Bay, Ontario. August 23-26.

Murray, M. (ed.) 1982. Forest regeneration at high latitudes: Experiences from northern British Columbis. Proceedings, Third International Workshop. SALRM, UAF, in cooperation with U. S. Forest Service. Pacific Northwest Forest and Range Experiment Station, Misc. report no. 82-1, Portland.

Scorup, P. C., T. H. George, J. D. Swanson, and M. P. Kinney. 1982. Mapping Seward Peninsula reindeer ranges. (abstract) IN: Proceedings, 33rd Alaska Science Conference. American Association For the Advancement of Science, Arctic Division, University of Alaska. pp. 224-225.

Swanson, J. D., M. P. Kinney, P. C. Scorup. 1982. Reindeer range vegetation inventory procedures. IN: Proceedings, Third International Reindeer/Caribou Symposium. Helsinki, Finland.

Uresk, D. W., J. G. MacCracken, and A. J. Bjugstad. 1982. Prairie dog density and cattle relationships. IN: Proceedings, Fifth Great Plains Wildlife Damage Control Workshop. April. Lincoln, Nebraska. pp. 199-201.

Van Cleve, K, A. Viereck, and C. T. Dyrness. 1982. Dynamics of a black spruce *(Picea mariana)* ecosystems in comparison to other forest types: A multi-disciplinary study in interior Alaska. IN: Proceedings, International Symposium on Dynamics of Boreal Forest Ecosystems. Thunder Bay, Ontario, August 23-26.

CIRCULARS AND EXTENSION PUBLICATIONS

Gasbarro, A. F. (ed.) 1982. Alaska Branching Out (Quarterly newsletter). SALRM, UAF; CES, UAF.

Quarberg, D. M., C. W. Knight, C. E. Lewis, and F. J. Wooding. 1981. (omitted from 1982 list). Successful barley production practices for the Delta-Clearwater area of Alaska. Cooperative Extension Service, University of Alaska, and USDA Cooperating. P-147.

Quarberg, D. M., W. W. Mitchell, G. A. Mitchell. 1982. Adapted varieties of permanent grass for forage production in Delta Junction. Cooperative Extension Service, University of Alaska, Fairbanks, USDA.

Wooding, F. J., J. H. McBeath, J. T. Hanscom, and G. M. Delucchi. 1982. Performance of cereal crops in the Tanana River Valley of Alaska, 1981. Agricultural Experiment Station, School of Agriculture and Land Resources Management, University of Alaska, Fairbanks. Circular No. 42, 25 pp.

POPULAR PUBLICATIONS

Brundage, A. L. 1981 (omitted from 1982 list). The computer and the Alaska dairy cow. *Alaska Farm Magazine 1*(1):13.

Brundage, A. L. 1982. Dairy under the aurora. *Alaska Farm Magazine 2*(1):19.

Brundage, A. L. 1982 Dairy under the aurora. *Alaska Farm Magazine 2*(2):19.

Brundage, A. L. 1982. Dairy under the aurora — Ration balancing for protein. *Alaska Farm Magazine 2*(3):33.

Brundage, A. L. 1982. Dairy under the aurora — Energy an important component in rations. *Alaska Farm Magazine 2*(4):8.

Brundage, A. L. 1982. Dairy under the aurora — Use of forages in rations. *Alaska Farm and Garden 2*(6):19.

Brundage, A. L. 1982. Dairy under the aurora — Culling the dairy herd is both voluntary and involuntary. *Alaska Farm and Garden 2*(7):31.

Brundage, A. L. 1982. Dairy under the aurora — Pasture breeding verus artificial insemination. *Alaska Farm and Garden 2*(8):35.

Brundage, A. L. 1982. Dairy under the aurora. *Alaska Farm and Garden 2*(9):21.

ABSTRACTS

Bleicher, D. P. 1981 (omitted from 1982 list). Seasonal activity and control of *Hylemya floralis* in Brassica plantings. (abstract) IN: Proceedings, 32nd Alaska Science Conference, American Associaton For the Advancement of Science, Arctic Division, University of Alaska. p. 149.

Brundage, A. L. 1982. Drawing for Alaska agriculture land disposal lotteries by computer. (abstract) IN: Proceedings, 33rd Alaska Science Conference. American Association for the Advancement of Science, Arctic Division, University of Alaska. p. 227.

Brundage, A. L., and F. M. Husby. 1982. Sequential degradation of soybean meal in marine waste meals in two-stage *in vitro* system. (abstract) IN: *Journal of Dairy Science 65*(Suppl. 1):125.

Conn, J. S., and J. A. DeLapp. 1982. Alaskan weeds: A study of geographical distribution and succession using ordination methods (abstract) IN: Proceedings 1982 Meeting Weed Science Society of America. pp. 78-79.

Delucchi, G. M., and F. J. Wooding. 1982. Relative effectiveness of three phosphorus fertilizers and two methods of application for barley grown in interior Alaska. (abstract) IN: Proceedings, 33rd Alaska Science Conference. American Association for the Advancement of Science, Arctic Division, University of Alaska. p. 156.

Delucchi, G. M., and F. J. Wooding. 1982. Response of barley to broadcast and band application of three phosphate carriers in central Alaska. Agronomy Abstracts, 74th Annual Meeting of the American Society of Agronomy, Anaheim, California, p. 275.

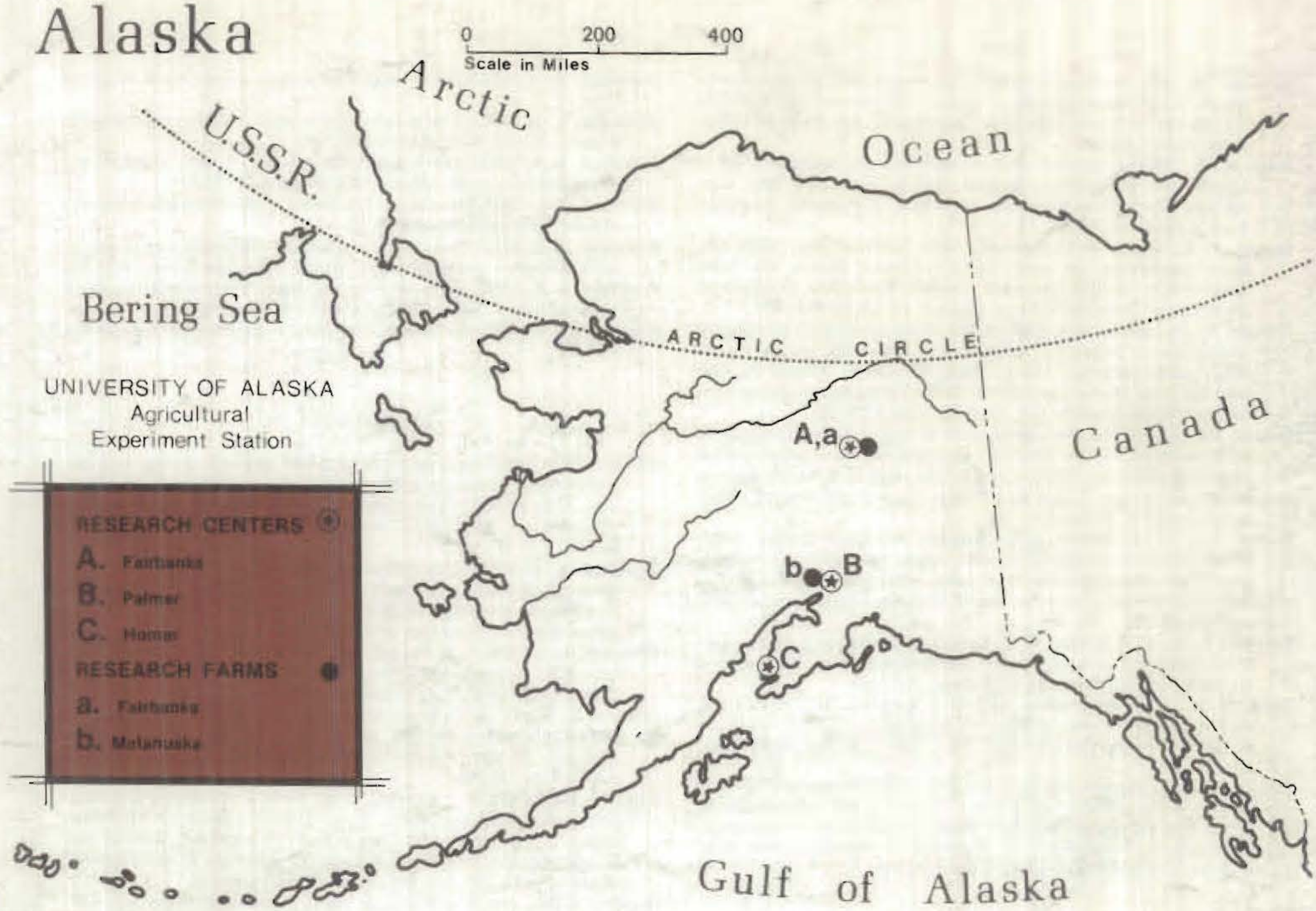
Juday, G., and D. Taylor. 1982. The contrast in structure between an upland and a bottomland white spruce (*Picea glauca* [Moench] Voss) Forest in the White Mountains of interior Alaska. (abstract) IN: Proceedings, 33rd Alaska Science Conference. American Association for the Advancement of Science, Arctic Division, University of Alaska. p. 165.

Larson, D., and W. Workman. September 1982. Outdoor recreation economics: Some Alaska policy issues. (abstract) IN: Proceedings, 33rd Alaska Science Conference. American Association for the Advancement of Science, Arctic Division, University of Alaska. p. 169.

McBeath, J. H. 1982. Barley disease research in Alaska. (abstract) IN: Proceedings of the Second Alaska Integrated Pest Management Conference, Fairbanks. pp. 47-49.

Mitchell, G. A., and J. R. Offner. 1982. Urea-nitrogen transformations and availability in sub-arctic agricultural soils. Agronomy Abstracts, 74th Annual Meeting fo the American Society of Agronomy, Anaheim, California.

Workman, W., and P. O' Brien. 1982. Revealing preferences for public resource use: Some unsettled issues. (abstract) IN: Second Alaska Behavioral Science Conference. Psychology Department, University of Alaska, Fairbanks.



Agricultural Experiment Station
University of Alaska
Fairbanks, Alaska 99701

J. V. Drew, Director

Publication

Address correction requested
Return postage guaranteed

POSTAGE PAID
U.S. DEPARTMENT OF
AGRICULTURE
AGR 101
THIRD CLASS
BULK RATE

U.S.MAIL

If you do not desire to continue receiving this publication, please check here ☐; cut off this label and return it to the above address. Your name will be removed from the mailing list.